Technological Ambiguity & the Wassenaar Arrangement

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A thesis submitted for the degree of Doctor of Philosophy

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Abstract

International cooperation on export controls for technology is based on three assumptions, that it is possible: to know against whom controls should be directed; to control the international transfer of technology; and to define the items to be controlled. These assumptions paint a very hierarchical framing of one of the central problems in export controls: dual-use technology. This hierarchical framing has been in continual contention with a competitive framing that views the problem as the marketability of technology. This thesis analyses historical and contemporary debates between these two framings of the problem of dual-use technology, focusing on the multilateral Wassenaar Arrangement on Export Controls for Conventional Arms and Dual-Use Goods and Technologies. Using a framework of concepts from Science & Technology Studies and the theory of sociocultural viability, I analyse the Arrangement as a classification system, where political, economic, and social debates are codified in the lists of controlled items, which then structure future debates. How a technology is (not) defined, I argue, depends as much on the particular set of social relations in which the technology is enacted as on any tangible aspects the technology may have.

The hierarchical framing is currently hegemonic within Wassenaar, and I show how actors that express this framing use several strategies in resolving anomalies that arise concerning the classification of dual-use technology. These strategies have had mixed success, and I show how they have adequately resolved some cases (e.g. quantum cryptography), while other areas have proved much more difficult (e.g. focal plane arrays and computers). With the development of controls on intangible technology transfers, a third, egalitarian framing is arising, and I argue that initial steps have already been taken to incorporate this framing with the discourse on dual-use technology. However, the rise of this framing also calls into question the fundamental assumption of export controls that technology is excludable, and therefore definable.

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To Grandmother, one of the most inspirational women I have ever known.

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There are many people and institutions that have played a part in this thesis, and I am grateful to all of them for the support and encouragement they provided along the this long and winding walk. I was a part of the James Martin Institute for Science and Civilization from its inception until it transformed into the Institute for Science, Innovation, and Society. It consistently provided a stimulating academic environment, particularly as the DPhil student body grew. The Institute was very generous in its financial support for me, providing funding through the Research Training Fund, various jobs, and finally a research assistantship with Sir Crispin Tickell helping run the Policy Foresight Programme.

I had the good fortune to have two visiting research positions during my thesis, both funded by the James Martin Institute. The first was as a Young Summer Scholar at the International Institute for Applied Systems Analysis (IIASA) outside of Vienna. IIASA provided a rich environment of interdisciplinary scholars, and a venue away from Oxford for me to sort out exactly what the topic of my doctoral thesis would be.

The second stint of time away from Oxford was as a Visiting Researcher with the Center for Peace and Security Studies (CPASS) in the Walsh School of Foreign Service at Georgetown University. CPASS provided a chance for me to take courses in international security, and I am particularly grateful to Kai-Henrik Barth, Jasen Castillo, and Dick Van Atta for their time and support. Georgetown also provided an excellent base for conducting many of my US interviews.

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New College was one of the main reasons I found my time in Oxford so satisfying. The graduate community there is always a rich source of interesting ideas and personalities. The sports and the chalet in the French Alps provided excellent diversions from the daily grind. I also thank the College for granting me travel awards for various trips, plus a grant to help me finish writing up.

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Statement of Originality

I declare that this thesis has not been previously submitted to this or any other University for a degree, and that it is my own work.

Abstract

International cooperation on export controls for technology is based on three assumptions, that it is possible: to know against whom controls should be directed; to control the international transfer of technology; and to define the items to be controlled. These assumptions paint a very hierarchical framing of one of the central problems in export controls: dual-use technology. This hierarchical framing has been in continual contention with a competitive framing that views the problem as the marketability of technology. This thesis analyses historical and contemporary debates between these two framings of the problem of dual-use technology, focusing on the multilateral Wassenaar Arrangement on Export Controls for Conventional Arms and Dual-Use Goods and Technologies. Using a framework of concepts from Science & Technology Studies and the theory of sociocultural viability, I analyse the Arrangement as a classification system, where political, economic, and social debates are codified in the lists of controlled items, which then structure future debates. How a technology is (not) defined, I argue, depends as much on the particular set of social relations in which the technology is enacted as on any tangible aspects the technology may have.

The hierarchical framing is currently hegemonic within Wassenaar, and I show how actors that express this framing use several strategies in resolving anomalies that arise concerning the classification of dual-use technology. These strategies have had mixed success, and I show how they have adequately resolved some cases (e.g. quantum cryptography), while other areas have proved much more difficult (e.g. focal plane arrays and computers). With the development of controls on intangible technology transfers, a third, egalitarian framing is arising, and I argue that initial steps have already been taken to incorporate this framing with the discourse on dual-use technology. However, the rise of this framing also calls into question the fundamental assumption of export controls that technology is excludable, and therefore definable.

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Arma virumque cano

— Virgil, *Aeneid, Book I*

1 Introduction

On a cool and wet February morning, I made my way down Victoria Street in London to the old Department of Trade and Industry building for one of the first interviews I conducted on the Wassenaar Arrangement. Going through the normal bureaucratic badge-signing and waiting, I was greeted by a member of the British delegation to the Arrangement and led to a meeting room, where I met another member of the delegation from the Ministry of Defence. The coffee was poured and I, a young researcher, was unsure how to proceed, though I had prepared copious notes and questions. I gave a brief background on my institute and assured them that I was funding my own way through my doctorate rather than on some government or corporate payroll. And then they asked a question that was asked by most of my interviewees when I introduced my topic to them. With a curious tone in his voice, one of them asked, "So what made you focus on the Wassenaar Arrangement?"

"Jointly, I think," laughed the other one, "it was one of our questions. *Why Wassenaar?*" The reason for this curiosity was simple. No one studies the Wassenaar Arrangement. When many people hear 'export controls', they think about arms control, about preventing the proliferation of nuclear bombs or other weapons of mass destruction. Or perhaps they think about the arms trade, selling guns to third world countries and thereby possibly propagating injustices. My research concerns neither of these topics, though I readily admit that they are areas which deserve—and are receiving—much attention.

The Wassenaar Arrangement is an international arrangement among forty governments which "contribute[s] to regional and international security and stability by promoting transparency and greater responsibility in transfers of conventional arms and dual-use goods and technologies, thus preventing destabilising accumulations" (Wassenaar Arrangement, 2008*c*). It does this primarily through maintaining a common list of technology that should be controlled in international trade because of its perceived potential military use. Participating States of the Arrangement also share information about transfers of controlled items and work towards harmonising their export control systems. Except in a few instances, Wassenaar does not concern itself with technologies related to weapons of mass destruction (WMD). Instead, it focuses on non-WMD, or 'conventional', weapons and related 'dual-use' technologies.

The Arrangement is one of the attempts by governments to address the problem of dual-use technology. The idea is simple. Since technologies can be used against a country, the government should control who has access to those technologies. This idea is based on three assumptions: that it is possible to know from whom a government should keep a technology; that it is possible to control access to the technology; and that it is possible to know which technologies to control.

My interest in the Wassenaar Arrangement is based on an analysis of these assumptions. One does not have to search very far to find arguments that it is no longer clear from whom militarily significant technologies should be kept. Many of these arguments draw on the point that most of the apparatus of modern export control systems is based on having a clearly identified enemy. While the Wassenaar Arrangement is not directed at any state or group of states, it takes much of its structure and operating procedures from its predecessor, the Coordinating Committee for Multilateral Export Controls (CoCom), which controlled the flow of technology from the West to the Communist Bloc during the Cold War.

Similarly, there are many reviews of the inadequacy of current export control systems' ability to control the transfer of technologies. Controls, such critics claim, are either too cumbersome, too expensive, too time-consuming, too restrictive, not restrictive enough, or some combination of these and other factors.

Very little research, however, has so far been conducted on whether it is possible to know which technologies governments need to control. For instance, the yearly review of armaments, disarmament, and international security published by the Stockholm International Peace Research Institute (SIPRI) usually has a page or two on developments within the Wassenaar Arrangement, but only a few sentences which say, "The WA control lists were amended to take into account technical and security developments" (Anthony & Bauer, 2007, p. 647).

On first glance, this seems entirely appropriate. While the SIPRI Yearbook is a specialist publication for the arms control community, it must cover a substantial amount of material each year. It is likely that only a very small portion of its readership would like to know that the Arrangement decided to include controls, for example, on "non-'space-qualified' non-linear (2-dimensional) infrared 'focal plane arrays' based on 'microbolometer' material having individual elements with an unfiltered response in the wavelength range equal to or exceeding 8,000 nm but not exceeding 14,000 nm." Nor would the publication have the space to discuss (nor the time to research) the other dozens of modifications made each year to the Dual-Use List, each of which likely involves a substantially different body of expert technical knowledge.

But times, as they say, are changing. Calls for the reform of national export control systems and the international arrangements of which they are a part have been increasing in both their quantity and depth of analysis, particularly in the United States (US). Export controls, these reports/journal articles/testimonies claim, are a relic of the Cold War and no longer adequate in a world of global commerce and cooperation. Moreover, in trying to prevent the international distribution of militarily sensitive technology, they may actually be making the country less secure by undermining the competitiveness of companies that rely on a global market to remain at the forefront of research and development. These calls, however, are rarely connected to an analysis of the mundane practices within a national system or an international arrangement such as the Wassenaar Arrangement.

The need for political support for export control reform is recognised both outside and inside governmental institutions. However, it is my contention that, even with political support, reform will not happen from the top down in this system, which is heavily based on the employment of experts to perform its day-to-day operations. Moreover, by over-politicising the work of export controls, governments run the significant risk that positions will become too polarised to achieve any progress. A more useful way to generate the needed reforms—and indeed to define what reforms are needed—is to begin with an analysis of the basic practices within an export control system.

This thesis is an analysis of one of those practices: the process through which modifications are made to the Wassenaar Arrangement Dual-Use List. The analysis is both grounded in the history of the lists and enmeshed in recent debates within the Arrangement. I take an unconventional approach to viewing the Arrangement, characterising it not as an international regime trying to solve a clearly defined problem, but rather as an incompletely theorised agreement that must contend with multiple definitions of the problem to be solved. Rather than analysing it as primarily a political arrangement among governments, I view it as a classification system that is maintained by a mix of technical experts, political and economic motivations, and social and institutional constraints.

The value of such a perspective is that it provides a fresh look at a system that is likely to see significant changes in the next few decades but is at the moment still trying to escape from its current institutional and intellectual framing. The thesis is not intended to provide answers for practitioners as to how to structure an export control system. It is, instead, meant to show some overlooked benefits of the current system and provide some insight into ways to foster the emergence of changes to that system.

The thesis is structured around exploring three inter-related questions. The first is “What is a dual-use technology?” The question does not have a single answer, nor is the answer ever permanently set. Today’s dual-use technology may be tomorrow’s mobile phone. The continual re-definition of dual-use technology should not be taken necessarily as a sign of the ever-advancing and inescapable development of technology. Nor is it a continual refinement, set eventually to arrive at an objective list of technology that is inherently dual-use. Rather, I argue that the definitional process serves much the same purpose that it serves in language more generally: it codifies particular sets of social relations, which allow for people to do some things more easily, while making other things more difficult. Defining dual-use technology is a pragmatic process where there is no over-arching theory used to objectively identify technology or parts thereof that are ‘dual-use’. Definitions rest on many contingencies, from perceived military significance to controllability to the fact that translations of a definition must work in over a dozen languages.

The second question the thesis explores is “What is the Wassenaar Arrangement trying to do?” Like the first question, the answer to this one is multiple and contingent. Under the broad heading of preventing destabilising accumulations, Wassenaar Participating States pursue several, often contradictory, objectives, most notably the objectives of security versus economy. These objectives are not always contradictory, and the case of intangible transfers of technology shows how the objectives of both are in alignment. But both of them, I then point out, may be contradictory to the objectives of openness characteristic of the academic world, which relies on intangible transfers for its livelihood.

The third question is "How is the Wassenaar Arrangement trying to achieve its goals?" The Arrangement is the current manifestation of a long history of international collaboration on export controls, and has maintained facets of its rules, procedures, and lists from that history. As a result, while some parts of the Arrangement are very up-to-date in addressing the needs of the contemporary international system, other parts are still based on a system that was developed over half a century ago. I argue for viewing the Arrangement as a long series of institutionalised decisions, each of which is a fixed point and serves as a marker of the balance of the different framings on the problem of dual-use technology present in the debate at the time. Decisions are reached when and where they can be, with little thought given to creating a cohesive overall theory of how the Arrangement works and what it should control.

Thesis overview

To explore these questions, the thesis is divided into three main sections. The first provides the broad theoretical and historical landscape within which I define my arguments, as well as the methodology I used to gather and analyse the data to make those arguments. The second is an in-depth analysis of the changing structure of the international lists of controlled items from the 17th Century to the current day. I then analyse a set of changes to the Wassenaar Arrangement Dual-Use List, through which I explore the ways that Participating States of the Arrangement use these list changes for multiple purposes. The third section looks at the addition of controls on intangible aspects of technologies and the development of controls on the intangible transfers of technology to show how the Arrangement may be trying to push the bounds of the definition of dual-use technology beyond the realm of acceptability to all of the different communities of practice to which it is accountable.

Chapter 2 provides the reader with an overview of the theoretical landscape in which the thesis sits. It begins with a discussion of different ways to understand what technology is, and what is the role of technology in society. I situate my argument within the literature that describes technology as text and explore the ways that certain configurations of technologies afford some types of interaction more than other configurations. I then review the literature on classification systems, and in particular systems of classifying technology. Rather than arguing that technologies have essential properties that place them in an objective classification system, I take up the position that categories of technologies are interpretively flexible and established largely on a pragmatic basis. Technologies need to serve many communities of practice, and often each community will have a different way of describing and interacting with similar technologies. When trying to establish a classification system that will accommodate multiple communities, then, much effort will likely be spent on deciding which aspects of the technology to define and which aspects to leave ambiguous. The chapter then turns to a review of theories of export controls, which come mainly from the literatures on law, international relations, and institutional analysis. I conclude the chapter with a review of the theory of sociocultural viability, which draws together many of the strands of thought on technology, classification, and international relations.

Chapter 3 outlines the analytical framework and methodology I use in this thesis. I employ the concept of a 'wicked problem' to analyse how multiple framings of the problem of dual-use technology can be present in classification debates. Each framing will be trying to establish a different form of social organisation and in the process possibly create 'uncomfortable knowledge', which is knowledge that one framing in the debate knows is relevant, but undermines the form of social organisation that framing is trying to institutionalise. To prevent knowledge from becoming uncomfortable, each framing can employ several strategies for handling anomalies in the classification system, and I outline the strategies for the hierarchical framing, which dominates most of the discourse on dual-use technology. In addition to looking at individual debates, this thesis also considers the Wassenaar Arrangement as a whole, and its ability as an institution to accommodate often-conflicting framings of the problem of dual-use technology. By employing the concepts of 'incompletely theorised agreements' and 'clumsy solutions', I provide a framework to analyse this ability. The chapter concludes with an overview of my research questions and the methodology I employed to gather and analyse my data.

Chapter 4 provides an overview of the international development of export control systems. I provide a brief history of export controls to show how there have been continual debates between economic and security concerns on which items should be controlled in international trade because of their military significance. I provide background on Wassenaar's predecessors, CoCom and the New Forum. I then examine in depth the internal workings of the Arrangement, from its founding documents to the structure of the meeting rooms and the functioning bodies. In doing so, we can see how the Arrangement allows for multiple framings of the problem of dual-use technology to interact with each other.

The second part of the thesis begins with Chapter 5, which provides an extended analysis of the development and structure of the Wassenaar lists, especially the Dual-Use List. I place the lists in historical context, showing how such lists have existed, and have influenced succeeding lists, from the 16th through 20th Centuries. Analysing the changing structure of the CoCom lists, we are able to see how the balance between framings of the problem of dual-use technology shifted over time, as well as how the lists were able to incorporate ambiguity into their definitions in order to satisfy each framing. The chapter concludes with a description of the guidelines used to modify the lists, and the structure of the proposal process through which modifications normally go.

Chapter 6 analyses three cases of modifications made to the Wassenaar Dual-Use List. Each case demonstrates how different mixes of anomaly-handling strategies are employed by the hierarchical framing, which views the problem of dual-use as one of control, in responding to arguments made by the competitive framing, which views the problem as one of the marketability of technology. The first case is the addition of quantum cryptography, and shows how the definition of a dual-use technology is sometimes purposefully left vague, but also how there are often many cases where agreement is reached quickly and easily on list modifications. The second case covers the much more contentious modification process concerning focal plane arrays. The case provides a rich example of (a) the different—often non-technical—factors that play into technology definition, (b) the difficulty of controlling something that is already in commercial production and the need to engage blame-management strategies, and (c) how agreement sometimes is only reached through concessions on all sides, but such concessions are acceptable because what a framing loses in one debate it may win in another. The third case analyses the modification on computer controls, including the eventual effective elimination of the controls and shift to controlling software. This case demonstrates the very pragmatic approach to defining dual-use technology, where agreement is reached when and where it can be. Years of negotiations led to the acknowledgement that, even though the technology was militarily significant, there was little a government could do to prevent its transfer. The case therefore shows how there may be some areas of the lists where controls serve more symbolic importance than actually controlling the technology.

Chapter 7 then looks at the development of controls on intangible aspects of technology, and on intangible transfers of technology. Since the 1970s, at least one country, the US, has explicitly equated the tangible aspects of technology—the ‘things’, artefacts, objects—with the intangible aspects—the knowledge and skills necessary to engage with the artefact to some end. This logically makes sense, some Participating States argue, as there is little point controlling a technology if an adversary knows how to make it herself. However, controlling knowledge flows rather than the flow of tangible aspects of technology also presents unique challenges, which this chapter covers. Primary among these is the creation of a space for a new framing of the problem of dual-use technology—an egalitarian framing that views the problem as one of open access to knowledge and technology. I relate the developments on intangible transfers in Wassenaar to the development of the WTO's TRIPS agreement to show some likely consequences of continuing down the current path of development.

At the same time, however, I show how being an incompletely theorised agreement may help the Wassenaar Arrangement in this regard, because it defers the need to reach agreement on all levels about what should be done with regards to intangibles. Instead, by continuing to reach agreement where and when the Arrangement can, it allows for any future control to be grounded in trial runs within countries, such as those currently being carried out in the US. I provide an analysis on how a clumsy solution space may be created within the export control system, and argue for the need to deliberate, not only on the actual lists of controlled items, but also on the balance between the policy goals of each actor.

In recent years, little attention has been given to the integration of, or conversion between, civilian and military technology in [Science & Technology Studies].

—Rappert, Balmer & Stone (2008, p. 726)

2
Literature Review

Contents

This chapter sets out the theoretical landscape of the thesis, providing an overview of the main areas of theory I use in understanding the field and constructing my arguments. I have divided the literature into four broad areas in order to highlight my focus on the Dual-Use List modification process.

The first section looks at theories of technology and how technology and social relations interact. Research over the past thirty years in the field of science and technology studies (STS) has developed several strands of thinking on what constitutes technology and how technology shapes, is shaped by, and constitutes social relations.

The second section provides a history of ideas about classification, focusing particularly on the progression of thinking from classifying discrete entities into discrete categories to classifying ambiguous entities into ever-fluid categories. Particular attention is paid to how classifying is done under non-ideal conditions, e.g. constraints due to time, institutional structure, politics, economics, and linguistics. I also review the literature on the concept of dual-use technology.

The third section outlines the relevant areas of international relations theory, in particular regime theory and institutionalism. I provide an overview of the significant literature within this tradition that relates to the Wassenaar Arrangement in particular and export controls generally.

Technology, classification systems, and international relations have all been areas of analysis within the theory of sociocultural viability, and I conclude the chapter with a review of this literature.

2.1 Technology & social relations

"Technology has been taken as configured by and configuring, affected by and affecting, as well as shaped and shaping. A key question and matter for disagreement though has been exactly how to articulate the relation between the social and the technical, while not treating the latter as simply indeterminate. This is where the conceptual difficulties and differences for sociologists begin."
— Brian Rappert (2003, 569–570)

How people understand technology has an effect on the types of arguments they present on how to define what is dual-use. The etymology of the word 'technology' takes us back to the Greek τεχνηλογία, which comes from τέχνη ('techne'), meaning 'craft' or 'skill', and λογία ('logia'), meaning 'knowledge, reasoning, or argument'. Since the industrial revolution, when the division of labour between making and using tools increased, we have increasingly found ourselves interacting with technologies with origins and internal workings that we do not understand. The technology, in this sense, has often been 'black boxed' (Latour, 1987; Pinch & Bijker, 1984); we provide it with an input and get an output, not aware of how the input gets transformed into the output. Black-boxing is pervasive in advanced industrial societies today. Most people are not able to explain, for instance, how electricity works, or how an automobile is made, or how the food supply chain works. When asked 'what is technology?' most people would respond with an example of an *artefact*, most likely based on electronics, such as a computer or a mobile phone. Technology, however, also includes the *practices* that allow humans to make and use these artefacts; thus, manufacturing techniques and word processing skills could also be considered technology. In addition to artefacts and practices, technology is also *knowledge*, specifically knowledge about how to make and use artefacts.

If the goal of export controls is to prevent one's enemy or potential enemy from getting certain technology, then it is not only the transfer of physical artefacts with which one must be concerned. There must also be controls on access to, training in, and knowledge of, how to design, build, and use an artefact. The Wassenaar Arrangement has all of these aspects of technology on its lists, but interestingly defines only the last as 'technology'. Specifically, 'technology' is "specific information necessary for the 'development', 'production' or 'use' of a product," where 'information' is either 'technical data' ("such as blueprints, plans, diagrams, models, formulae, tables, engineering designs and specifications, manuals and instructions written or recorded on other media or devices such as disk, tape, read-only memories") or 'technical assistance' ("such as instruction, skills, training, working knowledge, consulting services. 'Technical assistance' may involve transfer of 'technical data'") (Wassenaar Arrangement, 2007*b*, p. 203). There is no single term to describe artefacts, as will be shown in Chapter 4. In this thesis, I use 'technology' as a general term to mean any human construction, coupled with the practices and knowledge of how to engage that construction towards a particular end. I put the term in single quotes only when employing it according to the Wassenaar definition.

Technology is inherently social, and the nature of the relationship between technology and society more broadly has been the source of much debate, as we will see below. In this section, I review the main arguments that have been put forward to explain the technology/society relationship. This debate is relevant to the Wassenaar Dual-Use List modification process in two ways: first, the dominant approach to understanding the interaction between technology and society in the middle of the 20$^{\text{th}}$ Century, technological determinism, is still the understanding that is employed by many practitioners today; second, through current work that highlights how technology and social (and in particular governance) relations are co-constitutive, we are able to analyse the maintenance of the Dual-Use List as a process that maintains social as well as technical order.

Technological determinism

Much of the literature on the distinction between technology and social relations can be sorted into three main groups: scholars who argue that technology drives societal development; those who argue that society drives technological development; and those who mix the two, i.e. society and technology are co-constructed or co-constitutive. Much of the work today is done in the third category, but this is in large part in response to previous work in the first two. There are difficulties in categorising the literature in this way. Langdon Winner, for instance, has been put in both the first and third category (see Grint & Woolgar, 1997).

Early attempts at analysing the relation between technology and social relations tended to draw a causal link from the first to the second, that is, they described technology mainly in terms of artefacts that exist independently of social interaction but also define overall development of society (Ellul & Wilkinson, 1964; Mumford, 1967; Winner, 1977, 1986).[1] 'Technological determinism' takes technology to be the determining factor in the drive for social change, for good (Lenin, 1921) or ill (e.g. Ellul & Wilkinson, 1964).[2] In every generation, there are a few inventions that are seen as providing the doorway to the next level of civilization, and these are the ones that are taken up and thereby transform society. This view, however, leaves little room for human choice, and much work has been done to show its inadequacy.[3] The view, however, is not dead (Winner, 2001).[4] As Sally Wyatt (2008) shows, technological determinism still plays a significant role in policy making.[5] Wyatt uses the work of Heilbroner (1967), Bimber (1990), Freeman (1987), and Hughes (1994) to argue that technological determinism should not be seen as a naive view of technology to be dismissed, but rather that the view should be a point of (reflexive) analysis for researchers. To a significant extent, this is the view of technology that is held by the majority of practitioners in the Wassenaar Arrangement,

[1] Marxism is often considered a form of, or even the basis for, technological determinism (Burns, 1969; Hansen, 1921; Heilbroner, 1967; Shaw, 1979), but this is a perennial debate in the field (Bimber, 1994; MacKenzie, 1984; Miller, 1984).

[2] Some researchers add Marcuse (1964) here (e.g. Wyatt, 2008), though others disagree (Grint & Woolgar, 1997, p. 25–6).

[3] A perusal through the journal *Science, Technology, & Human Values* quickly shows the breadth of this critique.

[4] For an in-depth discussion on this point, see (Smith & Marx, 1994).

[5] An earlier example of this is the 1945 report of Vannevar Bush, the US President's first science advisor, titled *Science, the Endless Frontier* (Bush, 1945).

as we will see in later chapters. We should—and in this thesis I do—ask 'Why would this person hold the view that technology shapes society?'

Social determinism & social construction of technology

A sustained critique on technological determinism has come from the area of the 'social shaping of technology' (SST) (see Edge, 1995; MacKenzie, 1996; MacKenzie & Wajcman, 1985; Williams & Edge, 1996). Instead of looking at how technology shapes society, this approach aims to show how economic and political factors shape the direction of technological development. A significant area of this line of research for our purposes is the work done on the relationship between society and military technology. MacKenzie (1987) uses the idea of 'technological systems' (Bijker et al., 1987; Hughes, 1983) to show that what constitutes an 'accurate' missile depends on the organisational and political interests involved. Different actors will have different goals that missile accuracy will be serving, be they political, economic, or technical. MacKenzie goes further, however, and shows how these different goals direct the development of the technology. Indeed, even "[s]etting a design parameter such as missile accuracy is [ ][6] a political matter" (MacKenzie, 1987, p. 203). Restated, the choice of which characteristic of the technology (in this case, 'accuracy') would be the one upon which debate centred is itself a topic of debate.

Another critique of technological determinism comes from Grint & Woolgar (1997) who argue for moving away from what they call the 'essentialist' view of technology, where a technology would have some independent 'essence'. For example, this would mean that what constitutes a gun depends on how it was constructed (when did it become a gun rather than a bunch of parts?), what it contains (does it need a rifled barrel? bullets?), how it is used (as a tool for political repression, as a security measure for an old lady, or as a door stop?), and other factors that involve the gun's interaction with humans (and their

[6] I use [ ] to denote where I have removed a single word from the quoted text.

organisational and discursive forms).[7]

But does this mean that there is a technology independent of social interaction? Grint & Woolgar take a very strong view here, deploying the 'onion model' of technology to show that the realist idea that social constructions sit around a hard technical core is only accepted because "the effort in continuing to peel away layers increases. Ultimately, we suggest, it is only the surrounding layers and the associated difficulty of removing them which sustains the illusion that there is anything at the centre" (Grint & Woolgar, 1997, p. 155). At the same time, they point out, "[c]onstructivists do not necessarily deny the existence of a world beyond our capacity to reconstruct it; the point is that our reconstructions of whatever it is are not true reflections of it. It is not a question of saying 'guns don't kill anybody' but of asking how we know that, in this case, a particular causal relationship exists between gun ownership and murder" (p. 149).[8]

Similar arguments are taken up as well by Edwards, Ashmore & Potter (1995), who argue against what they take as bottom-line objections in relativist arguments. As an example, they argue that a realist will slam his hand on the table and say, "surely this (Bang!) must be real..." (p. 29). But what does it mean for it to be real? If the argument is that it is solid, then on the level of atomic particles, most of the table is empty space. Does it mean that the whole table is real, or only the part that was hit? The example demonstrates rather that the table was *invoked* as real by our consensual common sense.

[7]See Grint & Woolgar (1992) for a constructivist account of being shot.

[8]The final position of Grint & Woolgar on this point is contested in their own work, however. In the following quotation, they do indeed seem to suggest that there is no world outside of our interaction with it (p. 164):

> Even at the very centre of the onion, then, we would argue that there is no residual technical core which is in principle impervious to social analysis. In principle layers can continue to be stripped away until it is evident that there is nothing at the centre. The layers themselves are what constitute the core. The incremental costs of removing further layers might persuade us to stop at any particular point. At that point the notion of the core becomes a convenient shorthand for the fact that we have been persuaded that further deconstruction is inappropriate.

One of the difficulties with these approaches, however, is that they—as was the case with technological determinism—draw a single causal line between technology and society: in this case social relations create and drive technology. This is shown in Figure 2.1.

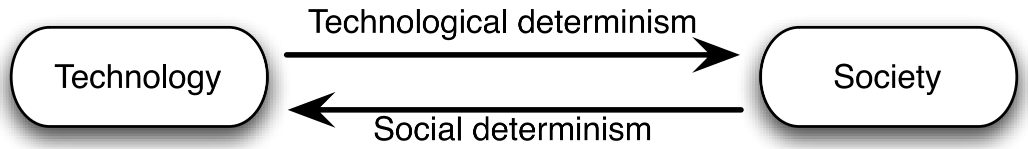


Figure 2.1: *Two relationships between technology and society: technological determinism and social determinism*

One response to this difficulty is the 'social construction of technology' (SCOT) approach developed by Wiebe Bijker, Trevor Pinch, and others (Bijker, 1993; Bijker et al., 1987; Pinch & Bijker, 1984). Largely an outgrowth of the work done on the sociology of scientific knowledge,[9] SCOT develops the notion of 'interpretive flexibility' of technology whereby different 'relevant social groups' can have very different understandings of technology, including different understandings of technical characteristics.

> Demonstrating the interpretative flexibility of an artifact amounts to showing that one seemingly unambiguous 'thing' (a technical process, or some material contraption of metal, wood, and rubber as in the case of the bicycle) is better understood as several different artifacts. Each of the different artifacts hidden within that seemingly one 'thing' can be traced by identifying the meanings attributed by the relevant social groups (Bijker, 1993, p. 118):

'Relevant social groups' are any group, formal or informal, where all members "share the same set of meanings, attached to a specific artifact" (Pinch & Bijker, 1987, p. 30). The most famous example of SCOT is Pinch & Bijker's (1987; 1984) social construction of the bicycle. In the 19th Century, there were different groups in favour of different versions of bicycle design (and also groups against bicycles in general). For instance, women were seen to have

[9]See Shapin (1995) for a review of this field.

special needs (e.g. moral decency and dress-wearing) that needed to be met by bicycle design (for it to be safe and relatively easy to ride), whereas the 'macho' men wanted a bicycle with higher wheels providing more risk. For the latter group, the high-wheeled Ordinary bicycle was a desirable technology because of its 'macho' status and therefore development of even higher wheels was something to be encouraged, whereas for the former group, the same artefact was an unsafe machine and they encouraged the development of lower wheels. A single artefact, therefore, is interpretatively flexible depending on which relevant social group one is looking at, and that flexibility can lead different groups to develop the artefact in different directions.

Technology & social relations are co-constitutive

One critique of the research we have so far discussed, however, is that technology and social relations are still seen as being two separate things. SCOT argues that the social can construct the technical and that the technical can construct the social, but later research down this train of thought sees the line becoming increasingly blurred. Many researchers argue for abolishing the technical/social distinction as the unit of analysis for researchers, because it does us no service analytically (e.g. Law & Mol, 1995; Orlikowski, 1992; Woolgar, 2002). Bijker (1993) proposes replacing it with the 'sociotechnical ensemble', since all technologies are imbued with social relations, and all social relations are mediated through, and encapsulated in, technologies. This is a dynamic and constant process, where relevant social groups are continually seeking to stabilise their group through an acceptance of their reading of the technology by other social groups. Rip & Kemp (1998) develop the idea of a sociotechnical landscape to describe how any one technology is not an 'isolated artefact', but only a label we apply to part of the landscape in which we live, and which sustains us. "The motorcar," for instance, is "made up of steel and plastic, concrete (the roads), law (traffic rules), and culture (the value and meaning of personal mobility)" (p. 335).

Actor-Network Theory (ANT) is another area which argues for treating human and non-human entities in the same analytical light (i.e. agency is distributed) when looking at sociotechnical systems (Callon, 1986; Latour, 2005; Law & Hassard, 1999). ANT explores how actor-networks are formed, persist, and dissolve. Any actor-network is a transient phenomenon and must be continually performed in order for it to hold together. One key aspect of ANT on which I will draw in this thesis is that entities do not reflect the actor-network, but rather that it is through these entities that the actor-network is constructed. Relating directly to the work of the Wassenaar Arrangement, this would mean that the Dual-Use List, for example, does not reflect the tensions between security and economic concerns. It actually constructs those tensions by being a performative site of the actor-network.

Technology as text

Focus on the processes involved in interacting with technology is meant to show that "many discussions and analyses of the impact of technology may be premature, in the sense that they tend to adopt a relatively fixed view of the capability of the technology in question" (Woolgar, 1991, p. 37). Woolgar developed the idea of 'technology as text' to serve as a reminder of this (Grint & Woolgar, 1997; Woolgar, 1991). Woolgar describes three ways that technology can be perceived as text. The first, which he calls the 'instrumental response', "merely reemphasizes the interpretive flexibility of the character and capacity of technology" (Woolgar, 1991, p. 37). It does so to show that arguments which claim to have the definitive view on the impacts of a technology may be premature. The second, 'interpretivist response', argues for the need to understand "the ways in which technology texts are written and read" by practitioners (p. 38). Doing so can show how different readings relate to the organisational structure in which the technology takes shape. The third way that technology can be seen as text is the 'reflexive response', characterised by showing that "readings of the technology text are accomplished both by technologists [i.e. practitioners] *and by the analysts* [i.e. researchers] in the course of sociological argument" (p. 39, emphasis original). In so doing, Woolgar argues for analysis to start from the position that "the textuality of technologies and the textuality of argument is essentially similar" (p. 39). Woolgar is quick to draw a distinction between 'ordinary' texts and technologies, which is key to our argument here:

> We can ask how and why technologies can be read as relatively robust pockets of interpretation in a sea of interpretively flexible texts. Their robustness, or relative stability, consists in the extent to which they are credited with the capacity to act or to effect action. Whereas the effects of 'ordinary' texts upon the reader are largely indeterminate, by contrast, technologies are texts with largely (designable and) predictable effects (p. 39).

Why should technologies and 'ordinary' texts be different? Because technologies are credited with being able to act, to effect action. Put slightly differently, "the relation between readers and writers is understood as mediated by the machine *and* by interpretations of what the machine is, what it is for, and what it can do" (Grint & Woolgar, 1997, p. 70, emphasis added). I return to this point when looking at the concept of 'affordances' below.

Throughout this thesis, I argue that the lists of the Wassenaar Arrangement and the items on them sit somewhere in between technologies and texts. They describe characteristics of technologies, and yet also serve as technologies themselves, allowing some actions and constraining others. The technology, in this sense, *is* text. It is *text* that is formed through national processes and gets sent to the Wassenaar Arrangement. It is *text* that is debated in the meetings of the Arrangement. And it is *text* that is the primary output of those meetings. The questions that now arise are whether these texts can be anything, and what is the relationship between the texts and artefacts that are actually exported.

Affordances

One answer to these questions is that technologies have 'affordances'. Coming from cognitive psychology, 'affordance' is a term coined by James Gibson (1979) (and used by Norman (1988)) to explain how we perceive things other than ourselves. Rather than perceiving the thing directly, we only perceive those properties that are relative to ourselves. A chair 'affords' sitting upon if it is of a certain shape/strength/etc. relative to the person perceiving it. Gibson would seem, at a first reading, to be separating the physical from the social (or what he calls 'psychical'): there is a thing perceived, there is a perceiver, and there is a lens (the affordance) through which the two are connected. Moreover, he states that it is possible to perceive the correct affordance of a thing (p. 142). But his insistence that affordances are subjective is also clear, for instance when he states (p. 139) that objects are only defined and classified in relation to one's social circumstances:

> The theory of affordances rescues us from the philosophical muddle of assuming fixed classes of objects, each defined by its common features and then given a name. As Ludwig Wittgenstein knew, you *cannot* specify the necessary and sufficient features of the class of things to which a name is given. They have only a "family resemblance." But this does not mean you cannot learn how to use things and perceive their uses. You do not have to classify and label things in order to perceive what they afford.

The lack of clarity of Gibson's concept is addressed by Ian Hutchby, who argues that "affordances are functional and relational aspects which frame, while not determining, the possibilities for agentic action in relation to an object. In this way, technologies can be understood as artefacts which may be both shaped by and shaping of the practices humans use in interaction with, around and through them" (Hutchby, 2001, p. 444). Hutchby uses the concept of affordance to advance research on the 'technological shaping of sociality' rather than the social shaping of technology, in line with criticisms that Science & Technology Studies (STS) focuses too much on the latter (e.g. Vincenti, 1995).

He criticises Grint & Woolgar's 'technology as text' metaphor as assuming that artefacts are *tabula rasa*, shaped only by the persuasiveness of arguments (Hutchby, 2001, p. 446).

Instead, artefacts (and all material things) possess different affordances, "and these affordances *constrain the ways that they can possibly be 'written' or 'read'*" (emphasis original, Hutchby, 2001, p. 447). Hutchby describes four aspects of affordances. Affordances are functional, in that they enable and constrain the ability of an artefact to engage in some activity. They are relational, in that the same artefact will offer different sets of affordances depending on what it interacts with. When humans interact with an artefact, what affordance they choose will also depend on social conventions. Finally, affordances can be designed into an object as well as naturally arising. It is important to note here that Hutchby is not employing the same concept of technology I am. He is referring only to artefacts, and not to practices or knowledge of those practices. I extend the concept of affordances to include practices, e.g. by saying that certain actions people do afford certain readings about what they are doing.

Hutchby's view is critiqued by Brian Rappert (2003).[10] While recognising that describing the relationship between social and technical, without saying the former completely determines the latter, is a perennial topic of debate in STS, Rappert argues that most attempts to ascribe more importance to the technical—Hutchby's included—fall short. What Woolgar is trying to do with the 'technology as text' metaphor, according to Rappert, is continually to remind the reader that closure on what constitutes the technology always entails assumptions—political, social, and otherwise—about the role of technology in society (Rappert, 2003, p. 572). There are four ways in particular that Hutchby's concept of affordances falls short: "it generates non-controvertible claims that border on the banal or unhelpful; it closes down debates in often arbitrary ways when they could be usefully opened up; it relies on a series

[10] And also briefly by Woolgar (2002).

of unstated shared agreements; and it fails to provide a place for critical self-examination" (Rappert, 2003, p. 573). Hutchby's focus, in short, is on resolving the properties of devices rather than on sensitising ourselves to the debates that created the technology.

Granting Rappert's critique, there is still an important point in Hutchby's article (see also Hutchby, 2003). Given that a technology has been *inscribed* through discourse, can it function as inscribed? If an oven is meant to heat to 200C, but only heats to 190C, then it is not performing as we believe it should. While we can deconstruct what we mean by 'oven', 'heat', and '200C', given what we mean, does the oven do what we believe it should do? The *functioning* of the technology is constrained by something else in addition to discourse. In this example, Hutchby would say that the oven 'affords' reaching 190C but not 200C. We could modify our concept of oven, heat, or 200C. Similarly, we could modify the arrangement of the artefact we are calling an 'oven', say by making a knob that turns further than the 190C marking.[11]

It is this second point to which I want to bring attention here. While the two modifications are similar, they are also different in a very important respect. The first involves a change in the definition of the technology (i.e. its social construction), while the second involves a change in material or practice. This is highlighted in the following two points:

- The discourse creates a technology.
  - '*What is* technology X?'
- One must then determine whether an artefact (or practice) is an example of the technology.
  - 'Is this thing (artefact or practice) *an example of* technology X?'

[11] Or, if we hold that technology is made up of practices and knowledge of those practices, in addition to artefacts, then we could also e.g. modify the practice of the knob-turner (perhaps it is a sticky knob).

The concept of affordance conflates the technical and the social by equating an artefact (or practice) with the label we put on it. Hutchby cannot ask the question 'what constitutes the artefact?' because for him the (material) artefact is the (discursively defined) technology. This point can be made clear by revisiting Grint & Woolgar's (1997, p. 65-94) work on 'configuring the user'. In a set of trials for a new computer (the Stratus 286), a user, Ruth, was asked to connect the computer to a printer. The two are supposed to go together, but Ruth's attempt to put them together failed in the end because "it turns out that Ruth had been asked to connect a printer to the Stratus 286 [...] using a lead designed for use with the earlier K-series machine" (Grint & Woolgar, 1997, p. 89). This, in turn, leads Hutchby to argue that "[w]hat is missed in this interpretation is precisely the sense in which Ruth's interaction with *the machine* is underpinned by a material substratum in which she encounters, not a text, but an array of affordances" (Hutchby, 2001, p. 452, emphasis added). Grint & Woolgar 'miss it', however, because they are following a very different philosophical argument on the question of agency. For them, it is not about whether the technology has affordances, but rather how people decide what affordances the technology has.

This differentiation between the discourse *about* technology and the artefacts and practices to which the discourse relates is important for this thesis. In maintaining the Wassenaar Arrangement lists, member states spend their time discussing 'what is a dual-use technology?' and thereby engage in discourse about the technology. It therefore makes sense to employ the 'technology as text' metaphor to analyse these debates. In contrast, once the lists are decided and enacted in national legislation, export control officials are then tasked with determining whether the license application they have in front of them is an example of a dual-use technology as defined in the lists. There is therefore a vested interest by at least some of the actors to make sure that the characteristics of the technologies that are decided at Wassenaar are ones that (a) are meaningful to the export licensing officers, and (b) can be related to actual artefacts in existence. While the items on the lists are the result of debates involving politics, economics, and social and cultural considerations, they are also bounded by technical considerations—by the relationship between text on the lists and the artefacts that get exported. This will be elaborated upon in relation to the Wassenaar Arrangement in Chapter 4 when we look at the *Criteria for the Selection of Dual-Use Items*.

Whoever decides what the characteristics of a technology are and how humans relate to the technology has great power. It is often not a single person, or even a single group, that makes such decisions, however. This is certainly true in the Wassenaar Arrangement, where all decisions on modifications to the Dual-Use List must be made by the consensus of the 40 member states. These points, I argue, can begin to be addressed by looking at work on ambiguity.

Ambiguity

A significant use of the term ambiguity in the area of list making is in the work of Bowker & Star (1999), which I will address in detail in the next section on classification. Some of the main arguments in their book *Sorting things out: classification and its consequences* call for the need for a "topography of [...] the distribution of ambiguity" (p. 31), for "zones of ambiguity" (p. 150, 215, and 324), to define "the degree of ambiguity that is appropriate to the object in question" (p. 158), and for an "ethics of ambiguity" (p. 313). They do not directly address what they mean by such terms until the end of their book, where they provide suggestions for those developing and changing classification systems:

> Classification schemes always represent multiple constituencies. They can do so most effectively through the incorporation of ambiguity—leaving certain terms open for multiple definitions across different social worlds (p. 324).

This definition is a useful starting point for us. In order to talk about 'zones of ambiguity' or the typography of the distributions of ambiguity, however, we first need to be clear about what it is that is ambiguous. For the purposes of this thesis, ambiguity will refer to *technological ambiguity*, which resides both in the definition of the characteristics of a technology, and in the choice of which characteristics the list-makers are going to define. For example, in the process of modifying the Dual-Use List, participants may choose not to select particular characteristics to use in the definition in order to make sure that a technology is or is not controlled. By making that selection, they are creating a 'zone of ambiguity' around the characteristics that they did not choose. This does not mean that there is a finite number of characteristics of a technology, nor is the debate ever about a single technology. Theoretically, an infinite number of technologies will share the same characteristic, and each technology has an infinite number of characteristics.

This is similar to the stance of Rappert (2001, 2003, 2005), who argues for the need to "move away from attempts to detail the social basis of technology to consider instead where the ambiguities associated with technology are resolved" (2001, p. 557). In analysing how ambiguities are resolved in the relationship between technology and politics, Rappert is clear in noting that he is looking at the framing of capacity through the definition of technology.[12] Translated into terms that I used earlier, Rappert is concerned with how an artefact and practices come to be related to a conception of technology. The conception of a technology, he argues, is always ambiguous because its 'capacities' can only be defined in relation to the context of a particular artefact in a particular

[12]Thus, he builds on, but also rejects part of, the post-essentialist view of Grint & Woolgar (Rappert, 2001, p. 571-2). He himself is not engaged in the definitional process, and so does not make a claim about which definition is 'right'. Instead, he analyses why the technology, in his case 'non-lethal weapons', is framed in certain ways by certain social groups. I share his outlook on the nature of technology in discussion around, in his case, non-lethal, and in my case, dual-use technology:

> The ultimate status of the claims is not something to be resolved here. Whether they are, in some absolute sense, 'real' or 'perceived' claims, there is some justification for the statements made, they are treated as real issues in that they must be responded to by many of the actors involved and, therefore, whatever their ultimate merits they shape the interpretation of events by participants and the manner in which notions of responsibility are negotiated (2001, p. 573).

environment employed by a particular person in a particular way. He goes further, however:

> It is not just that non-lethal [weapons] are difficult to define, but that alternative definitions point to fundamentally different ways of making sense of the contribution of non-lethals to conflict resolution. The assumptions implicit in the definitions of non-lethal weapons inform notions of their legitimate deployment, and thus the proper standards for their control (2001, p. 566).

Rappert makes a crucial shift here. He argues not only that there are different ways to define a technology, but also that different definitions are related to different stances in the broader debate about the relations of accountability between actors. In his case, how non-lethal weapons are defined will determine the legitimacy of organisations that employ them. As we will see in Section 2.4, this is very similar to the stance taken in the literature on the theory of socio-cultural viability. When looking at the Wassenaar Arrangement, I will analyse how the different arguments that people make when debating the definition of items on the Dual-Use List relate to the different types of social structure that they are trying to legitimate.

In this section, I have provided a broad review of the thinking on the interaction of technology and social relations, and a more fine-grained look at recent work on the ideas of technological ambiguity, affordances, and technology as text, all of which play a role in later arguments of this thesis when I address the question of 'What is dual-use technology?' The reader should now see that I do not intend to answer this question directly. Rather, one of my purposes in conducting this research has been to learn many of the different ways that dual-use technology is defined within different communities of practice, in different contexts.

To be is to be in relation to something else. Dual-use technologies, like anything, fit within a system of classification. But what is that classification system, and is there only one? Such a question is important when analysing the process by which technologies come to be classified as dual-use (or not). We have seen above that the technology that is classified is likely to be ambiguous, but what about the classification system itself? Are we likely to find rigid categories that have existed relatively unchanged for decades or longer, or a nebulous ever-shifting scheme where a single technology could fall within multiple non-exhaustive and non-exclusive categories? To aid an analysis into such questions, we turn now to the literature on classification.

2.2 Classification

Classification is core to civilization. It is the basis of linguistics, engineering, social networks, philosophy - in short, our engagement with anything. List-making goes back to the advent of writing (Goody, 1977, 1987). One may think, on first glance, that the structure of the Wassenaar Arrangement Dual-Use List has little to do with, say, the structure of society as a whole. One describes a collection of technologies while the other describes a collection of humans. Surely such different sets of things require different ways of classifying.

This is representative of the debate on whether there is a difference between 'natural kinds' and 'social kinds'.[13] Since at least the beginning of western philosophy, similar classification systems have been used for categorising our thoughts on both natural and social kinds. For instance, take the ontological debate between *realism*—the idea that there is a world external to, and prior to, individual cognition—and *nominalism*—that this world is contingent upon individual cognition and does not exist without that cognition. This debate is played out in the social sciences (e.g. is there an international order in which nations sit, or do nations create the international order?)[14] and religious studies (do(es) god(s) exist(s) outside of our perceptions?), just as much as

[13]For a relatively recent review of this debate as it relates to international relations, see Wendt (1999, p. 68–78).

[14]For another example see Goodman & Quine (1947).

in mathematics (are mathematical truths universal or contingent?) and the natural sciences (is there a state of nature outside of interactions?).

There is a similar spread of thought in these (and all other) fields involving epistemology, which asks not whether the world exists, but rather what can we know about the world. A *positivist* epistemology argues that we can uncover/create regularities and causal relations between things, whereas *relativism* argues that knowledge is conjectural. It is not the purpose of this thesis to thoroughly explore the depths of these debates. Rather, in this section, I will be moving fluidly between discussions of classification in the social and natural world, in part to show that there is little to be gained by keeping them separate, as we saw in the last section. I begin with the essentialism debate in order to draw out the tensions between competing ways of classifying things in the world, and show that the idea of a polythetic classification system may be useful for describing both the Dual-Use List and the different sets of social relations in which people engage. I then provide a recent example of a polythetic classification system at work.

Essentialism

The debate over whether things have 'essences' is as old as Western philosophy itself. Aristotle, in his *Metaphysics*, Book IV, argues that we cannot think or speak of things if they do not have an essential property, that is, a property that a thing cannot both have and not have at the same time and that defines 'what it is'.[15] This is similar to Plato's earlier idea of the ideal world of forms that he developed in the *Republic*.[16] This 'essentialist' view uses essences as the logical basis of classification, because things with similar essences are said to be of the same *kind*. For instance, if I am a human essentially (i.e. in virtue of being the very thing that I am), and you are human essentially, then both of us belong to the same general kind, *being human*. Essentialism makes

[15]Aristotle's actual term that he uses is τὸ τί ἐστι, which roughly translates 'what it is' (Cohen, 2008) (cf. Plato (c400BC) on 'what is' vs. 'what is not').

[16]especially Book V.

either/or distinctions, rather than there being degrees of a kind, and leads to the development of static typologies and rigid classification systems. There is a necessary and sufficient set of conditions which things need to meet to be part of a kind. In this sense essentialism is ontologically realist and epistemologically positivist.[17] There is a world external to our perception of it and we can have true knowledge of this world.

This view can be seen in much of the writing on technological determinism that I discussed above. With regard to developing a list of technologies to control in international trade, an essentialist stance would state that a nuclear bomb is a weapon essentially, and therefore belongs to the kind 'weapon', which warrants the control on its trade. Something is either a weapon or it is not. It either has military capacity or it does not. This essentialist line is taken by previous researchers regarding the CoCom and Wassenaar lists, as we will see in the next section. It also forms the basis of the international treaties on 'weapons of mass destruction'—the Nuclear Nonproliferation Treaty (NPT) and the Chemical and Biological Weapons Conventions (CWC and BWC)—because the use of such weapons in any situation is seen to be abhorrent. This essentialist line is mirrored in the realist position that states have essences, and therefore are the basic unit of analysis in the international system.

One of the primary difficulties with an essentialist argument is in the handling of anomalies, with things that cross the boundaries of the classification. In short, anomalies do not exist in an essentialist world. We may perceive anomalies because we are not able to see the true form of the thing (according to Plato), or because we have not yet uncovered the essence of the thing (Aristotle), but anomalies are the result of imperfect perception rather than an imperfect world.

Most of the rest of the literature covered in this section, and my argument in this thesis, does not support the essentialist position as a useful way to classify

[17] I recognise that I am characterising only a part of essentialism, but I do so in order to provide a strong contrast to the alternatives. See Leplin (1988).

dual-use technology. Instead, I take a more pragmatic line, arguing that the system of classification in use by a particular person or group exists because it serves the needs of that group. Let us look, for instance, at the development of classifications in natural science and mathematics.

Pragmatic classifications

In *The Structure of Scientific Revolutions*, Thomas Kuhn (1964) argues that most scientific research works within an established classification system, or 'paradigm', which is provided by the current set of established theories. In the course of normal scientific research, anomalies will naturally occur in experiments and theory development, but they are generally either accepted or the theory is modified to account for their presence. As research progresses within a paradigm, the anomalies may begin to build up, but scientists will tend to hold onto the current theory rather than simply reject it (cf. Popper, 1972) unless an alternative is presented. If there is an alternative that can explain and predict the anomalies along with a majority of the findings of the current paradigm, a 'paradigm shift' may occur where the old set of theories is rejected and the new set adopted, often overturning many other previous ideas in addition to the one that caused the paradigm shift in the first place. Kuhn is careful to note, however, that this process of creating an increasingly detailed and refined understanding of nature should not be equated with "the notion, explicit or implicit, that changes of paradigm carry scientists and those who learn from them closer and closer to the truth" (p. 170).

A much stronger statement against the essentialist position can be found in Lakatos' famous *Proofs and Refutations* (1963*a*; 1963*b*; 1963*c*; 1964), where he demonstrates how 'mathematical kinds' are not objective truths, but human constructions, where humans draw the boundaries of natural kinds (and thus the kinds are fully relative).[18] He does this through a playful dialogue between

[18] Kuhn and Lakatos were in frequent contact (see, for example, Kuhn, 1970), so it is little surprise that their thinking during this period was progressing along the same lines.

students and a teacher over the proof of Euler's theorem for polyhedra, which mirrors a very intense debate that occurred from the time Euler provided the theorem in 1758 until Poincaré's work in 1899. What constitutes a 'mathematical kind', according to Lakatos, depends on how people respond to things that are anomalous to their definition of that kind. Lakatos provides different strategies which one can use to deal with anomalies:

- Monster-barring: this is an argumentative term that focuses on excluding anomalies from the concept (they don't exist).
- Monster-adjustment or concept-stretching: this changes the boundaries of the kind in such a way that the monster is no longer monstrous.
- Exception-barring: this excludes monsters by subdividing the kind (they are kept on the outside). This amounts to reducing the applicability of the kind.

We shall return to these anomaly-handling strategies in Section 2.4, where I will connect them to the theory of sociocultural viability.

If we cannot speak of things as having essential properties, any classification will necessarily have to be based on relationships between things, rather than on properties that they have. This 'anti-essentialist' stance places an emphasis on the context of the thing and how that context shapes the thing's identity.

Perhaps the most famous example of a classification system based on non-essential properties is Wittgenstein's (1953, §65–71) work in philosophy on 'family resemblances', where items in a category are connected by similarities between them, but no single similarity is shared by all of them. Wittgenstein shows that items in the category 'games' cannot be described by a single common trait, and yet they can still commonly be thought of as games—i.e. they are in the 'family' *games*. For example, football, cricket, and bowling all involve balls, but chess does not. All of those involve two or more players, but solitaire does not. Wittgenstein also gives the example of a rope spun from many threads, where not a single thread runs through the whole rope and the strength of the rope lies not in any thread but in the relationships between them. As Rayner (1982*a*) points out, Vygotsky (1962/1986) developed an almost identical notion in psychology with his idea of a 'chain complex' rather than a rope in describing the way children form categories.

Needham (1975) develops on both Vygotsky and Wittgenstein to apply their work to anthropology, and in so doing draws a connection to the concept of a 'polythetic' classification system based on work done in the natural sciences (Beckner, 1959; Simpson, 1961; Sneath, 1962; Sokal & Sneath, 1963). This is as opposed to 'monothetic' systems such as that used by Aristotle, where there is a single set of necessary and sufficient conditions for an item to be in a category.[19] A polythetic classification has the following three characteristics (Beckner, 1959, p. 22):

> A class is ordinarily defined by reference to a set of properties which are both necessary and sufficient (by stipulation) for membership in the class. It is possible, however, to define a group K in terms of a set G of properties $f_1, f_2, \ldots, f_n$ in a different manner. Suppose we have an aggregation of individuals (we shall not as yet call them a class) such that:
>
> 1. Each one possesses a large (but unspecified) number of the properties in G;
> 2. Each f in G is possessed by large numbers of these individuals; and
> 3. No f in G is possessed by every individual in the aggregate.
>
> By the terms of (3), no f is necessary for membership in this aggregate; and nothing has been said to warrant or rule out the possibility that some f in G is sufficient for membership in the aggregate.

Needham (1975, p. 364) argues that conception of a polythetic classification is of limited value in social anthropology because of an *essential* difference between the social and natural sciences, as shown in the following excerpt:

[19] The monothetic/polythetic classification debate can also be seen as being between the work of Linnaeus and Buffon (see Desrosières, 1991, Bowker & Star, 1999, p. 62).

> In what has been presented here as the most relevant example of taxonomic method, namely quantitative bacteriology, the researchers are in no doubt concerning what is or is not lactose or about whether it is or is not present: it can be exactly defined in advance, and its chemical properties and reactions are known or testable. This kind of certainty about the materials under study (whatever ambiguity may attend the discrimination of forms or the assessment of degrees of resistance, etc.) permits the method of classification by differences: a definite feature can be definitely determined as either present or absent.
>
> But in the realm of social facts this aspect of polythetic classification is hardly to be found. A main reason is that in social anthropology the determination of the constituent features of a polythetic class cannot be carried out by reference to discrete empirical particulars, but entails instead a reliance on further features of the same character which themselves are likewise polythetic.

This conclusion is not necessarily warranted, however, because it is based on an assumption that natural kinds and social kinds are *essentially* different. As has been shown by, for example, Latour's (1986) work on the construction of a scientific fact, a fact is not so much discovered but created in the process of negotiating the sociotechnical landscape. Latour's study, and many others like it, show that scientific and mathematical concepts are not 'exactly defined', but rather are the upshot of, and constitutive of, many social processes. Therefore, if polythetic classifications have been useful in the natural sciences, there is no reason why they cannot be applied to the social sciences, as has already been done in archaeology (Briault, 2007) or religion (Satlow, 2006), or indeed, as we shall see below, to the theory of sociocultural viability (Rayner, 1982*a*).

The link between natural and social classifications was drawn out in detail by Durkheim & Mauss (1903/1963) in *Primitive Classification*. They show how the Zuni, the Sioux, and the Australian aborigines all base their natural classification system on their social classification system. "It was because men were grouped and thought of themselves in the form of groups, that in their ideas they grouped other things" (p. 82). This idea—that our social classifications shape our natural classifications—has been heavily critiqued (see Lukes, 1973), but also strongly supported. Bloor (1982), for instance, takes up the idea and uses Hesse's (1974) network model of classification to show how Newton and Boyle were influenced on how to classify natural phenomena based on their theological and political preferences. This is very similar to the argument presented above by Lakatos, and we shall see in Section 2.4 how Bloor ties Lakatos' work into that of Mary Douglas.

Intertwining classifications of the natural & social world

In the 1960s and 1970s, the anthropologist Mary Douglas drew together the natural and social worlds in her work explaining how societies handle anomalies in their classification systems, drawing heavily on the work of Durkheim. In *Purity and Danger* (1966), Douglas analyses the abominations of Leviticus. The abominations are set out in a list and form the basis of separating clean from unclean things, and prescribe rules for relationships with both the natural world and with other people. Both *Purity and Danger* (1966) and *Implicit Meanings* (1975) argue that classification systems of what is clean and unclean help to bind a society together, and that "some pollutions are used as analogies for expressing a general view of the social order" (1966, p. 3). The discussion centres on anomalies in the natural and social worlds and how a society's responses to them strengthen the bonds of that society. This is therefore a clear example of how lists formed the focal point of both social and natural order. Animals that deviated from the ideal of what an animal should be—e.g. if they were on land but did not have feet (such as snakes)—were to be avoided. They could neither be eaten nor brought into the Temple. Similarly, people who deviated from being the ideal Israelite—e.g. by having sexual relations with a non-Israelite—were ostracised from the society. Classifications, then, have a *symbolic* role. They are a representation of an ideal form of organisation, and an affront to the symbol is an affront to the form of organisation itself. The symbolic importance of classification systems will be addressed in more detail in Chapter 7.

Douglas (1986) further develops these views in describing how systems of classification are (un)institutionalised. She posits that social classification systems, in order to gain legitimacy, must be seen to embody a natural classification system. “To acquire legitimacy, every kind of institution needs a formula that founds its rightness in reason and in nature” (p. 45). But, critically, there is not only one way to understand natural order, and the way that we choose to understand it signifies the type of social classification we wish to substantiate. This point is elaborated in the theory of sociocultural viability described below. Douglas is quick to point out that “comparison of cultures makes it clear that no superficial sameness of properties explains how items get assigned to classes. Everything depends on which properties are selected” (p. 58). This is mirrored in the work of Nelson Goodman (1972), whose *Seven Strictures of Similarity* begins with the statement that similarity is “a pretender, an impostor, a quack. It has, indeed, its place and its uses, but is more often found where it does not belong, professing powers it does not possess” (p. 437). Sameness is not a property of nature, but a thing conferred by our current institutional structure, our current system of classification (Douglas, 1986, p. 63).

While we may shape classification systems, it is important to note that classification systems also do a lot of work for us. A classification system is a codification of social and natural order, and as such allows us to have to no longer think about that order. If something is labelled as being taboo—or being export controlled—it is much easier for us to accept that taboo than to challenge it. This is because classifications, through repeated enactments, become institutionalised within a society (Douglas, 1986, ch. 5). To challenge an established (i.e. institutionalised) classification system would be to step out of that system into a different system, and try to tear down the institutional structures of the first so as to install the second. We can see similarities here to Kuhn’s work on paradigm shifting.

Another point of note in Douglas’ work on the institutionalisation of classification systems is that it is through a society’s institutional structure that certain things are remembered and forgotten (Douglas, 1986, ch. 6). This is similar to Kuhn's statement that new paradigms deem some problems to be nonsensical because they are based on a completely different system of classification. The field of the social construction of ignorance (e.g. Proctor & Schiebinger, 2008; Smithson, 1985), which these works touch upon, analyses how we decide what *not* to know as well as what to know. I will draw on this occasionally in this thesis to show how certain systems of classification prevent us from seeing certain framings of a problem.

An example analysis of a polythetic classification scheme

A classification system, according to Bowker & Star, is "a spatial, temporal, or spatio-temporal segmentation of the world. [It is] a set of boxes (metaphorical or literal) into which things can be put to then do some kind of work—bureaucratic or knowledge production" (1999, p. 10). An ideal classification system would have unique, consistent classificatory principles in operation, categories that are mutually exclusive, and would be complete (i.e. it would be essentialist). It is unlikely that such an ideal could ever be achieved,[20] however, because: there are often contradictory classification principles in operation; there will likely always be objects that can be placed in multiple categories; and a complete system would imply perfect knowledge (p. 10-12).

These researchers explicitly draw out how classifications of the natural world shape and are shaped by classifications of the social world. Indeed, they argue that "our approach [...] is to offer fine-grained analyses of the nature of information infrastructures such as classifications systems and thus to demonstrate how they simultaneously represent the world 'out there', the organisational context of their application and the political and social roots of that context" (p. 61). Rather than asking what an ideal classification scheme would *be*, in analysing the International Classification of Disease (ICD) and a number of

[20] Bowker & Star say they have never seen one.

smaller cases they ask three questions: What work do classifications and standards *do*? Who does the work in establishing and maintaining classifications? What happens to the cases that do not fit? In answer to their first question, these systems are not only for ordering diseases, but also for codifying and coordinating social relations (cf. Douglas, 1986). Thus, they point out that "the material culture of bureaucracy and empire is not found in pomp and circumstance, nor even in the first instance at the point of a gun, but rather at the point of a list" (p. 137).

Regarding who does the work to maintain the lists, they show that it is a set of communities and organisations with conflicting requirements (p. 141–2). In collecting international information on diseases, different countries have varying senses of obligation to submit their data, different bureaucratic structures that lead to different types of reporting, and different emphases on how a disease is represented in the society. Moreover, the collecting agency (the ICD) is not simply a repository of data, but is itself "politically charged in terms of its internal bureaucracy" (p. 142). In short, the lists are made and maintained by multiple groups including government officials, statisticians, anthropologists, medical analysts, epidemiologists, and diplomats. The resemblances between the ICD and the Wassenaar Arrangement are striking in this respect—at least until one recognises that the classification problems that the ICD and Wassenaar address have "parallels with power struggles, control, and containment in the multinational firm and its management—classic problems of decentralized control in the post-Fordist era" (p. 143–144). These resemblances will be explored more in further chapters of this thesis.

How does the ICD handle the heterogeneous definitions and goals that are present in its classification process? Bowker & Star provide an inventory of working solutions, several of which are useful in analysing the Wassenaar Arrangement.

Distributed residual categories The first solution involves the distribution of residual categories (p. 149–150). Residual categories are categories of things that do not fit nicely in the overall classification. The creation of residual categories (the 'other' option on surveys, for example) is a recognition of anomalies in the classification system. The maintenance of residual categories is a process of maintaining ambiguity in the lists. These categories are characterised by their very vague boundaries, and are often distributed throughout a list in order to maintain the appearance that the list as a whole is still a valid classification.

> These garbage or residual categories, then, tend to fix the maximum level of granularity that is possible. Their advantage is that they can signal uncertainty at the level of data collection or interpretation under conditions where forcing a more precise designation could give a false impression of positive data. The major disadvantage is that the lazy or rushed death certifier will be tempted to overuse 'other'. By their nature, forms of this kind are only manageable if there is a zone of ambiguity written into them. In this case, precise definitions would drive a wedge among doctor, statistician, and epidemiologist (p. 150).

I will return to this solution in a moment when discussing the concept of boundaries below.

Heterogeneous lists There has always been a debate within the ICD over whether its lists constituted a nomenclature or a classification. A nomenclature could be, for instance, a list of indicators that may lead something to be categorised as a particular disease. A classification, on the other hand, would be a list of disease definitions. "Classification systems are more immediately convenient in that they carry more complex information, but [. . .] they change every few years with the development of new medical techniques or knowledge" (p. 150). Bowker & Star argue that, rather than settling on either of these principles, the ICD has "incorporated a workable (practically and politically) level of ambiguity. The ICD has been as heterogeneous as possible to enable the different groups to find their own concerns reflected" (p. 150–151).

Similarly, there has been a debate within the members of Wassenaar as to whether the Dual-Use List should be based on specific characteristics of the technologies (a classification system, in the sense that is employed here) or on functions that the technology may do. For instance, should the list contain the exact material parameters of all photon-sensing devices that may find their way into night vision goggles (such as types of material or manufacturing processes used), or should it contain the parameters of any night vision device (such as the ability to discern movement at a certain distance or overall weight)? This debate will be explored especially in Chapter 6.

Computerisation "The chief advantage that computing offers today to the ICD and similar schemes is the ability to maintain uncertainty at the level of closure on analysis" (p. 154). This is because, instead of having to force diseases into one of a limited number of categories based on a very small number of characteristics, the ICD can now use a polythetic classification to delay deciding whether an outbreak of a particular disease has occurred, and thus hold out on delegating resources for preventing its further spread.

The [redacted] is heralded, by all of the people to whom I talked, to be a greatly beneficial step in the development of international cooperation on export controls, and was a key aspect of the Arrangement's founding (Wassenaar Arrangement, 2008*c*). The impact of computers and the internet, however, has also been very detrimental to the Arrangement in that the control of intangible technology transfers (ITT) is now much more difficult. This will be a point of analysis for Chapter 7.

Standardised forms "It is clear that standard forms [e.g. death certificates] are essential for the ICD to work and that these standard forms cannot be overprecise or people will not be able to use them... Standardization procedures must be tailored to the degree of granularity that can be realistically achieved" (p. 155).

The Wassenaar Arrangement also has standard forms for developing changes to the lists and for reporting the transfer of controlled items. The latter is not of direct relevance to this thesis, but the form is analysed in Chapter 4.

Bowker & Star provide a list of recommendations for what to keep in mind when developing and changing classification systems that will also be useful in developing similar recommendations for the Wassenaar Arrangement (p. 324-325):

- *Recognise the balancing act of classifying* "Classification schemes always represent multiple constituencies. They can do so more effectively through the incorporation of ambiguity—leaving certain terms open for multiple definitions across different social worlds."
- *Render voices retrievable* "By keeping the voices of classifiers and the constituents present, the system can retain maximum political flexibility."
- *Be sensitive to exclusions* "A detailed analysis of these others throws into relief the organizational structure of any scheme."

They are clear that any classification will be understood and used by people in different contexts with different needs and wants. It is better to design the classification in such a way that it can work, and continue to work, in as many of these contexts as possible. By analysing the things that a classification scheme leaves out, we can better see the structure of the scheme itself. These points help form the basis of my analysis of the Wassenaar Arrangement.

The Wassenaar Arrangement is built on a classification system that distinguishes technologies from each other according to whether or not they are perceived to be militarily significant. At the same time, however, Wassenaar exists because this classification system is not ideal. While all of the technologies on the Munitions List are classified as militarily significant, the Dual-Use List, which occupies most of the Arrangement's time and resources, covers technologies that span the military/non-military divide. We should therefore take a brief look at the different ways that the concept of 'dual-use technology' has been understood in the literature.

The concept of dual-use technology

One way to categorise the interpretations of dual-use is based on the relation between the uses that constitute the 'dual'. I have identified three groups in this categorisation. One of the groups holds that dual-use technologies are ones that are military (or hostile, malevolent, prohibited, or illegitimate), but that they can be applied to civilian (or peaceful, benign, or legitimate) purposes, an interpretation often called 'spin-off' (Albrecht, 1987; Cowan & Foray, 1995). Often this view has a focus on revitalising the economic base of a country by finding non-military uses for existing military technology—the 'swords into ploughshares' idea developed in the inter-war period by Low (1940). More recently, The US Defense Science Board (2001, p. 2–3) report on *Protecting the Homeland* pointed to the negative implications of such a transition:

> Weapons are now integrated within the civilian and commercial infrastructures rather than military specific. This dual-use nature of technology makes capabilities such as early warning, determining what is out there and what can people do, increasingly difficult.

In contrast, another grouping of interpretations of 'dual-use' sees the flow going the other way. For this group, the technology is civilian (or peaceful, benign, or legitimate) but could be put to military (or hostile, malevolent, prohibited, or illegitimate) use. Sometimes called 'spin-on', this way of viewing dual-use is expressed by the United Nations (1988) and the US National Research Council National (2005). It is also the view employed by many researchers (Dando, 2002; Evan & Hays, 2006; Grimmett, 2004; Lloyd, 2004; Mallik, 2004; Smit, 2001). Some of these researchers are directly concerned with the Wassenaar Arrangment (Dursht, 1997; Smith & Udis, 2001) or its predecessor CoCom (Cupitt & Grillot, 1997; Meese, 1981–1983). This is also commonly the view taken when researchers prepare reports for government agencies about export controls (Cevasco, 2001; Fergusson et al., 2003; Fisher, 2001). The concern often expressed here is the fear (or hope) that novel military capabilities can come from employing widely available technology, and is a key aspect of the idea of a 'Revolution in Military Affairs' (RMA) (Alic et al., 1992). This interpretation of 'dual-use' has also been linked to the view in 19th Century liberalism that military technology is a corrupt form of technology, which corrodes society rather than enhances it (Edgerton, 1987).

The last grouping under this categorisation scheme is one that takes a balanced view that a technology is dual-use if it can be used in either or both settings. This is often the approach used by researchers who are concerned with the term itself (Balmer, 2006; Branscomb, 1993; Davis, 2002; Klaus, 2004; Mastanduno, 1992; McLeish, 2007; McLeish & Nightingale, 2007; Molas-Gallart, 1997; Reppy, 1999; Roberts, 1999; Rudney & Anthony, 1996; Stowsky, 2004). This view, which is more in line with the concept of 'conditional contraband' that I discuss in Section 5.1, has also in recent years been employed by US government agencies, such as in the definition in Code of Federal Regulations (15 CFR §730.3), the National Academies (1987) and the General Accounting Office's definition of dual-use as "items which have both commercial and military applications" (GAO, 2002, 2006*a*,*b*,*c*).

Another way to categorise the different interpretations of 'dual-use' is by the types of technologies at which they look. There is the broad distinction between how the term is employed in the literature on weapons of mass destruction (WMD)[21] and conventional technologies. Work done on nuclear dual-use technologies, for instance, tends to focus only on the problems of preventing the spread of nuclear weapons (e.g. Scheinman, 2006), whereas work on conventional dual-use technology—while still concerned about proliferation—places emphasis on the point that there are large economic gains from many of these items because they are (or could be) dispersed widely in society for non-military uses.

Within WMD research, there has been a significant increase of interest in the problems with biological technology and research. For example, Dando (2002) argues that while "differences between a BW [Biological Weapons] facility and a legitimate facility might be detectable, it is equally true that biotechnology is classically dual-use—legitimate civil technologies could be misused for offensive military purposes" (p. 19). Much of this research develops the concern over the regulation of basic scientific research in biology because of its direct application to weapons (James, 2007; McLeish & Nightingale, 2007; Rappert & McLeish, 2007).

Another difference between WMD technology and conventional technology is that there are international agreements banning the use of WMD, and also restrictions on their possession. The Nuclear Nonproliferation Treaty (NPT) restricts the possession of nuclear weapons to five countries. The Chemical Weapons Convention (CWC) and Biological and Toxicological Weapons Convention (BTWC) state that no state should possess chemical or biological weapons. In contrast, states are allowed to possess conventional weapons sufficient for purposes of national defence (UN Charter, Article 51).

There is a distinction between how the term 'dual-use' is used in academia and how it is used by the practitioner. While these literatures are often separate, there are a few examples of where they overlap. A recent example is the

[21]WMD typically includes chemical, biological, radiological, and nuclear weaponised technology.

work of Caitríona McLeish and Paul Nightingale (McLeish, 2007; McLeish & Nightingale, 2007), who try to clarify the different interpretations of 'dual-use' that are used in practice. Their work deals primarily with biological technologies and research, but I will use it as a basis for developing a similar set of interpretations employed in the practice of defining conventional (i.e. non-WMD) technologies. Building on the work of Molas-Gallart (1997), they define dual-use as "the tangible and intangible features of technologies that enable them to be applied to both (illegal) hostile and peaceful ends with little or no modification" (McLeish & Nightingale, 2007, p. 163). This definition draws from the perceived need to incorporate non-state uses of the technology for malignant purposes (e.g. terrorism), and hence the choice of hostile/peaceful rather than military/civilian.[22]

McLeish outlines three 'models' of policy response to the question of what is meant by 'dual-use' (McLeish, 2007, p. 194–199):

- *Context-driven*: the technology is only dangerous when it is in certain contexts. It should therefore be prevented from getting into the wrong hands. This is the model, she argues, used in export controls.

- *User-driven*: rather than trying to control the transfer of technology, this model tries to control the way users interact with the technology, and the type of users that interact. Hybrids of these first two models are "those governance efforts which emphasise both the future contexts of users and the transfer of intangible elements of technology, such as knowledge" (p. 198).

- *Dual-use as an inherent characteristic of technology*: advocates of this view deem the "potential for misuse to be so high, and the outcome of any potential misuse so grave as to warrant implementing controls covering

[22]McLeish & Nightingale classify dual-use in yet another way, showing how it is employed as a positive (for industry) or a negative (for military applications) argumentative tool.

all users, in all contexts" (p. 198). Such is the argument presented in some efforts to moderate scientific publications.

Critiques of the concept of dual-use

The move in the middle of the 20th Century from favouring the term 'contraband' to 'spin-off' to 'dual-use' was part of a much larger transition in (mainly Western) civilization that began with the Industrial Revolution. With the advent of technologies that allowed humans to do things on scales never before known, the control of those technologies became a central tenet of power, be it the 'means of production' or 'means of destruction'.

'Contraband', which we will look at in Chapter 5, was a term used wholly for the description of items during their transition from one place to another. 'Spin-off' was used wholly to describe the usefulness of military technology in civilian industries. 'Dual-use', by contrast, has been employed to discuss means of production as well as the things that are produced and the transfer of those things. The difficulty with this term is a point that will be addressed periodically in this thesis, and therefore I provide a brief overview of the limited literature in this area.

The inadequacy of the term 'dual-use' as a tool for analysis (rather than an object *of* analysis) was established early on. Gummett & Reppy (1987) point out the inadequacy of the term 'spin-off' in describing the innovation and production process of technologies. In so doing, they also draw out problems with the term that was replacing it: 'dual-use'.

> In addition to the cases of 'pure' military or 'pure' civil technologies, there is a large class of mixed or dual-use technologies, which are nourished by a common technology base. Indeed, the variety of institutional and market structures in the civil sector may make it more appropriate to refer to 'multiple-use' technologies. Most new technology at the generic level falls into this class, as well as most of society's existing stock of technical knowledge, accrued over time. The difficulty in differentiating military from civil applications in this class of technology suggests that spin-off is not a particularly useful concept here (p. 3-4).

Similarly, Gummett (1991, p. 66 note 36) notes this point in a report to the British Parliament about the future relations between defence and civilian science and technology:

> These terms ['dual-use' and 'dual-market'] are themselves inadequate. They suggest too sharp a dichotomy between the defence and civil sectors, missing, for example, the shading between defence and 'quasi-defence customers' like the nuclear industry or telecommunications which resemble defence ministries in being expert and monopsonistic customers with high technical requirements. However, possible alternative terms have other difficulties. For example, 'generic technologies', which captures part of the sense intended here, is sometimes used to refer to too narrow a set of technologies for our purposes.

Reppy (1999, 2007, unpub. ms.) has devoted much thought to the inadequacy of the term. She argues that 'dual-use' is largely seen as a self-explanatory concept (Reppy, 1999, p. 273; see also Albrecht, 1987), but that the term can at least mean two very different things. The first meaning came about because of a perceived separation of civilian and defence manufacturing capabilities, primarily during the Cold War. This created 'two sectors' divided by two common assumptions: "that most technologies can be coded as either military or civilian (i.e. dual-use technologies are a relatively small set of all technologies) and that shifting resources from military to civilian purposes (i.e. conversion) will be difficult for technical and cultural reasons" (Reppy, 1999, p. 273). Based on these assumptions, at least two policy implications arise: 1) that it is possible to identify the technologies with military applications and control them; and 2) since moving between sectors is difficult, international transfers of civilian technology are not a security concern. Using this meaning, dual-use technologies are an outcast of the classification system, a residual category (Star & Bowker, 2007).

Conversely, one could make the assumption that "military technology is... embedded in a larger civilian technology base, with shared roots in a common educational system, shared interest in a range of generic technologies and process technologies, and links into the commercial sector through companies that serve both military and civilian markets" (Reppy, 1999, p. 273). With this assumption, the opposite policy implications arise: 1) it is not possible easily to separate technologies into civilian and military and therefore to control their dispersion in society; but that 2) this dispersion is important because conversion between civilian and military is easy. In the 1980s, Reppy argues, there was a shift in the US from thinking of the separation of civilian and military technology as difficult to cross, to thinking of it as easy to cross. This shift was done subtly, "papering over political differences and providing cover for the shift from [US] policies focused on export controls to the development of a mercantilist policy of promoting competitiveness from within the defense budget" (Reppy, 1999, p. 273). In so doing, however, political attention was no longer on the potential for dual-use technologies to be used for military applications by an adversary. Reppy argued that control might still be possible because technology is made up of not just artefacts, but also the knowledge needed to build, maintain, and operate them. This 'intangible technology' is often 'tacit knowledge' (MacKenzie & Spinardi, 1995) that is not easily transferred without significant contact between supplier and end-user, and therefore controls should focus more on the control of intangible technologies—but this poses a new set of problems (Reppy, unpub. ms.).

McLeish (2007) is well aware of these problems and the lack of critical examination of the concept of dual-use. The lack of conceptual clarity, both on the part of the practitioner and the academic—particularly in recognising that there *are* multiple conceptions—"centre[s] on competing conceptualizations about what constitutes technology, and what is the relationship between technology and function and the innovation process" (p. 200). Reppy places herself within a culture that emphasises the second of her assumptions of 'dual-use' and argues for the need to remember that dual-use technologies still have security implications. McLeish, conversely, places herself within a community that heavily emphasises the security implications and argues for the need to "accept that the dual use issue is not just a security issue" and therefore that careful attention should be given to "understanding the dual use issue within a technology governance framework" (McLeish, 2007, p. 200). They both argue for the need to recognise that the concept of 'dual-use' is multifaceted. Reppy (2006) is willing to relegate the concept to the dustbin if a more useful concept becomes available. McLeish argues for more engagement with the concept at a conceptual level, because making policy based on competing understandings of dual-use is likely to result in "inadequate and/or short-term policy responses to the long-term anti-proliferation goal" (McLeish, 2007, p. 200). An initial step, she offers, involves recognising that the different understandings of dual-use rest on different understandings of what constitutes technology. This thesis is primarily about how different understandings of dual-use technology interact with each other, and whether the term is likely to weather the inevitable tension between alternative understandings.

Dual-use technologies are, by their very name, straddling a boundary between two categories. There is a strong tradition within Science & Technology Studies to analyse the boundaries between categories, as they often provide valuable information about the structure of the classification system as a whole. We now turn to a brief review of this literature.

Boundaries

Work on boundaries flows across the social sciences. Boundaries, Lamont & Molnàr (2002) point out, are a basic conceptual tool of social science, having been employed since Marx (1898), Durkheim (1915), and Weber (1968/1922). Douglas' work analysed above on the abominations in Leviticus is a clear example of the need to control the boundary between clean and unclean.

In looking at issues of science and technology, the work of Gieryn (1983) on boundaries showed how scientists, from Victorian England to (then current-day) America, are constantly (re)creating the boundary between science and non-science. Guston (1999, 2001) develops the work on boundaries along a different line, building the idea of a boundary organisation, which continually crosses the science/politics divide to develop policy recommendations that are acceptable to both bodies. Star and her collaborators (Bowker & Star, 1999; Star, 1992; Star & Griesemer, 1989) use the concept of boundaries to show how what a technology is varies according to the context in which it is found, thus developing the idea of a 'boundary object'. Boundary objects are "those objects that both inhabit several communities of practice *and* satisfy the informational requirements of each of them" (Bowker & Star, 1999, p. 297). In addition, they can be tailored to meet the needs of specific contexts while also having an identity that is common across several contexts. They can therefore be both ambiguous and concrete.

Boundary objects embody polythetic classifications. De Laet & Mol (2000) provide a prime example of a boundary object in their paper on the Zimbabwean bush pump. The bush pump is, in their view, an exemplar of an object that has no substantive core; rather, it is interpretively flexible depending on the social, political, economic, and environmental contexts—that is, the sociotechnical landscape—in which it exists. Moreover, it only 'works' when it exists within a certain set of social and technical relations. It is of little use, for instance, for people who do not know how to install or maintain it. It will not work very well without a well of the appropriate dimensions from which to pump water, unless the pump is reconfigured to sit within a landscape for which it was not originally designed. The pump is able to be reconfigured with remarkable dexterity, and in addition satisfy economic costs and cultural requirements for local sourcing.

In a move away from viewing objects that cross boundaries as things to be shunned, Bowker & Star (1999) argue instead that they can be used as tools for communication and knowledge production. As will be argued repeatedly in this thesis, items on the Wassenaar Dual-Use List, and the list itself, are boundary objects. They are on the list because they need to serve more than one community of practice, and the way that they are described is telling of what the informational requirements are of each community.

We now have an overview of research on how classification systems are structured and the central role that they play in social and technical relations. Classification systems are not something that exist 'out there', reified entities that guide our lives. They are, instead, co-constitutive of the social and natural environments through which people enact and institutionalise them. Making and maintaining a classification system is a pragmatic endeavour, as it needs to be constantly serving multiple communities of practice, each with its own problems which it is trying to use the classification system to solve.

The Wassenaar Arrangement, in addition to being a classification system and concerning itself with the definition of technology, is an international arrangement between 40 different governments. Most analyses of the Arrangement to date have come from the literature on international relations and law.

2.3 Regimes, institutions, & transnational science and technology issues

Having provided an overview of the literatures on technology and classification, I can now turn to the various academic analyses that have so far been conducted on the Wassenaar Arrangement, CoCom, and multilateral export controls in general. Most of these analyses come from the literature on regime theory and organisational theory, and provide some perspective on the political and structural frameworks that are constructed by and constrain these international efforts. They lack, however, any significant analysis on the way that technologies are constructed within the debates. Similarly, they do not consider how knowledge of technologies that are or might be under control is developed and employed to further alternative strategies in shaping the international export control framework. In order to conduct such an analysis in this thesis, I draw on previous work about the role of science and technology in international affairs, which I outline at the end of this section.

Realism & regime theory

Much of the research on international export control efforts flows from work in international relations on regimes (Keohane, 1984; Krasner, 1983; Rittberger & Mayer, 1993; Young, 1982). Regime theory defines a regime as a set of implicit or explicit principles, norms, rules, and decision making procedures around which actors' expectations converge in given areas of international relations (Krasner, 1983). It has mainly developed within one of the largest theoretical areas of international relations research, realism (Morgenthau, 1948; Waltz, 1959), including contemporary manifestations in neorealism (Keohane, 1986; Waltz, 1979). Realism contains a broad range of theories, but it can be characterised by at least five common assumptions: states are the primary actors on the international scene; the international scene is anarchic; states are self-interested, rational, and their primary motive is survival; states have uncertainty about the intentions of other states; and the point of analysis is on power relationships. Realism is mainly essentialist in its grounding, arguing that rational actors pursue gains (relative or absolute), and therefore in a given international structure their actions are predictable. While much of the regime literature follows this line of thought, the concept of a regime is broad enough to allow for other, non-essentialist, approaches as well. For instance, the neoliberal tradition (Keohane & Nye, 1977; Nye, 1993; Rosenau, 1990) also lays claim to the idea of regimes.

While the multilateral export control arrangements are generally considered to be regimes,[23] it is important to point out that they are informal. They are not based on any treaty, they are non-binding, and (apart from the Missile Technology Control Regime) they have non-committal names—e.g. the Wasse-

[23] They are often called Multilateral Export Control Regimes (MECRS).

naar Arrangement rather than the Wassenaar Agreement.[24] Why this is the case, at least for the Wassenaar Arrangement, is a point of analysis in this thesis.

A classic example analysis of export controls from within regime theory is Mastanduno's (1992) thorough account of CoCom in a book published shortly before CoCom disbanded, entitled *Economic Containment: CoCom and the Politics of East-West Trade*.[25] Mastanduno uses regime theory to analyse CoCom from three angles. First he shows how states who were members of CoCom engaged in four different types of 'economic statecraft'—using economic measures to reach political ends (Baldwin, 1985)—over the life of the organisation. CoCom started out as a tool of economic warfare, where the idea was to weaken Communist economies by denying almost all trade, military or otherwise, because of the (believed) adverse affect it would have on that state's military capabilities (Mastanduno, 1992, p. 40-46 & Ch. 3). That stance did not last for more than the first few years of CoCom, Mastanduno argues, after which time it became a tool of strategic embargo, whereby only trade in items of direct military significance were controlled (p. 47-52 & Ch. 4). The other two types of economic statecraft, tactical and structural linkage, focus on expanding trade with an adversarial state rather than constricting it (p. 52-57). Tactical linkage increases trade in response to, or as an incentive for, an improvement in an adversarial state's behaviour. CoCom served to foster these positions during the 1970s (Ch. 5), after which there was an (unsuccessful) attempt to return to economic warfare (Ch. 7).

The second angle from which Mastanduno analyses CoCom is looking at how states were able to cooperate. He argues against the idea that a hegemonic power is needed to create and sustain international regimes (c.f. Keohane 1980; Keohane 1984, p. 32-39; Adler-Karlsson 1968). Rather, it was only when the

[24] The Arrangement may better be thought of as an informal group of states, for instance (on informal groups, see Prantl, 2006).

[25] See also Mastanduno (1988).

non-hegemonic (i.e. non-US) states' interests were appeased with effective US leadership that decisions were made in CoCom.

Finally, Mastanduno analyses CoCom to show that US trade policy was an uneasy mixture of wanting to minimise government intervention in the international market (economic liberalism) while at the same time purposefully intervening on grounds of national security. This is in contrast to earlier work that only highlighted economic liberalism (e.g. Maier, 1978; Ruggie, 1983).

CoCom's 'effectiveness', according to Mastanduno, was determined by "the extent to which member states, given their commitment to a strategic embargo, faithfully formulate, implement, and administer their multilateral controls" (Mastanduno, 1992, p. 15). In order to be effective, CoCom had to have members that were able to define accurately the technology to be controlled and then prevent exports of controlled technology.

> The *construction* and *interpretation* of the control list is similarly important. It is a sign of regime weakness if items of direct military significance are left off the list (consciously or inadvertently) or if member governments interpret controls differently, that is, some allow sales that others presume to be restricted. Conversely, the undertaking of list revisions that lead to the addition of items of military significance or of policies that lead to uniformity in interpretation can be taken as an indicator of regime strengthening (emphasis original, Mastanduno, 1992, p. 16).

Drawing on the literatures about technology and classification above, we can see how this definition of effectiveness is severely lacking because it assumes that a technology's military significance is independent of how it is interpreted, and therefore that there is only one 'correct' interpretation of the technology. While Mastanduno addresses many of the debates on list revision in CoCom, showing how there are continuous compromises between economic and security drivers, he does not demonstrate how the particular technology under consideration in these debates is differently represented by those arguing for either its addition or removal.

Another approach used within the regime theory literature is that of game theory, which tries to develop formal, logical rules that can describe and predict international politics (Oye, 1986). In game theoretic models of international interactions, participants (be they governments or groups within or between countries) are taken to be unitary actors who make choices between strategies in order to maximise expected payoffs. Zürn (1989) performs a game theoretic analysis of CoCom, which is elaborated upon by Noehrenberg (1995). Noehrenberg uses a two-level game approach (Putnam, 1988) that shows how domestic and international factors both play into the negotiation dynamics at CoCom meetings. Noehrenberg analyses five states (US, Britain, The Federal Republic of Germany, France, and Japan) to draw out the following domestic and international factors that affect their decision making: perceived security risks from target states; perceived global competition in trade of strategic technologies; perceived economic gains from trade with target states; public and official antipathy towards target states; and turf battles between government departments (Noehrenberg, 1995, Ch. 7).

As these factors changed throughout the life of CoCom, Noehrenberg argues that the states took different stances on the 'size' of the lists. These domestic and international factors were meditated through the negotiation structure of CoCom, which was characterised by: a high level of secrecy; a pattern of repeated games; transparency; and the unilateral veto of each member (p. 173-183). Noehrenberg then uses these factors in a game analysis on what the optimal 'list size' (small, medium, or large) would be given the different preferences of each of these major actors in CoCom (p. 183-204). What Noehrenberg means by 'list size', however, is clarified nowhere, nor does he ever discuss the make-up of the lists, except in listing (incorrectly) the 'technologies controlled under CoCom's Dual-Use List' in an Appendix.[26] Such focus on the politics

[26]Noehrenberg lists the categories of technologies on the September 1991 lists, though he leaves several of them out and does not articulate the structure of the lists in any depth. He also calls it the 'Dual-Use' List, when at the time it was still called the 'Industrial List'. The September 1991 lists, as will be shown in Chapter 4, also had a radically different structure

of CoCom leaves much of the structure and process of the organisation analytically untouched. For example, there is little that he can say about how different perspectives could be reconciled in debates on list modifications.

Organisational & institutional theories

While there may be ways that regime theory can be considered a subset of institutional theory (Powell & DiMaggio, 1991, p. 6–7), insofar as it supports realist assumptions there is a disconnect. There is a prominent strand of institutional theory—new institutionalism—that rejects realist assumptions, instead focusing on "an interest in institutions as independent variables, a turn toward cognitive and cultural explanations, and an interest in properties of supraindividual units of analysis that cannot be reduced to aggregations or direct consequences of individuals' attributes or motives" (Powell & DiMaggio, 1991, p. 8). Lipson (1999) uses new institutionalism to argue that the Wassenaar Arrangement sits within an 'organisational field' (DiMaggio & Powell, 1991) of nonproliferation export controls, which allows for a diffusion of shared practices, professional expertise and norms of conduct to spread between and within Wassenaar and the other multilateral export control arrangements.

Risse-Kappen (1995) develops 'transgovernmental coalitions' as the unit of analysis to look at how international institutions allow "networks of government officials which include at least one actor pursuing her own agenda independent of national decisions" (p. 9). As such, an international institution can be thought of as a body with a degree of independence from the governments that constitute it.

Along a similar train of thought, Slaughter (1997) argues that a new world order, transgovernmentalism, is developing through the proliferation of 'transnational government networks', which are ways of coordinating between functionally similar units within different governments. Such a network can be described

than the forty years of lists before them, and thus do not reflect the documents that formed the framework of negotiation for much of CoCom's existence.

as one of regulators who focus on: exchanging information; coordinating policy; cooperating on enforcement issues; collecting and distilling best practices; exporting particular regulatory forms; bolstering their members in domestic bureaucratic politics; and transmitting information about their members' reputations (Slaughter, 2004, p. 40). These regulators work with some degree of autonomy from their national political leadership, and Slaughter divides the types of networks they can make into three kinds.

The first, information networks, focus on distilling the collected information from different national regulatory processes into sets of 'best practices' that can then be reintroduced at the national level in a recursive process. In enforcement networks, regulators assist each other in enforcing national laws by tracking down violators of national and international regulations. Harmonisation networks work on making national laws in different countries consistent with one another. Within harmonisation networks, "regulators entrust many important choices to technical expertise and [ ] allow network members to bolster one another in domestic bureaucratic struggles. Such bolstering could mean the privileging of a technocratic over a democratic regulatory voice against corrupt political pressure" (Slaughter, 2004, p. 63).

Building on Slaughter's ideas, Lipson (2006*a*) argues that the Wassenaar Arrangement is a transgovernmental network of export control officials in order to draw out its contrasts with international organisations and agreements. International organisations facilitate international cooperation through a centralised semi-independent structure in order to reduce transaction costs (Abbott & Snidal, 1998), and formal international agreements are precise, legally binding obligations (Abbott & Snidal, 2000). Lipson argues that these forms of 'hard law' will not work for Wassenaar because of its "large number of states, divergent preferences, varying levels of consensus across different sub-issues, and varying levels of state capacity" (2006*a*, p. 64). Rather, what is needed—and what Wassenaar provides—is 'soft law', which "facilitates compromise, and thus mutually beneficial cooperation, between actors with different interests and values, different time horizons and discount rates, and different degrees of power" (Abbott & Snidal, 2000, p. 423).

While such a theory is useful to describe the larger picture of the Wassenaar Arrangement, it does not have much to say about how internal debates play out and how preferences are formed and institutionalised through practice. Nor does it pay particular attention to the alternative conceptions of Wassenaar, or to the technology on its lists, that are continually at play within the Arrangement. The literature specifically on science and technology in international security does address these points, but, as we shall see below, there are also difficulties in applying its arguments to the study of the Wassenaar Arrangement.

Science, technology, & international security

Many international security issues today require scientific and technical expertise to be significantly addressed. There is a growing literature that looks at the role of scientific and technical expertise in developing and maintaining international efforts on these issues, though many researchers still find the paucity of research in this area perplexing (Gummett, 1990; Rappert, 2007; Sapolsky, 1977; Smit, 1995).

Early thinking at the end of World War II tended to focus on the promise (Bush, 1945) or danger[27] of the development of a technocratic elite who held a privileged place in the policy making process. This was driven by the idea that threats to national security could largely be dealt with by advancing science and technology. This train of thought has a recent manifestation in the work on epistemic communities.

[27]Such as in Eisenhower's Farewell Address as President on 17 January 1961: "in holding scientific research and discovery in respect, as we should, we must also be alert to the equal and opposite danger that public policy could itself become the captive of a scientific-technological elite."

The work of Haas and others operates loosely within regime theory, but expands it to incorporate "network[s] of professionals with recognized expertise and competence in a particular domain and an authoritative claim to policy-relevant knowledge within that domain or issue-area" (Haas, 1992, p. 3), otherwise known as 'epistemic communities' (Adler, 1992; Haas, 1989). Epistemic communities arise in policy areas that are heavily dependent on scientific and technical expertise and reliant on policy coordination between multiple states. These communities become institutionalised by consolidating bureaucratic power within governments and international organisations.[28] However, such an approach has been criticised for assuming that science stands divorced from politics, that 'truth' is separated from and speaks to 'power' (Litfin, 1994; Stone, 1988). One of the major difficulties in employing an epistemic communities approach to studying the Wassenaar Arrangement is that the development of the Arrangement was not driven by a scientific or even technological group of experts, but rather by a political need to control access to militarily significant technologies. The concept of an epistemic community also depends upon the need for agreement on the definition of the problem to be addressed (Haas, 1989). This is in contrast with the position I take in this thesis, as I show how such agreement is not likely, nor is it necessarily desirable, within the Wassenaar Arrangement. These points will be drawn out more in Section 2.4.

One question addressed by the literature on science and technology in international affairs is whether the regulatory mechanisms currently in place are the right sort of mechanisms for the types of problems they are trying to tackle. This is a concern that has existed throughout the history of export controls (Rappert, 2006). There is concern, for instance, that regulatory mechanisms for controlling access to militarily significant technologies are fundamentally unable to address the types of challenges likely to arise in response to developments in biotechnology, nanotechnology, and the devices terrorists use (Arquilla, 2003;

[28]There is therefore a strong resemblance to the concept of an advocacy coalition (Sabatier & Jenkins-Smith, 1993).

Whitman, 2007). Part of the reason for this is that it is no longer the most advanced technology that is causing the most damage to societies. For instance, on 11 September 2001, it was through the employment of several box-cutters and some commercial airplanes that members of Al Qaeda were able to bring down the World Trade Center buildings in New York City. Another problem is that international cooperation on export controls was designed on the assumption that technologies developed on an extended timeframe. As the pace of technological advancement continues to increase, regulatory mechanisms are falling further and further behind (Skolnikoff, 2001).

There is an area of this literature that emphasises that science and technology are not the primary or most powerful drivers of security policy that *prime facie* concern science and technology (Spinardi, 1997). Science and technology factors should still be given weight, but it is not a case of science speaking truth to power (Jasanoff, 1990). Instead, this area of the literature focuses on how different groups each constitute what is the relevant science and technology to discuss on a particular issue. A major concept in this literature, discussed above in the sections on technology and classification, is the idea that social order and technical knowledge are co-constructed (Jasanoff, 2004). One train of thought that shows particular merit in being able to provide a new look at international security issues involving science and technology is the theory of sociocultural viability, to which we now turn.

2.4 Sociocultural viability

A theory that develops from many of the literatures discussed above is the that of sociocultural viability, also known as the Neo-Durkheimian theory of institutional viability, or Cultural Theory.[29] The theory began with the work of Mary Douglas (1966) as an anthropological tool to explain how systems

[29] I have chosen to use the perhaps more cumbersome name to avoid confusion with the vast arrays of approaches that fall under the general label of cultural theory (lower case). See Smith (2001).

of classifications handle anomalies and ambiguity, with an emphasis on the analysis of lists. It has always been concerned with the relationship between the natural and social worlds, arguing that they are co-constituted. It is a theory of power relations, social accountability, and sense-making. Today, it is employed by researchers and practitioners in fields as diverse as town planning, climate change, and gun control.[30] In this section, I review the basic tenets of this theory, drawing out its connections and tensions with the other literatures.

Douglas' focus on classification, as shown above, is the starting point for one of the two bases that she uses to form a two-dimensional matrix of social relations, the 'grid/group typology' (1970/2003, p. 62). In a very ordered system of social classification, each individual will have a place in society that will be different from that of other individuals. Douglas calls this the 'grid' axis (cf. Durkheim, 1951). The other dimension, which Douglas calls 'group', is defined by the degree to which an individual sees herself as part of a larger collective. This typology therefore develops four quadrants of social relations. When a person is in one of the quadrants, she will tend to use that model of ordering as a general basis of cognition. Thus, when speaking about nature, the higher a person goes on the grid axis, the more she will order the system of natural classification, and the more each piece of nature will be put into a specific category. The higher she goes on the group axis, the greater the degree to which she will interrelate the categories of nature. Douglas does not believe that society completely shapes cognition, however. An individual can choose to hold different views of nature than those of the system in which he/she currently resides. Douglas' point is that the individual, in expressing those views about nature, will be trying to change the system of social relations. Thus, the typology is dynamic. It is also important to note that "Douglas instructs us to treat the processes of classification and contention as inseparable, since the dominant concern in any social context is how to organize together in society" (Tansey, 2004, p. 20). Bloor (1978) uses this typology, graphically represented

[30]For a recent collection of these analyses, see Verweij & Thompson (2006).

in Figure 2.2, to devise the different anomaly-handling strategies each quadrant uses for maintaining a classification system, upon which I will elaborate in the next chapter.

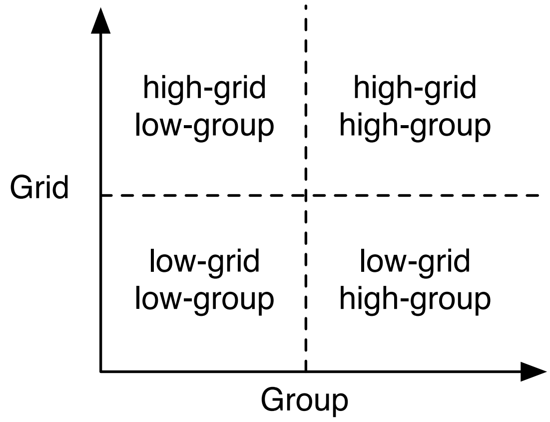


Figure 2.2: *The grid/group typology*

This typology was developed further by Thompson, Ellis & Wildavsky (1990) to create the theory of sociocultural viability. They argue that each of the quadrants in the grid/group typology represents a combination of a style of social relations and a cultural bias (Douglas, 1978), which is a shared set of values and beliefs. When people express their cultural bias through patterns of behaviour, they are reinforcing a particular set of social relations, and when they are in a certain set of social relations, they will tend to conform to certain patterns of behaviour. It is from these patterns of behaviour that people begin to develop preferences, whether they be regarding mathematics, risk, technology, or anything else (Thompson et al., 1990, ch. 3). How these preferences develop in relation to the Wassenaar Arrangement will be a matter of analysis for this thesis.

The theory argues that there is a limited number of combinations of social relations, patterns of behaviour and cultural biases, called *solidarities*. It is these solidarities that form the unit of analysis. The actual number of solidarities that it is useful to include is a matter of debate. It is at least three (Rayner, 1995)—to ensure complex interactions—and not more than five

(Thompson et al., 1990, p. 48-51), to maintain parsimony. The different types are shown overlaid on the grid/group typology in Figure 2.3. When there are only three, they are usually defined as the 'active voices' in the debate, and are the hierarchical, egalitarian, and competitive voices. The fatalistic voice is not one that would generally engage in the debate, as individuals in this type of social relations or holding this cultural bias would feel that their voice would not get heard even if they used it (due to high classificatory structure and a low sense of group membership). The hermit, which sits in the middle of the graph here, is taken up by those who wish to withdraw from all forms of social relations and has no voice (Thompson et al., 1990, p. 7).[31]

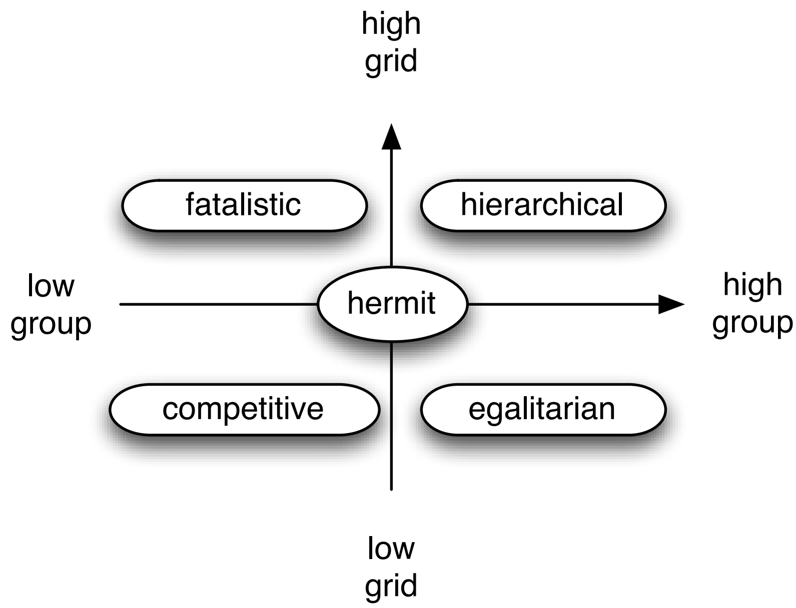


Figure 2.3: *The cultural theory typology*

Steve Rayner (Rayner, 1995; Rayner & Malone, 2000; Thompson & Rayner, 1998) provides an alternative derivation of the solidarities, beginning not with the work of Douglas, but rather synthesising the various dichotomies that social theorists have used over the past 150 years to explain the progress of social institutions. For instance, Durkheim (1893) speaks of the movement of society from forms of mechanical solidarity, where agents are bound by similarity, to

[31]The names of each voice vary within the literature. I have chosen the most common set.

forms of organic solidarity, where they are bound by by interdependence of specialised roles. Lindblom (1977), Williamson (1975), and Weber (1958) all distinguish between markets and hierarchies. Similarly, Maine (1861), Tönnies (1887), and Bernstein (1971) all describe social relations—from the interpersonal to the international level—in a dichotomous framework, but when overlaid, the dichotomies of all of these scholars are not collapsible into a single uber-dichotomy. As Rayner argues: "there is a great deal of overlap among these grand dichotomies of social theory. However, they are far from perfectly congruent and, in sum, give rise to three, rather than two, basic forms of social solidarity" (Rayner, 1995, p. 61). These three are the three active solidarities: hierarchical, competitive or market, and egalitarian.

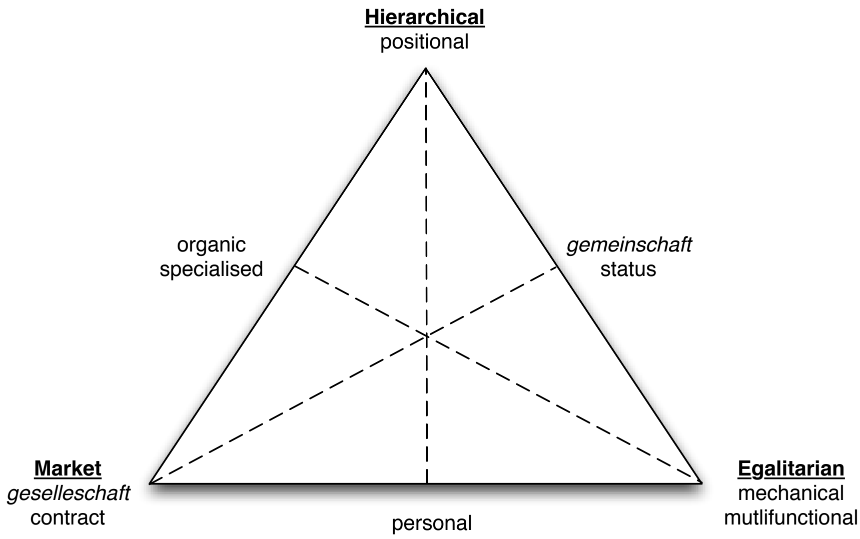


Figure 2.4: *Two-dimensional map of kinds of social solidarity underlying human values preferences (redrawn from Rayner, 1995)*

Rayner (1995) develops a two-dimensional map of human values to show these overlaps, as shown in Figure 2.4. He proposes that these three forms of solidarity create a dynamic space for social interaction. Any human activity will be an effort to strengthen at least one of these forms of solidarity, and any institution will be some mixture of each of these solidarities. Rayner shifts from emphasising the individual (or institution or state) as the unit of analysis to emphasising the solidarity, and is thus able to show that the individual is actually a 'dividual' (Marriott, 1976), composed of a dynamic mix of solidarities and able to perform complex strategy switching (Rayner & Malone, 2000) between them. The same is true of any institution, and therefore when speaking generically about a person/group/institution that takes up a particular solidarity, I will refer to it as an *actor*. An actor may express different solidarities in different contexts, but within a particular context, it will tend to adopt the patterns of behaviour, cultural biases, and form of organisation of only one of the solidarities to the extent that the context will allow it. Actors do not come to an issue with their preferences already formed for a particular solidarity, but rather their preferences emerge as a result of interactions within a particular institutional context and with other actors (Thompson et al., 1990, Ch. 3).

The solidarities

A brief review of each of these solidarities is useful here, and will be complemented later in the thesis by an elaboration of each one within the discourse on dual-use technology. Each solidarity legitimates its form of organisation with reference to a corresponding organisational style that is found in nature. The importance of the connection between natural and social systems is explained by Douglas (1986, p. 48):

> There needs to be an analogy by which the formal structure of a crucial set of social relations is found in the physical world, or in the supernatural, or in eternity, anywhere, so long as it is not seen as a socially contrived arrangement. When the analogy is applied back and forth from one set of social relations to another and from these back to nature, its recurring formal structure becomes easily recognized and endowed with a self-validating truth.

Each solidarity has a distinctive style of *framing* a particular issue, where a frame is defined as "the overarching or organizing concept that represents the application to a specific context, of the general cognitive commitments of a given solidarity, in its more moderate or more extreme form" (6, 2005, p. 104).

The problem and solution framing that each solidarity will take on a particular issue is also legitimated by a natural analogy (Rayner, 1991).[32]

These basic natural analogies for social relations and issue framing can then be used to generate all manner of preferences on which each solidarity will have a different stance, be it risk (Rayner, 1984), energy (Schwarz & Thompson, 1990), the distribution of goods and services (Rayner, 1995), international relations (Verweij, 2000), perception of time (Rayner, 1982*b*), or fairness (Rayner & Cantor, 1987), to name a few. For a thorough list of these preferences, see Schwarz & Thompson (1990, p. 66–67) and Thompson & Rayner (1998, p. 331). These natural analogies also generate the distinctive patterns of behaviour and cultural biases of each solidarity.

The hierarchical solidarity

The natural classification system upon which the hierarchical solidarity is founded is the relationship of the head to the body. This is a relation of dominant to subordinate, and provides the basis for the separation of society in a top-down fashion, be it in regards to class, role, expertise, etc. The head-to-body analogy encapsulates the importance that the hierarchical solidarity puts on both group cohesion and social regulation.

Problem and solution framing within the hierarchical solidarity is based on the analogy of nature as tolerant within bounds. The natural system can be pushed, but if pushed too much, it will collapse. As such, the problem is framed as a problem of management, of keeping the issue within the bounds of acceptability. The solution to the problem can be achieved by segregating the problem and segregating society, assigning the appropriate part of the problem to the appropriate part of society, much as the head co-ordinates the hands for manipulating and the feet for walking. Because of the reliance this solidarity has on knowing where the bounds of acceptability are on an issue, much of the

[32] These analogies are based on the work of Holling (1977).

effort of institutions and other actors that take up this framing of an issue will be spent on measuring and defining the boundary.

The types of transactions that the hierarchical solidarity supports are based on rules and procedures, whereby decisions are made in a committee where the authority rests with the most senior person there. Fairness is judged as equality before the law. The distribution of goods and services should occur based on the principle of proportionality, where the administrative determination of rank, contribution, or need establishes how much each actor should receive. Time is seen as bounded, but manageable; thus, everything has its time, and things will be done in their proper order.

When looking at the issue of, for instance, radiation hazards in hospitals (Rayner, 1984), an actor using a hierarchical framing looks towards establishing rules and procedures for making sure that radiation doses do not go above a certain level, which is defined by an expert committee. Within the issue of climate change (Thompson & Rayner, 1998), an actor expressing this framing seeks to identify, again through a committee of relevant experts, the bounds of climate variability, and then to set up institutions to ensure the climate stays within those bounds. Within the issue of flood protection (Linnerooth-Bayer et al., 2006), actors using this framing employ expert judgement to determine the likely frequency and strengths of floods, and then create institutions that would ensure a that city could withstand those floods.

Any risks that occur within an issue should be addressed through established institutions (which preserve the system of hierarchy already in place). Consent to make decisions on behalf of society is considered to be hypothetical; the individual, by being part of the society, consents to allow the governing institutions to make decisions on his behalf, even if he may not like the particular outcome. Liability, when things go wrong, is handled within the hierarchical solidarity through redistributive taxation, which will ensure not that everyone bears the same cost, but that the most important parts of society survive. All of these preferences are tied back to the relationship of the head to the body, and to viewing nature (and thus any issue) as something to be managed.

The competitive solidarity

The natural classification system upon which the competitive solidarity is founded is that of predator to prey. It is focused on those individuals who have the means to succeed. Neither group cohesion nor social regulation are as important as individual motivation and capabilities.

The problem and solution framing for the competitive solidarity is based on the analogy of nature as robust. There is no need to consider the bounds of nature, as the focus is entirely on the individual. If nature is disturbed in the process of self-improvement, there is little concern as it will bounce back. Thus, a competitive framing sees the issue not as a management problem, but as a problem of competition between other individuals. The only social relations of value are networks that are established on a contractual basis and broken when the contract terminates.

This competitive mode of transaction means that fairness should be based on equality of opportunity. The market is open to anyone, but it is only those with the skills and networks who will succeed. The distribution of goods and services is therefore based on the principle of priority: first in time is first in right. This is complemented by a view of time that focuses on the short-term rather than the long-term. There is a constant need to reassert an actor's position within a competitive form of organisation because the actor cannot rely on established rules and procedures to ensure its place. This creates an 'innovate or perish' mentality.

To use the same examples as above, an actor using a competitive framing addresses radiation hazards in hospitals by accepting a high level of risk in order to reap the rewards of being the first to innovate a new medicine or technique. When looking at climate change, an actor in this framing seeks to create markets for carbon and also boost markets for technologies that consumers believe will help alleviate the effects of climate change. On the issue of flood prevention, a competitive framing favours individual responsibility for insuring against floods and siting decisions.

Risks are accepted within the competitive framing as inevitable if one is to succeed. They are not something to be managed, as the hierarchical framing would suggest. Consent of society to bear these risks is revealed through their consumption patterns. Should something go wrong, the liability mechanism is one of loss-spreading, where market mechanisms like insurance determine who bears the losses. Once again, we can see how all of these preferences are linked to the natural classification of predator to prey.

The egalitarian solidarity

The natural classification system upon which the egalitarian solidarity is founded is that of equality within groups. For example, migratory birds form a V-pattern in flight, where each takes turns being in the front of the V and therefore breaking the wind-resistance for all the others. Group cohesion is important within this solidarity, but regulation within that group is minimal. Objectives are therefore best achieved through cooperation among equals rather than through competition among rivals or hierarchical committees.

The problem and solution framing for the egalitarian solidarity is based on the analogy of nature as ephemeral. Nature is a fragile system in a delicate balance. Anything disturbing that balance may cause the complete collapse of the system as a whole. This analogy therefore supports a precautionary approach to a particular issue. It is important to view the issue not as an isolated case, but as part of a larger interconnected system. The conception of time in an egalitarian framing comes from the solidarity's ability to compress its perception of all of the past and all of the future into the present. This is because the solidarity is as certain of the departure of the previous state of the world as it is of the impending future.

The cooperative mode of transaction preferred by the egalitarian solidarity means that fairness should be based on equality of result. The distribution of goods and services should therefore not be guided by the principles of proportionality or priority, but by the principle of the parity of outcome. There are no dispute-resolving mechanisms in an egalitarian framing other than expulsion from the group. This usually comes about through labelling the actor to be expelled as an 'outsider', and therefore not really part of the group at all.

To once more use the same examples as above, when addressing radiation hazards in hospitals, the idea that nature is vulnerable and needs protection translates into the idea that radioactive materials require far too many safeguards and other hierarchically orientated control mechanisms to achieve any semblance of safety; and the safety achieved would never be good enough to bear the burden of preventing any accident from occurring. When dealing with climate change, actors expressing the egalitarian framing see the profligacy of humanity as the cause of the problem and the solution as a radical shift towards more sustainable living standards. Within the issue of flood preventions, any attempt at bending the river to suit the needs of humans will have an adverse effect on the natural environment. Instead, an actor expressing the egalitarian framing would argue for allowing the river to take its natural course and focusing instead on modifying human behaviour so as to be less disruptive to the environment.

Any risks that occur within an issue must be agreed to by explicit consent of all actors involved, rather than consent being hypothetically implied simply by being part of society or revealed through consumption patterns. Liability for unforeseen costs, from an egalitarian framing, falls on those directly responsible for the risk; it is therefore a strict-fault system. This stance on liability allows for the group as a whole to continue to survive. Each of these preferences gains its legitimacy from its relation to natural systems of equality and from the analogy of nature as ephemeral.

Each of the solidarities is summarised in Table 2.1.

Table 2.1: *Preferences for each framing of the problem of dual-use technology (Schwarz & Thompson, 1990; Thompson & Rayner, 1998)*

	Solidarity		
Preferences	Hierarchical	Competitive	Egalitarian
Natural classification system:	head/body	predator/prey	collective
social regulation (grid) & social integration (group):	high/high	low/low	low/high
Nature analogy for issue framing:	tolerant within bounds	robust	ephemeral
Solution to issues:	management of problem	encourage markets	shift social order
Transactional mode:	rules & procedures	competition	cooperation
Fairness:	equality before the law	equality of opportunity	equality of outcome
Distribution of goods and services:	proportionality	priority	parity
Conception of time:	bounded	short-term	long-term
Consent to risks:	hypothetical	revealed	explicit
Liability for risks:	redistributive	loss-spreading	strict-fault
driving values:	maintain status quo	expansion	equality

The theory of sociocultural viability is a theory of dynamics within and between solidarities. Each actor is continually *enacting* one or another form of organisation through performing or institutionalising certain sets of preferences. In doing so, the actor is also disorganising the other forms of organisation (Thompson, 2008). Thus we can speak of positive feedback dynamics, which allow one solidarity to become further institutionalised within a particular context, and negative feedback dynamics, which are the resistive forces that each solidarity can use against the others (6, 2003).

A key aspect of this typology is that each solidarity relies on the other for counter-balancing its assumptions.[33] None of them has a fully accurate view of the world, and reliance solely upon one often results in ineffective institutions. For instance, Hood, Rothstein & Baldwin (2001) note that proponents of the hierarchical solidarity will always propose a management-oriented solution to the problem, even when such a solution may be more symbolic than effective. This symbolism is important, however, because it allows the solidarity to remain intact. Marco Verweij (2006) has noted how the Kyoto Protocol on greenhouse gas emissions may be an example of this. Perri 6 (2007) describes ways that the different solidarities can co-exist with each other, which he calls 'forms of settlement', and in the process create viable institutional forms.

The theory of sociocultural viability is intimately concerned with power (Tansey, 2004). Each of the solidarities incorporates a different conception of the appropriate power relations. Within the hierarchical solidarity, power is distributed according to position and status, whereas to the egalitarian solidarity, it is distributed equally among all in the collective. Both of these are contrasted with the competitive solidarity, where power is in the hands of the individual. The theory of sociocultural viability, Rayner (1992, p. 102–103) argues,

> enables us to analyze cultural values and beliefs as carefully maintained regulators of social organisation, rather than as mere reflections of the economic or political order. Through cultural theory analysis, we are able to see how symbols are invoked by people in order to convince and coerce each other to behave in a certain way, as well as to justify their own actions. Cultural theory shows how culture works as a social control mechanism and a means of accounting for actions.

[33]This is called the 'requisite variety condition' (Thompson et al., 1990, p. 86).

The theory has often been applied to technological decision making. Technology is not something which can be brought under social control, Schwarz & Thompson (1990) argue, but rather is the thing through which social control is instituted. This is very apparent when debating acceptable levels of risk, be it for radiation hazards in hospitals (Rayner, 1984), nuclear waste siting (Gross & Rayner, 1985), or climate change (Rayner & Malone, 1998). The predominant approach in this research is to look behind the technical debate to see what forms of social organisation are being attacked or defended. This is not to discount the need for technical discussions to focus on the technically possible, but rather to state that which version of the (infinite number of) technically possible outcomes is realised will depend on the interplay of voices espousing different forms of organisation (Schwarz & Thompson, 1990; Thompson, 2003). The approach is thus closely related to the concept of a 'sociotechnical ensemble', which I discussed in Section 2.1. It is also similar to the notion of interpretative flexibility in technology, since each solidarity incorporates a different set of preferences for how to view 'the same' technology.

There is also a useful connection here with Rappert's work on ambiguity. Now, not only are we aware that social structure and the construction of technologies are related, but we also have a framework in which to put those different sets of relations. How ambiguities in technologies are resolved, in other words, will depend upon the type of social organisation one wishes to strengthen.

Within international relations, work within this literature suggests that international organisations need to be subject to similar democratic controls as are national governments (Verweij & Josling, 2003). The bureaucratic cultures within these organisations would become self-defeating without checks from at least markets (cf. Weber, 1968/1922) if not also civil society. Rayner (Rayner, 1994; Thompson & Rayner, 1998) argues that international issues often have a 'hegemonic myth' that is championed by one of the solidarities. Myths, within the social science literature, are not mystical tales. Rather, they are stories that embody fundamental assumptions about everyday or scientific reality (Thompson & Rayner, 1998, p. 283). The hegemonic myth describes the "fundamental propositions or assumptions that are unquestionable within the context of a particular discourse" (1994, p. 15). When one solidarity is hegemonic, the people wishing to strengthen an alternative form of social organisation must adopt the discourse of this solidarity, if only then to undermine it. Rayner contrasts the idea of a hegemonic myth with Haas' (1992) notion of a 'shared episteme'. Whereas Haas is concerned with the development of a cohesive epistemic community, Rayner emphasises the continual battle between solidarities. Hegemonic myths, then,

> set the rhetorical terms within which rival views and myths continue to compete, although in a more subdued manner. Arguments based on rival myths are likely to accept the general assertions of the hegemonic myth while providing for specific elaborations or exceptions that effectively undermine it—a 'Yes, but...' approach to debate. What a rival myth cannot do is directly challenge a hegemonic myth and expect to remain a credible participant in the dialogue (Rayner, 1994, p. 15).

As we can see, the theory of sociocultural viability has been incorporated into theories of technology, theories of classification, and institutional and international relations theories. It is well designed for a discourse analysis of how different framings work to institutionalise different forms of organisation, and how the ordering of people and the ordering of technology and nature are inextricably intertwined. In looking at the different goals that are being sought through the development and modification of the Wassenaar Arrangement list of dual-use technologies, I am in some ways returning the theory back to the original point of its formulation in Douglas' (1966) work on classification of purity and danger, of pollution and taboo. In the next chapter, I will use this theory as a basis for my analytical framework.

2.5 Conclusion

We have now reviewed the major sections of literature relevant to this thesis, highlighting the ideas that will be useful in the analysis of the Wassenaar Arrangement Dual-Use List modification process.

Technology is inherently social. The nature of the relationship between technology and society, however, has been the source of much debate. Technological determinism sees technologies as driving social relations, while social determinism draws the opposite causal line. Most work today sits somewhere in the middle, such as the Social Construction of Technology (SCOT) approach. A useful notion from SCOT that I employ in this thesis is that technology is 'interpretively flexible' depending on the 'relevant social groups' in which it is situated.

The differentiation between the discourse about technology and the artefacts and practices to which the discourse relates is an important one for this thesis. In maintaining the Wassenaar Arrangement lists, member states spend their time discussing 'What is a dual-use technology?' and thereby engage in discourse about the technology. It therefore makes sense to employ the 'technology as text' metaphor to analyse these debates. What constitutes a technology is always ambiguous because its 'capacities' can only be defined in relation to the context of a particular artefact in a particular environment employed by a particular person in a particular way. However, different definitions of technology are related to stances in the broader debate about the relations of accountability between actors.

When addressing literature on classification, I showed how classification systems are not things that exist 'out there', reified entities that guide our lives. They are, instead, co-constitutive of the social and natural environments through which people enact and institutionalise them. Rather than viewing things as having essential properties, I take up the argument that classifications are based on the relationship between things. The work of Mary Douglas centres on anomalies in the natural and social worlds and on how a society's responses to them strengthen its bonds. The resolution of anomalies is an act of conferring sameness, but sameness is not a property of nature; it is a thing conferred by institutional structure, by a system of classification.

'Dual-use' is a particular classification of technology used by the Wassenaar Arrangement, and we saw how the term has been analysed by different communities of practice, either emphasising a movement between military and non-military, or showing the ambiguity of use in the technology. Through a discussion on the inadequacy of the term, we saw that, once again, different understandings of the classification system rest on different understandings of technology and its role in society. Dual-use technologies are boundary objects, and as such can be used as tools for communication and knowledge production between different communities of practice that might not otherwise be able to communicate with each other.

The literatures on technology, classification, and dual-use help us to understand the case studies that we will be examining at in this thesis, but there is also the context in which those case studies exist. For a background on this, we turned to the literature on regimes, institutions, and transnational science and technology issues. While much of this literature provides some perspective on the political and structural frameworks that are constructed by and constrain international efforts to harmonise export controls, they lack any significant analysis on the way that technologies are constructed within the debates. There is, however, a small and growing literature that does take up these points. This literature points out, for instance, that regulatory mechanisms for controlling access to militarily significant technologies are fundamentally unable to address the types of challenges likely to arise in response to developments in biotechnology, nanotechnology, and the devices terrorists use. Once again, this literature also addresses the point that the social and technical orders are co-constructed.

The final section of this chapter drew together the previous literatures by elaborating the theory of sociocultural viability. Based on Douglas' work on classification, the theory devises a set of solidarities that are combinations of forms of social organisation, patterns of behaviour, and cultural biases. These solidarities are continually interacting with each other as different actors—be they individuals, organisations, states. . . even texts—use them to frame their preferred stance on an issue. The theory is intimately concerned with power, and has already been applied to analyse technological decision-making.

In drawing together the literatures on science and technology studies, classification, and international regimes, this thesis contributes to all three of the ideas expressed by Javier Lezaun (2002) about how to draw together constructivist theories broadly with other theories of international relations:

- This thesis examines "how knowledge is produced and deployed in practical interaction *by the actors themselves* that constitute the international system."
- This thesis argues that an analysis of the political constitution of the Wassenaar Arrangement is inseparable from an analysis of how knowledge (particularly about the technology being debated) is legitimated and utilised.
- While this thesis is concerned primarily with the discourse on the development of the Dual-Use List, this list is also a key part of the infrastructure of international export controls. The thesis is focused on how the material list and the social discourse constitute each other.

In the next chapter, I will use these literatures to design an analytical framework for understanding (a) how technology gets defined as dual-use; (b) what the Wassenaar Arrangement is trying to do; and (c) how the Arrangement is trying to achieve its goals.

3
Analytic Framework & Methodology

Contents

This thesis is predominantly a discourse and textual analysis of the debates about the definitions of dual-use technologies within and around the Wassenaar Arrangement. In this chapter, I outline my analytic framework and methodology.

3.1 Analytic framework

The analytic framework I employ in this thesis is drawn from recent work among researchers connected with Oxford University's Institute of Science, Innovation, and Society,[1] but is also very closely connected to the framework Hajer & Laws (2006) outline in *Ordering through discourse*. The framework is comprised of three points of analysis: how the problem being analysed is 'wicked'; how 'uncomfortable knowledge' arises and is addressed; and how different institutional structures allow and constrain different solutions to the problem. I treat the framework as an ordering device, structuring "the conceptual tools that analysts use to capture how policy actors deal with ambiguity and allocate particular significance to specific social or physical events" (Hajer & Laws, 2006, p. 252).

We begin with some definitional issues. These are working definitions that I employ in this thesis. Each of these terms has an entire body of literature discussing its meaning, but for the purposes of this thesis, I use them as described below. The topic of my analysis is the *discursive space* within which different framings of the problem of dual-use technology interact. The unit of analysis for this thesis is the *solidarity*, defined within the literature on the theory of sociocultural viability as a particular combination of a form of organisation, a pattern of behaviour, and an accompanying rhetorical framework of accountability and justification for actions. Taking the solidarity as my unit of analysis means that I view the discourse on dual-use technology as being a debate between different solidarities. The theory of sociocultural viability asserts that at there are at least three different solidarities—hierarchical, competitive, and egalitarian—which we reviewed in Section 2.4. We can identify solidarities by analysing the types of organisation and forms of rhetoric that actors use within the discourse on dual-use technology. An *actor* can be an individual, a company, a state... anything that embodies mix of solidarities. Actors likely hold a

[1]Formerly the James Martin Institute for Science and Civilization.

combination of different solidarities, with the strength of each solidarity varying in different institutional contexts (each of which will itself be a particular mix of solidarities) and interactions with other actors within that context.

Each solidarity has a different *framing* of the problem of dual-use technology. The framing involves the definition of the problem and its solution, along with the form of organisation, and the set of preferences of the solidarity. Solidarities can be applied to multiple issues, whereas framings are particular to a particular issue.

Within a debate there is often a *hegemonic framing* of the problem, a term I derive from the literature on hegemonic myths in Section 2.4. This hegemonic framing has institutionalised its form of organisation more than the others. In order for other solidarities to get into the discourse, they must 'steal' the rhetoric and patterns of behaviour of the hegemonic framing (Thompson et al., 1990, p. 263–265), but they do so in order to undermine the form of organisation of that framing.

My starting assumptions in this analysis are that the process of modifying the Wassenaar Arrangement Dual-Use List is often, if not always, a matter of contention and ambiguity. The framing that people choose within the Arrangement is shaped by the institutional context *and* by the solidarity they are trying to strengthen or undermine. Given these assumptions, *the question I am interested in is how people who hold different, and often contradictory, framings of the issue at hand are able to continue making policy to which all can agree.*

In this section, I outline each aspect of my analytic framework—wicked problems, uncomfortable knowledge, and alternative solutions—and develop the focused questions that I answer through my analysis.

Wicked problems

Wicked problems were first defined by Horst Rittel and Melvin Webber (1973), who addressed the need to disassociate planning problems in the field of operations research from natural scientific problems.[2] At the time, most policy research was conducted on the assumption that there were generalisable principles that could be discovered to solve social problems that were discrete and fully definable. Social science problems, in other words, could be treated as natural scientific problems and solved as such. The policy problems, according to Rittel & Webber, were considered to be 'tame'. They argue instead that such problems are not amenable to definitive definitions and solutions, and should be considered 'wicked'.[3] For a recent review of the concept, see Conklin et al. (2007, 2008).

Rittle & Webber provide ten characteristics of wicked problems which prevent them from being solved through a systematic and generalised method; Steve Rayner (2006) has collapsed these into six. In short, wicked problems:

- have multiple definitions, and each definition contains its own preferred solution;
- are persistent and insoluble;
- contain contradictory certitudes;
- are often symptoms of another (wicked) problem;
- tend to have redistributive implications for entrenched interests;
- have little room for trial and error learning.

The definition of a wicked problem depends on an actor's preference for solving the problem. If an actor frames the problem of dual-use technology, for instance, as a problem of control, then the solution is a matter of determining the appropriate level of control. If, however, an actor frames the problem as one

[2]For an analysis of the development of the term 'wicked problem' see Logue (forthcoming).

[3]Their distinction between natural and social problems has since been argued to be spurious (see Section 2.1), but their point still holds. The outcome is not that social problems are once more seen as natural ones, but rather that problems in natural science are now seen as having a significant social science component.

of competition, the solution will involve strategies for remaining competitive. Alternative framings of the problem will often involve contradictions in the solutions they propose. Remaining a competitive military power, for instance, may rely on exporting dual-use technology to provide a big enough market for continued research and development. This solution may be seen as being in direct contradiction to the need to control the spread of dual-use technology.

Wicked problems are often symptoms of other wicked problems. While one actor may define a wicked problem in narrow terms—say, constructing an adequate licensing process for dual-use technologies—others will likely define it in broader terms, such as balancing national security with economic competitiveness, or the need for open access to technology. Rittel & Webber (1973) use this point to draw out the constructed nature of wicked problems. "The level at which a problem is settled depends upon the self-confidence of the analyst and cannot be decided on logical grounds[. . .] it is not surprising that the members of an organization tend to see the problems on a level below their own level" (p. 165).

Wicked problems are always (de)constructed within an institutional framework that is some mix of solidarities. Since wicked problems are persistent and insoluble, at some point the balance of solidarities within the institutional framework will likely shift as one framing of the problem receives more legitimisation. As a result, other framings will weaken, causing a redistribution of power among the entrenched interests that those framings have institutionalised.

There is little room for trial and error learning in wicked problems. They are one-shot issues, where each attempt at a solution shifts the problem into a new context. Wicked problems, then, are continually being re-problematised.

There are two important points about wicked problems which are useful in this thesis but have not yet been drawn out in the literature. First is the distinction between simple and complex wicked problems, and second is the elaboration on how each definition of a wicked problem entails its own set of relevant knowledge. I now address each of these points in turn.

Simple versus complex wicked problems

Developing the point that wicked problems are constructed, rather than having an *a priori* existence, we should be able to speak, at least in general terms, of the degree of wickedness that an actor prescribes to a problem. Problems are not wicked, or indeed 'problems' at all, until an actor defines and enacts them as such. One can imagine, for instance, using Kuhn's (1964) concept of paradigms, that an actor—be it a scientist, a research institution, or even a theory—will first attempt to address a problem as if it neatly fits within the actor's current paradigm, and is thus susceptible to the established methods of its area of practice. The actor will consider the decision stakes and any uncertainties within the problem as being manageable; a state of 'normal science', according to Funtowicz & Ravetz (1992). The problem, then, is constructed as 'tame', since there is a single framing.

As an example, Verweij (2006) shows how the conceptualisation of climate change in the Kyoto Protocol on the United Nations Framework Convention on Climate Change is very much based on the hierarchical model of the ozone regime, especially the Montreal Protocol on Substances That Deplete the Ozone Layer. The Montreal Protocol occurred shortly before the issue of climate change became prevalent, and the policymakers at the time thought that this model would also work for what seemed to be the similar issue of climate change.

Should this framing come to be seen as inadequate—by the original framer or others—an alternative framing of the problem is always present. Judging between framings is not a matter of comparing like with like, of making a rational decision based on a logical analysis of comparative costs and benefits. Rather, it is a choice between competing sets of values, where the decision on which framing to use is based on the form of social organisation an actor wishes to strengthen and the institutional framework within which the actor sits.

To continue the example of climate change, Thompson & Rayner (1998), and later Rayner (2006), show how the debate mirrors an underlying debate between different solidarities. In a hierarchical framing, the problem is seen as a problem of planning. "What we need to be doing is building an international regime for the governance of the global commons, and both the commons and the global economy require monitoring and managing within limits" (Rayner, 2006, p. 8). In an egalitarian framing, however, the problem is seen as one of profligacy, of humanity's embrace of consumerism which has led to over-consumption. Both framings, however, are not on the issue of planning or profligacy itself, but on the mutual issue of climate change.

To the extent that these different framings interact, the actors that previously believed their problems to be unrelated, now see that resolving one problem must in some way entail resolving the other problem as well. *These two problems are therefore shifted into being different framings of a common, wicked problem.* At the heart of every wicked problem is the construction of an 'essentially contested concept' Gallie (1955). I am aware of the apparent contradiction in saying that an *essentially* contested concept is *constructed*. I take the position, though, that all language—and thus all concepts—are constructed. Gallie provides five 'conditions of essential contestedness' (1955, p. 171–172), of which the fifth is the most important here:

> each party recognizes the fact that its own use of [the concept] is contested by those of other parties, and that each party must have at least some appreciation of the different criteria in the light of which the other parties claim to be applying the concept in question.

According to this criterion, a concept can become and cease to be essentially contested according to the degree to which people who hold different framings of the concept are able to acknowledge the alternative framings. Essential contestation is a theme taken up in many areas of social science, including security studies (Buzan, 1983; Smith, 2005), political science more generally (Lukes, 1974), and in cultural studies (Verweij et al., 2006*b*).

The climate change problem that I have so far described is wicked, but only wicked in a simple way. With only two framings, discussion revolves around there being a 'balance' between profligacy and planning. We can easily fall into the trap of thinking that deciding on a resolution to the problem is a zero-sum game, where more emphasis on one framing means less emphasis on the other.

A *complex* wicked problem in contrast, is one that is recognised as having at least three valid framings. In such a situation, negotiating in favour of one of the framings is not necessarily taking a stand against one of the others. Rather than discussions being along a continuum between two poles, they now occur within a two-dimensional solution space. Perhaps the easiest way to think of the value of a third framing is that there are always two sides to a story (provided by two of the framings), but there is also always another story to tell—the third framing. A third framing always undercuts the assumption of the dichotomy to which the other two framings adhere. This can be seen if we return to Figure 2.4 (p. 65), which overlaid several social science theories on the typology of sociocultural viability. The hierarchical and competitive solidarities, for instance, are at opposite ends of Williamson's (1975) dichotomy between hierarchies and markets, and are divided by dichotomies between status or contract (Maine, 1861) and personal versus positional authority (Bernstein, 1971), but they share a commitment to specialised roles (Bennett & Dahlberg, 1990) and organic solidarity (Durkheim, 1893), neither of which are shared by the egalitarian solidarity. The hierarchical and egalitarian solidarities are also divided by the dichotomy of positional versus personal authority, but are thrown into contrast when debating specialised versus mechanical roles. The place where these two solidarities come to agreement—e.g. favouring status over contracts—is precisely what the competitive solidarity opposes. By recognising a third framing of a wicked problem, the actor doing the framing (a business, government department, academic. . .) is able to see that the assumption upon which any dichotomy rests is undercut by the third framing.

Multiple definitions and relevant knowledge

Each framing of a wicked problem comes with an understanding of what knowledge is relevant and irrelevant. In reviewing the literature on Science & Technology Studies in Chapter 2 we saw that there has been significant research on the social construction of knowledge and technology. The process by which a finding becomes a fact, or technology takes its final form, is not set, but is a matter of existing technical, environmental, and social structures, as well as personal preference. Technology is not in the driving seat, taking society down a deterministic path of development; nor can technology be anything we imagine. Our context shapes how we generate knowledge and how we develop technology by helping us decide what are the *relevant* things to focus on. Each of the solidarities outlined in the theory of sociocultural viability has a different type of knowledge that is relevant to (that solidarity's framing of) the issue at hand.

One characteristic of a sociocultural viability analysis is that we begin with a set of probable framings we are likely to find in any debate, which we reviewed in Section 2.4. Each actor, in the process of trying to solve its framing of the wicked problem, engages in acts of organising: determining the appropriate relations between people; constructing institutions for embedding their approach to the problem; identifying the characteristics of technology that most suit their preferred solution; and even pointing out the elements of the environment (natural as well as man-made) that support its view. These are all acts of classifying—of structuring the world to a set of preferences—and by engaging in one, an actor is supporting the legitimacy of the others. Moreover, each of these processes delimit what constitutes relevant knowledge for the actor.

Thus, if an actor emphasises hierarchical relations between people, it will tend to define the wicked problem as one of control and will work to institutionalise hierarchical relations through rules and procedures. Similarly, it will focus on creating knowledge about the controllable aspects of technology, and will justify its preferences by pointing out that natural and social systems have bounds of tolerance to disturbance and must therefore be kept within those bounds. In contrast, if an actor promotes competitive instead of collective action, it will define the problem as one of competition and will create and support institutions to that end. Knowledge about technology within the competitive framing favours showing how one technology is 'better' than another. The actor will defend its preferences with reference to a world in which it is better to be the hunter than the prey. Both of these actors are contrasted with the one that promotes social relations that are communal. This actor views the problem as one of open access, and institutions should seek to become more open by being transparent and non-discriminatory. The important knowledge about technology is the knowledge about how it promotes the communality, not how it drives wedges in society and disassociates people into 'haves' and 'have-nots'. The social and natural orders that are important for this actor are ones that promote views of humans as similar and their environments as interconnected.

The first two of the four main questions addressed in this thesis build on the concept of a wicked problem:

1) How do different actors involved in the Wassenaar Arrangement define dual-use technology?

2) How do those different definitions of dual-use technology relate to different framings of the problem? I.e. How wicked is the problem from the participants' perspective?

To answer the first question requires an investigation into the different sets of knowledge that different actors perceive as relevant to their framing of the problem. Some, for instance, may focus on the technology's marketability or foreign availability while others focus on its ability to subvert current military technology.

By defining what knowledge is relevant in solving its framing of the wicked problem, each actor also defines what is *irrelevant*. Deciding what *not* to know is often as important as deciding what to know. When strengthening the hierarchical framing, knowledge that does not aid in institutionalising a hierarchical form of organisation is deemed irrelevant. This is very important when we look at the strategies that other framings can use against the hierarchical framing.

Comfortable & uncomfortable knowledge

The second part of my analytical framework develops the concept of uncomfortable knowledge to draw out how the different framings of the problem of dual-use technology interact with each other in the definitional process.[4]

How is space created in a discourse for alternative framings? This is the question that I am trying to solve by employing the concept of uncomfortable knowledge.

Knowledge that is relevant within one framing can support that framing's form of organisation, or it can undermine the form of organisation, or be ambiguous as to whether it supports or undermines. I define the relevant knowledge that supports a framing's form of organisation as that framing's *comfortable knowledge*. For a hierarchical framing, comfortable knowledge is knowledge both about which things are, and are not, manageable, and how to manage the things that are. It is not sufficient for an actor expressing this framing to know that something *should* be managed (that is only *relevant* knowledge); the knowledge will only become comfortable when the actor is satisfied that a thing that should be managed *is* managed.

[4]While the formulation of uncomfortable knowledge I present here is my own, Steve Rayner is also working on another formulation grounded in anthropology. We share the basic point, however, which is that uncomfortable knowledge undermines the capacity of an organisation to act. I credit Rayner with first thinking of the concept, and am grateful to him for allowing me to publish my formulation of it here.

To continue with the climate change example, knowledge that carbon dioxide contributes to climate change and is manageable is relevant knowledge for the hierarchical framing, but it is not comfortable. It becomes comfortable as the actor—in this case we could consider the actor to be a government department tasked with implementing the Kyoto Protocol—becomes convinced that carbon dioxide is actually being managed.

The knowledge that undermines the framing's form of organisation is its *uncomfortable knowledge*. Uncomfortable knowledge is a threat to the legitimacy of the framing of the wicked problem, because the framing is not seen as adequate when measured by the framing's own metrics. Within the issue of climate change, uncomfortable knowledge for the hierarchical framing would be knowledge that carbon dioxide, while a key greenhouse gas emission, is not actually manageable. This in turn calls into question the assumption that the problem of climate change itself is actually manageable.

In addition to there being comfortable and uncomfortable knowledge for a particular framing of an issue, there is much knowledge that is ambiguous. There is often a process of forming what is an ambiguous piece of information into comfortable or uncomfortable knowledge. I call this ambiguous information an *anomaly*, taking on the meaning implied by (Bowker & Star, 1999, p. 311):

> Anomalies… come when some person or object from outside the world at hand interrupts the flow of expectations… [A]nomalies arise when multiple communities of practice come together, and useful technologies cannot be designed in all communities at once. Monsters arise when the legitimacy of that multiplicity is denied. Our residual categories in that case become clogged and bloated.

Anomalies arise in several ways:

- what was seen by an actor within one framing as irrelevant is now seen as relevant and has the potential to become either comfortable or uncomfortable for that framing;

- what an actor saw as relevant (either comfortable or uncomfortable) may now be irrelevant;
- or it could be an actor's first encounter with a piece of knowledge, in which case the actor may decide whether the knowledge is irrelevant or, if relevant, comfortable or uncomfortable.

In each of these cases, an anomaly can come about through an actor's interaction with the institutional context or because of arguments presented by other actors expressing different framings of the issue. Each of the actors tries to prevent anomalies becoming uncomfortable knowledge for its own framing, as the anomaly would undermine the underlying form of organisation on which the framing is based. One framing's uncomfortable knowledge, however, may be another framing's comfortable knowledge.

In this thesis we are primarily focusing on the interaction between the hierarchical framing (which is the hegemonic framing in Wassenaar) and the others, so it is useful here to lay out the role of the others as challengers to the hierarchical framing, and the available responses that actors expressing the hierarchical framing can use.

Anomaly-handling strategies

Each solidarity has its own preferred way of handling anomalies, whether they be social, natural, or even mathematical, as David Bloor (1978) points out in great detail when he relates the grid/group typology—the forerunner to the theory of sociocultural viability—to the work of Lakatos on the controversy over Euler's theorem about polyhedra, which I described above on page 32. Within an institutional context that is low-grid (low level of differentiation in the classification system, e.g. bi-polar) and high-group (high sense of collective identity, i.e. the egalitarian framing), the preference is for an immediate collective taboo on anomalies. Within a particular issue where anomalies arise, an actor that in other respects appears to be supporting an egalitarian framing, but does not immediately taboo an anomaly, is seen by other actors within this framing as not supporting the collective and is likely to be ostracised. Bloor relates this to Lakatos' idea of '*monster-barring*', where objects that did not fit Euler's theorem were emphatically refuted as not being polyhedra. Bloor imagines (p. 253–4) how this approach to anomalies could have been mirrored in the social institutions of the mathematicians:

> Imagine a closed group of practitioners with a leadership whose authority derives, say, from the discovery of a theorem. A counterexample becomes the basis for a revolution. Rivals can use it as a justification for a take-over. Attitudes towards the counterexample will have to polarize.

This anomaly-handling strategy is contrasted by Bloor with ones that would exist within an institutional context that is high-grid (lots of internal categories in the classification) and high-group, i.e the hierarchical framing. An actor within this context tends to be focused on the complex internal system of classification, rather than worried about the external boundaries. Responses to anomalies within a hierarchical framing can take two forms, according to Bloor. First, the anomaly can be accommodated within the system through a process of '*monster-adjustment*', where a category will be enlarged to hold it. Second, an anomaly can be be seen by actors supporting this framing as an exception to the classification, where caveats are then put in place to show the boundaries of applicability of the system ('*exception-barring*'). Exception-barring is a statement that the classification system has a narrower field of remit than previously thought. When looking at problems of mathematics, as Bloor did, this means that theorems have acknowledged exceptions. "All that a counter-example does is to restrict the scope of the theorem: its truth is untouched but the span of its authority, as it were, is narrower than had been thought" (Bloor, 1978, p. 255). An item is included in or excluded from a classification system, thereby removing the anomaly's status as anomalous.

Monster-adjustment can therefore be a process of creating comfortable knowledge, and exception-barring of turning comfortable knowledge into irrelevant knowledge, i.e. what used to be an object of control or a control practice is now seen as out-dated or in some way no longer necessary.

The third anomaly-handling strategy that Bloor points out is Lakatos' own one—a *dialectical method of proofs and refutations*—where the anomaly's status as being anomalous is embraced. This occurs in the low-grid, low-group (low sense of collective identity) institutional context, representing the competitive framing of the issue. Here, if a classification system does not work, it is discarded, because there is little collective attachment to it. Moreover, new classification systems only come about if an actor is able to question radically the basis of classification. This is an individualistic and competitive form of social organisation.

The fourth anomaly-handling strategy is touched on only briefly by Bloor, who says that it is a *primitive form of exception-barring.* This makes sense if we say that actors expressing this framing are in an institutional context with a complex classification system of which they do not feel part (high-grid but low-group).

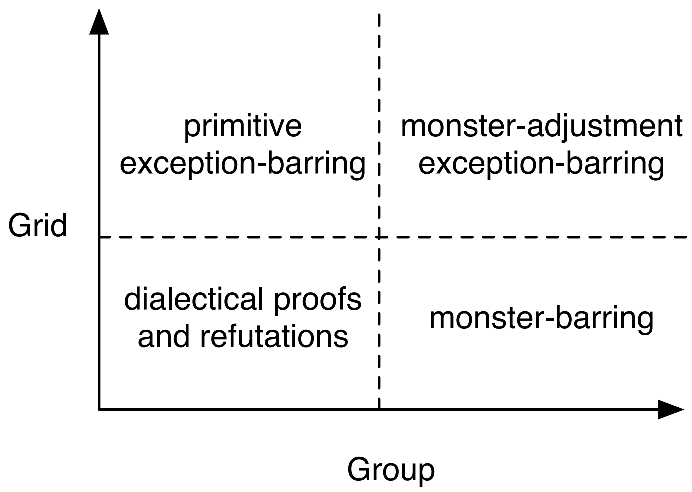


Figure 3.1: *Anomaly-handling strategies*

This description of anomaly-handling strategies leaves little room for constructive dispute between them. Lakatos points out each of the strategies, and Bloor connects them with the solidarities of the theory of sociocultural viability, but neither author considers in much depth how disputes between alternative anomaly-handling strategies—and therefore alternative solidarities—might actually evolve. Lakatos simply makes the argument that the strategy of proofs and refutations is better than the others. Bloor only shows how rhetoric and social structure are related.

Both authors demonstrate how each strategy fails from the perspective of actors that are employing other strategies, and therefore other framings of the issue. For example, they show how exception-barring (a strategy employed in the hierarchical framing) is unacceptable from the perspective of the competitive framing, which favours proofs and refutations. While Lakatos goes on to argue that the dialectical method of proofs and refutations—the preferred anomaly-handling strategy of the competitive framing, according to Bloor—does not suffer from any of the failings of the other strategies, he does not question how it may fail on its own terms.

A much more potent argument would be to show how exception-barring is, in practice, unachievable. That is, it may fail *on its own terms*. Once this is shown, it opens the discussion for alternative solutions.

Bloor focuses on how rhetoric is tied to institutional context. Changes in rhetoric about polyhedra, Bloor argues, should be accompanied by a similar change in institutional context. He points out (Bloor, 1978, p. 258) that each of the discussions around Euler's theorem was not just about mathematics:

> Take the pupils in Lakatos's classroom: what they are doing is rehearsing styles of life, and patterns of social interaction, as well as moves in the game of mathematics. But in doing this they are not doing two different things, nor are they doing sometimes the one and sometimes the other; [...] in doing the one they are doing the other.

Bloor (1978, p. 266) posits that Lakatos' desire to see the triumph of the competitive solidarity as the end-game in mathematics should be tempered:

> We should not expect that the emergence of a dialectical method in mathematics is a once-and-for-all phenomenon—a sort of methodological 'big bang'. We may expect it to have faded away in some circumstances after Lakatos's crucial year of 1847, and also to have been present well before that date. Earlier cycles through competitive social forms should also reveal mathematicians thinking dialectically.

Bloor hints that the theory of sociocultural viability might be able to help show how anomalies are related to shifts in the social structure. "For instance, it should help to show when and why an anomaly is turned into a crisis-provoking anomaly in Kuhn's sense, or why in Lakatos's terms a research programme can be said to be degenerating" (p. 266). This is not Bloor's main argument, but it touches on a valuable aspect of the theory of sociocultural viability—it is a theory of the dynamics of social relations. Like Bloor, I am interested in how social relations are tied to rhetorical style, but unlike Bloor, I see myself as engaged in an analysis of a continual battle between alternative solidarities, i.e. a wicked problem. This perspective requires that I look at the ways that actors expressing each of the framings of an issue can question the legitimacy of the other framings and thereby institutionalise their own preferred form of organisation and rhetorical style. The analytic tool that allows me to do so, I argue, is the notion of 'uncomfortable knowledge'.

Uncomfortable knowledge is generated when an anomaly-handling strategy of a particular framing of an issue fails by the metrics of that same framing. It is closely related, as Bloor points out above, to Kuhn's (1964) 'crisis-provoking anomalies', which take on many forms, of which Kuhn notes two that are significant here (p. 82):

> Sometimes an anomaly will clearly call into question explicit and fundamental generalizations of the paradigm... Or... an anomaly without apparent fundamental import may evoke crisis if the applications that it inhibits have a particular practical importance...

Kuhn is focused on the shift between 'paradigms', which are "particular coherent traditions of scientific research" (p. 10). These shifts occur through the development of crisis-provoking anomalies and the emergence of alternative paradigm candidates. This suggests a linear, if multiple-stream, advance of paradigms in natural science theory-making. Kuhn, however, explicitly draws a link between theory-making in the natural sciences and changes in political institutions in deciding to use the term 'revolution' to describe the shift of paradigms. He argues that there are two main parallels between political and scientific revolutions:

- "Political revolutions are inaugurated by a growing sense, often restricted to a segment of the political community, that existing institutions have ceased adequately to meet the problems posed by an environment they have in part created. In much the same way, scientific revolutions are inaugurated by a growing sense, again often restricted to a narrow subdivision of the scientific community, that an existing paradigm has ceased to function adequately in the exploration of an aspect of nature to which the paradigm itself had previously led the way" (p. 92).

- "Like the choice between competing political institutions, that between paradigms proves to be a choice between incompatible modes of community life" (p. 94).

Kuhn sees choosing between paradigms, then, as the same as choosing between incompatible modes of community life, or what the theory of sociocultural viability calls solidarities.

Revolutions, Kuhn argues, happen relatively infrequently in the natural sciences. In between these revolutions, there are long periods of 'normal science'. While this may or may not be the case for theoretical traditions in the natural sciences, revolutions in most other parts of society are a constant process. With all wicked problems, for instance, there is a constant calling into question of the assumptions upon which a particular framing of the problem is based.

Crisis-provoking anomalies, then, are ones that question the 'fundamental generalisations' of a particular solidarity. They are anomalies that are not able to be adequately resolved by employing the anomaly-handling strategy of an actor's preferred framing. This creates uncomfortable knowledge, undermining that framing's legitimacy and providing space for an alternative framing to gain strength.

The third question addressed by this thesis is derived from the concept of uncomfortable knowledge and the typology of anomaly-handling strategies:

3) How successfully are the actors expressing the hierarchical framing able to avoid the generation of uncomfortable knowledge—by adequately resolving anomalies—in the Wassenaar Arrangement debates about modifying the Dual-Use List?

This question brings out the interaction between multiple framings. The more contention there is in the Dual-Use List modification process, the more likely multiple anomaly-handling strategies will be employed.

Uncomfortable knowledge, then, is the tool through which alternative framings are able to be incorporated into a discourse. The more uncomfortable knowledge there is for one framing, the more likely people espousing the framing are to accept alternative framings. But how are multiple framings able to co-exist within a single discourse?

Alternative solutions

4) How is it that two or three framings of the wicked problem of dual-use technology are able to co-exist with each other over extended periods of time?

This is the final question addressed in this thesis. It allows me to move between analysing framings and analysing the institutional context in which the framings take place. To do so, I draw together the literature on the institutional aspects of technology, classification systems, and international relations using two concepts: 'incompletely theorised agreements' and 'clumsy solutions'. Each of these are outlined below.

Incompletely theorised agreements

Cass Sunstein developed the concept of an 'incompletely theorised agreement' in his book *Legal reasoning and political conflict* (1996). Incompletely theorised agreements are disassociated from completely theorised agreements, where there is acceptance by an actor on "both a general theory and a series of steps connecting that theory to concrete conclusions" (p. 35). Completely theorised agreements, Sunstein argues, are rare. Incompletely theorised agreements, in contrast, are very common, and take three general forms.

The first form of an incompletely theorised agreement is *on a general principle*, where "people who accept the principle need not agree on what it entails in particular cases" (p. 35). Thus, people may agree on principles such as 'murder is wrong', 'racial equality', or in our case, 'dual-use technology should be controlled', without agreeing on what that means in particular cases. The second form is where agreement is reached on a mid-level principle, but disagreements remain on both general theory and particular cases. The third form is an agreement on particular outcomes and the low-level principles that accompany them, with disagreements remaining about higher-level principles. Sunstein is quick to point out that the levels on which agreement is or is not reached are ambiguous and relative. His point, though, is that there does not have to be agreement on all three levels in order for a social system to function. Agreements are reached where and when it is possible. Sometimes this involves consciously avoiding topics that are contentious, sometimes it involves transforming the topic into one that is more likely to reach agreement.

In this thesis, I use the concept of an incompletely theorised agreement to draw draw out how the ambiguities in technology are selectively resolved (Rappert, 2001) and how classification systems may contain purposeful areas of ambiguity in order to function among different communities of practice (Bowker & Star, 1999).

Clumsy solutions

A 'clumsy solution' is a term used in the sociocultural viability literature to describe a solution where each of the active solidarities are voiced and responded to by all the others (Verweij et al., 2006*a*).[5] Clumsy solutions have two key features. The first is that the policy system on a particular issue must be accessible to each of the primary solidarities that the theory articulates: hierarchical, competitive, egalitarian, and fatalistic. Each of these solidarities has a plausible way of framing the issue, defining the problem, and suggesting a solution. But each of these ways is in counter-distinction to the others. Thus, "conflict in policy making processes is endemic, inevitable and desirable, rather than pathological, curable or deviant" (Verweij et al., 2006*a*, p. 18). The more solidarities that are included in the generation of a (re)solution to a problem, the more likely that solution will be able to adjust to the inevitable changes in the future environment in which it will sit.

The second key feature of clumsy solutions is that they depend on constructive deliberation between alternative framings. When the quality of deliberation is low, it is likely that positions will become or remain polarised, creating a deadlock where no agreement is possible. A viable solution space opens up only when "the 'rules of the game' permit or even force policy actor to take seriously different types of stories... [allowing] what Sabatier & Jenkins-Smith (1993) call 'policy-oriented learning' [to] take place" (Verweij et al., 2006*a*, p. 18). Clumsy solutions must emerge from the deliberative process; they cannot be formulated ahead of time in their complete form.

A clumsy solution is but one form of a long-term viable institutional framework. Perri 6 (2007) distinguishes three other 'forms of settlement' between

[5]The term has its origin in the work of Michael Shapiro (1987-1988), who talks about clumsy institutions for the selection of judges in the US.

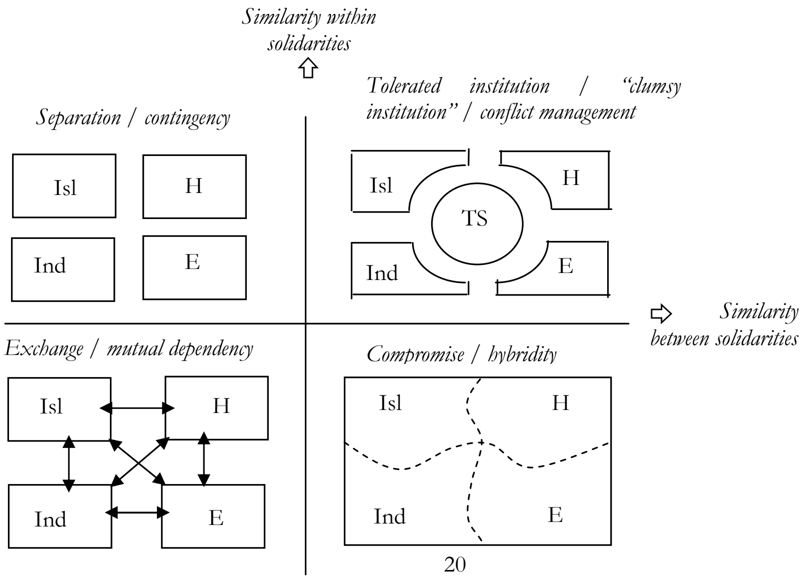


Figure 3.2: *Viable forms of settlement between solidarities (6, 2007)*

each of the solidarities within the theory of sociocultural viability, shown in Figure 3.2. His settlements are defined by two characteristics: whether they strengthen each solidarity's own identity and whether they strengthen the shared identities between them. Clumsy solutions create an institutional framework that both maintains each solidarity's identity and creates a shared space for each solidarity to interact. When there is a blurring of the differences both within and between solidarities, a settlement that emphasises exchange and mutual dependency will emerge. Where the solidarities are each very well articulated but there is little work done to draw them together, they will remain separate. Finally, where there is much emphasis on drawing the solidarities together and little drive to create cohesion within a single solidarity, we will find a settlement of compromise and a hybrid institutional structure.

I use the concept of a clumsy solution, and 6's work on settlements more generally, to analyse how the two framings of the problem of dual-use technology that have long dominated the debate might be able to incorporate a new framing that has been taken up by academics affected by export controls on intangible dual-use technology.

Now that I have outlined my analytic framework, I turn to a discussion on the methods I employed to gather my data and conduct my analysis.

3.2 Methodology

The purpose of this methodology section is to document the rationale behind my research design and data analysis (Silverman, 2005). The initial design and topic selection was a very extended effort, taking over a year and a half, and found me enmeshed in four very different research communities: as a DPhil student within the James Martin Institute for Science and Civilization at the Saïd Business School; as a visiting scholar with the Harvard Sussex Programme within SPRU at the University of Sussex; as a Young Summer Scholar at the International Institute of Applied Systems Analysis (IIASA) outside Vienna; and as a visiting researcher at Georgetown University's Center for Peace and Security Studies, part of the Edmund Walsh School of Foreign Service.

Initial candidate topics for my thesis were extremely varied, ranging from an analysis of the collapse of North Sea fisheries to terrorist threats to nuclear waste disposal sites to different understandings of biological dual-use technology. I first came onto the topic of dual-use technology through several research projects (Rappert & McLeish, 2007) connected with Britain's ESRC Science in Society programme, which was directed by my supervisor, Steve Rayner. Many of these projects were connected with the Harvard Sussex Programme at SPRU within the University of Sussex, and I made several visits there, including a week-long stay, to troll through their extensive archives on (mainly biological and chemical) dual-use technology reports and news items.

The concept of dual-use technology had immediate interest to me as it touched on my background in physics and my desire to analyse how security is a relative construction. My initial literature searches were heavily focused on security studies and policy analysis. Within security studies, I focused on work that tried to displace the nation-state as the dominant unit of analysis and traditional military concerns as the dominant topic (so-called "critical security studies") (Barnett, 2001; Booth, 2005; Krause & Williams, 1997; Wyn Jones, 1999). This work widened the concept of security to cover, for instance, the environment, economy, energy, and food. I found it difficult then to connect this work to my interest in dual-use technology. In the end, as can be seen from my literature review, this body of knowledge has had little direct impact on my eventual research design. This is neither to say that one could not nor should not conduct an analysis of the Wassenaar Arrangement from within a critical security studies paradigm. One could, for instance, use these theories to draw out further the tensions between economic, political, and humanitarian concepts of security and how they shape the institutions of multilateral export control arrangements. The theories are not an acceptable tool, however, to draw out how technological and social relations are co-constructed.

During my summer (2005) at IIASA, I shifted my focus to different approaches to policy analysis. This shift was spurred on by my interest in the then-emerging concept of 'clumsiness', of which my supervisor has been a primary architect. My intention in conducting this literature review was primarily theoretical. I wanted to situate work on clumsiness within a broader literature than just the theory of sociocultural viability, not realising that Steven Ney (2006) was doing the exact same thing but with a few years' head start.

As I continued to search for a defined topic, my motivations were:

- a desire to study an international security issue involving multiple understandings of the role of technology and what technology is important to control.
- to work on something about which I already had some empirical knowledge (ruling out chemical or biological dual-use technology)
- a desire not to focus on nuclear technology, as it has a mainly linear path of development from non-military to military use.

These motivations led me, through extensive web-searching, onto the Wassenaar Arrangement website.[6] It was not until a month after I left IIASA that I discovered the Wassenaar Arrangement Secretariat was in the heart of Vienna, a short bus ride from the Institute.

Document access & developing research relationships

Having decided on the Arrangement as my site of analysis, I then had to figure out how to develop my research relationship with the people connected to the Arrangement, and get access to document sources. The Arrangement's website provided the initial document access, with the current lists of controlled technology and documents on its founding and major political agreements so far reached. These documents, however, contained little information on the *way* that decisions were reached, such as dissenting opinions, concessions made, and alternative framings. The latest major change was in January 2006, when the entire site was redone, moving from a purely basic HTML environment to XHTML and CSS.[7] Since then documents of a variety of types have been appearing on its pages, such as their own analysis of the Arrangement (Auer, 2005).

Textual analysis is central to this thesis. My argument rests on understanding the variety of factors that shaped the documents that the Wassenaar Arrangement produces, and in particular its List of Dual-Use Goods and Technologies. There is a wide range of documents that provide background information, such as research articles, press articles, public government reports, and the publicly available documents on the Arrangement's website. There are other documents that have been extremely helpful in this research which are not publicly available. These documents include the proposals that Participating States have made to modify Wassenaar documents and the *Guidelines for the*

[6] http://www.wassenaar.org

[7] This change can be seen by viewing the website through the Internet Archive's WayBackMachine: http://web.archive.org/web/*/http://www.wassenaar.org

Drafting of Lists. Of these I have been allowed to make both versions of the latter fully public and they can be found in Appendix G. The proposal documents are often sensitive in nature, particularly if they concern ongoing negotiations. Regarding the reasons for this sensitivity, one government official[8] remarked:

> In fact they are, obviously, confidential to the Arrangement. That's very much the idea. If you were to make these broadly available, first thing is information would dry up. States are not going to volunteer information that might be based on intelligence, if it's going to become publicly available. It's very much one of the understandings within the Arrangement; you respect the confidentiality. That's where you get the general benefit from. We very much try to encourage that general level of information exchange where we can.

This confidentiality is explicitly enforced through Article IX of the *Initial Elements*, the founding document of the Wassenaar Arrangement. As a result of this clause, I have agreed to anonymise all of my sources connected with the Arrangement. I have also agreed, when analysing the internal discussions of the Arrangement, only to identify states if I have received the information directly from that state.[9]

My access to documents connected to the Arrangement was generally heavily monitored, such as being only able to look at them for a few seconds while in the office of a government official. These short data collection instances were nevertheless very helpful in elucidating the structure of the proposals and providing some of the more nuanced parts of the debates I analysed. I was also allowed to publish an example proposal, which can be found on page 196. I view these texts as being "produced on the basis of certain ideas, theories or commonly accepted, taken-for-granted principles" (MacDonald, 2001, p. 196).

[8]Interview with British Government Officials A & B, 9 February 2006. For a full reference of all interviews conducted, see Appendix E. In agreement with my governmental interviewees, I maintain a variegated system of attribution. I never list their names, only country and unit within that country. On sensitive topics, I may further anonymise them. These are the stipulations under which I was given access to the data.

[9]For example, if I heard that The Netherlands took a certain position in a debate, unless I was able to verify that information from a Dutch member of the Wassenaar delegation, I will refer to the state as, e.g., 'Country A'.

Many of the press articles about the Arrangement contain misleading or inaccurate information, which drew out early on the need to triangulate (Denzin, 1970) as many of my primary data sources as possible.

Since access to primary documents was limited, I relied heavily on interview data with people who either had been in the negotiations I was analysing, or at least had access to the primary documents and could relay information based on the questions I asked. To find out who these people were, meet them, and define and acquire the information I needed to conduct my research involved significant effort, sometimes over the course of a few years. Their names and contact details are seldom listed in any publicly available directories, and even when I did have the details, I worked under the assumption that cold-calling should be used as a last resort (Useem, 1995).

Through a fortuitous exchange programme between the James Martin Institute[10] and Georgetown University, I was able to spend five months over the course of a year (June 2006–June 2007) as a Visiting Researcher at Georgetown's Center for Peace and Security Studies. While there I took courses on International Security and in particular became familiar with the work of Alexander Wendt (1999) on the social construction of international relations. Being within walking distance of many US government departments, as well as being a US citizen, aided my access to the US government, although initial attempts to connect with government officials through NGOs and think tanks proved wholly unfruitful. I ended up cold-calling the Department of State and was lucky to receive a warm reception.

The most important initial meeting I had, however, was completely by chance. Over the Christmas holiday in 2005–2006, I spent a few days in Washington, DC and called the University of Georgia's Center for International Trade and Security (CITS) Washington office. I discovered that the former head of one of the Wassenaar Participating States delegations had just arrived as a Research Associate. I set up a meeting and it quickly became apparent

[10]Now the Institute for Science, Innovation, and Society.

that this person could serve as a gatekeeper for my access to the Arrangement, as someone through whom I could discover other people to talk to, and who could vouch for my legitimacy to those other people (Morrill et al., 1999). It is also important to note that it was through my gatekeeper that I began really to understand the internal social structure of the Wassenaar Arrangement, which greatly aided me when deciding how to pitch my research to other members, and what areas of questioning would be best suited to each member.

Rather than speaking of 'gaining access' (Bogdan & Biklen, 1982) or 'negotiating entry' (Marshall & Rossman, 2006) to the Wassenaar Arrangement, I prefer to think of my qualitative data collection as establishing a continually evolving 'research relationship' with those I study (Maxwell, 2005). This reflexive stance emphasises the contingent nature of the data I collected, while also bringing out my role as a participant in their world of policy making. On more than one occasion, the line of questioning I pursued led to the interviewee mentioning that I provided an insight she would employ in her future work.[11] Speaking of a research relationship also brings out the more intimate nature of many of the connections I have developed with those I study. I often call members of various delegations to get a quick answer to a single question—a meeting too short to call an interview. I also have gone out for pints and dinner with several of the delegations, and at least one person jokingly considers me to be in a therapist's role.

Considering those I study to be collaborators in my research is a particularly useful approach when conducting elite interviews (Hertz & Imber, 1995; Richards, 1996). "One of the more important functions of an elite interview," Richards notes, "is to try to assist the political scientist in understanding the theoretical position/s of the interviewee; his/her perceptions, beliefs and ideolo-

[11] These insights varied from the mundane, such as adding titles to the sections of the Dual-Use List table of contents (provided during a interview with a member of the 2007 assessment year task force on standardising the Dual-Use List), to the abstract, such as providing an easy template for uncovering the different assumptions that underpin different framings in the Wassenaar debates (provided to several delegations already, mainly over dinner or pints).

gies. Such information can rarely be gleaned from examining books, documents or records" (p. 199–200). Elite interviewing usually places the one being interviewed in a position of power, as they know they have information that I want. In the early stages, this presented an obstacle because of the security concerns that Participating States had about my asking in-depth questions about negotiations within and between states. These concerns were obvious from my initial interviews with many countries, where one of the first questions asked was "who is funding you?" The fact that I was self-funded and had no ties to a particular government (other than being an American citizen), or to a think tank trying to push a certain view of export controls, alleviated much of this concern. The rest of it was alleviated by the particular approach I was taking to my data collection and analysis.

With a generally ethnographic design, I have assumed there are good reasons why the Wassenaar Arrangement works (or does not work) as it does, but these reasons were originally foreign to me. The goal of my research has not been to judge what constitutes 'right' designs or procedures for the Arrangement, nor to determine or uncover the 'real' definitions of dual-use technology. It has been, rather, to understand why the Arrangement is designed and operates the way it does, and how different conceptions of dual-use technology debate against each other and are codified in the Dual-Use List. This research design has had the double benefit of relieving security concerns and piquing the interest of most of the people with whom I have developed relationships.

How research relationships defined boundaries of analysis

I emphasise the last point because of its significance in my gaining such in-depth access to the Wassenaar Arrangement. My research differs from nearly all previous work on multilateral export control arrangements by focusing not on the few high-profile political moments in the life of the organisation I am studying, but rather on the mundane day-to-day practices of that organisation. I was not nearly as interested in the 2-day Plenary meetings as I was in the 11 months of work that went into developing the agenda for those meetings. Most of that work occurs within the Expert Group of the Arrangement, but most of the (small body of) research on Wassenaar focuses on the General Working Group, which is seen as the more political of the two bodies. The heads of delegations, who take an active role in the Plenary, do not usually take part in the Expert Group meetings leading up to it. My research was aimed primarily at the members of the Expert Group, who on the whole had more knowledge of the day-to-day operations of the Arrangement and were happy to speak with me, as they believed the Dual-Use List was where most of the action of the Arrangement took place and were happy to see someone actually studying it.

> Interviewee 1: What you are doing is *extremely interesting* to us. We will be extremely interested see what your research shows[...] In my view, the dual-use control list is the single most important thing that Wassenaar does. There are a lot of other things that are important, but it's really the foundation for everything else. Without that everything else is nice but-
>
> Interviewee 2: It's the reason for the Arrangement. If you don't have a viable list, all the political statements are worthless.[12]

While my topic and my gatekeeper opened many doors for data collection, I did not have full access to the Arrangement. I was not allowed to attend any of the meetings at the Secretariat in Vienna, though I was able to be in Vienna during several of the Expert Group meetings and met with various delegations out of working hours. It was during these Vienna trips that I was able to develop relationships with the Russian, German, Canadian, and Japanese delegations, as well as meet more of the American, Swedish, and British delegations. Many of these were more informal sessions—I cannot really call them 'interviews'—and provided valuable ethnographic data about relations between and within delegations.

I was able to meet most of the Wassenaar Secretariat as well, and while heavily constrained regarding what they could say about actual negotiations,

[12]Interview with US State Department Officials A & B, 11 September 2006.

they were able to provide valuable knowledge on the history of the organisation and the logistics of running it.

All of these factors helped draw boundaries around my analysis. Without full access to the meetings, I likely lost some of the richness of the debates and the dynamics between individuals. This was a necessary constraint, however, as access—and any publication as a result of that access—would have to have been approved by all forty Participating States; a task not well suited to the time constraints of a doctoral thesis.

However, through continually developing research relationships with several individuals, I have been able gradually to gain more knowledge of the history and intricacies of the Arrangement. Part of this is because of the development of trust between me and those I studied, but it is also due to the mutually reiterative process of defining what it is that the other person wants to know.

I am conscious, for example, that my research will likely be used to give weight to arguments that export controls are in need of reform because of some inadequacy. While I am not opposed to such use of my material, I believe that the same material can be used to show how the current system is also adequate. It depends on the form of social organisation the actor using my material wishes to institutionalise further. Expressing this adequately to those I study has been vital to their continued support of my research.

Reflexivity

Being reflexive in STS research can be crippling when it comes to writing. One is stuck trying to describe a technology while at the same time trying to impress upon the reader that the technology is fluid and constructed. It is easy either to turn to vacuous phrases, relying on the reader to perform all of the construction herself, or at the opposite end to dive into a technical/social description of the technology, hedging each sentence with an 'it could be otherwise' clause. Both of these outcomes, I feel, leave the reader frustrated.

The importance of being reflexive in social science research, however, should not be understated (Gouldner, 1970; Pels, 2000). My ability to conduct this research was directly related to my skills in communication, genuine interest in listening to those I studied, and not judging their answers until I had learned their own framework of judgement. Similarly, my ability to be fluent in English, but in no other language, both opened and closed opportunities for alternative perspectives on the Arrangement.

When deciding how deep into the technological analysis I needed to go in my research, I applied the idea of 'pragmatic reflexivity', similar to Dick Pels (2000) notion of reflexivity 'one step up'. This may seem a bit like a contradiction—that one who is reflexive questions assumptions and tries not to make them—but I contend that we all stop questioning at some point and the reason we stop is that we have other concerns. Pausing reflexive analysis often comes down to a lack of time, but our time may be constrained for myriad reasons. My logistical constraints were monetary and due to university regulations, but there were also methodological constraints. I cover a significant number of disciplinary fields in this thesis, from electromagnetics in the focal plane array case to international economics and politics to argumentation analysis, and of course the loosely coupled field of Science & Technology Studies. The purpose of being pragmatically reflexive is to state habitually what one believes to be the relevant assumptions one is making in the course of developing an argument. I have striven to do just that throughout this thesis.

It is impossible to find all of the answers to a question like "What is a dual-use technology?" because there are infinite contextual angles from which one can approach it. Rather, in this thesis I attempt to show some of the richness of those myriad angles by being reflexive enough about them to remind the reader that this is only one way that a person can address this question.

The original conundrum of technology for war or peace is articulated in the Old Testament—swords into ploughshares. But the fact is that it didn't rise with bronze or iron metallurgy. If you can lap flint, is it for a mastodon, or that tribe over there? The short answer is, it depends. 'Today it's for the mastodon, but if that sonofabitch tries to come over here and get any of my mastodon, it's for him.'

—Interview with US State Department Official A, January 19, 2007

4

The Wassenaar Arrangement & the wicked problem of dual-use technology

Contents

The problem of dual-use technology has existed since tools began to be used. This chapter serves two purposes. The first is to provide a brief history of dual-use technology, drawing out the different framings that people have employed to define and address the problem. This allows me to address both the question of how different actors understand 'dual-use technology' and how different framings have interacted throughout history, i.e. how wicked the problem has been. The second is to provide a background on the current and historical institutional structure for multilateral export control arrangements for conventional technology, which is necessary for my detailed analysis of list modifications in later chapters. This will be complemented in the next chapter by an analysis of the development of the lists of dual-use technology.

A wicked problem, as we recall from the last chapter has multiple definitions, and each definition contains its own preferred solution; is persistent and insoluble; contains contradictory certitudes; is often a symptom of another (wicked) problem; tends to have redistributive implications for entrenched interests; and has little room for trial and error. The theory of sociocultural viability predicts that there are at least three framings of the problem of dual-use technology. These 'ideal types' are often not apparent in their pure form, but we can see certain communities of practice reinforcing their preference for one of the framings by attempting to institutionalise one framing over another. In the next section, I go through each of these ideal types—hierarchical, competitive, and egalitarian—drawing out the interconnection between the preferences each framing has for: defining the problem; what is at risk; the goal to be sought; the transactional mode; the method of decision-making; and the driving values. The hierarchical framing is currently the hegemonic framing of export controls, and I explore the myth upon which this hegemonic framing is based. The competitive framing uses two rhetorics, one for speaking outside the context of export controls, and one for speaking inside, where it must conform to the hegemonic framing of the problem. The egalitarian framing is still nascent, and I elaborate on it further in Chapter 7, so here I only provide an overview of the likely characteristics such a framing would have.

After outlining each of these framings, showing how the hierarchical framing has been hegemonic throughout the international development of export controls, I provide an analysis of the institutional structure of CoCom and the Wassenaar Arrangement. It may come as little surprise to most readers that CoCom and Wassenaar are predominantly hierarchical, but what may be more striking is how the institutional framework of the Wassenaar Arrangement in particular is suited to accommodating multiple framings of the problem of dual-use technology, and as such helps to define the problem as wicked.

I start with the Arrangement's origins in the Coordinating Committee for Multilateral Export Controls (CoCom) after World War II, highlighting the structure of the CoCom control lists. I then briefly discuss the interlude between the disbanding of CoCom in 1994 and the creation of Wassenaar in 1996—the time of the New Forum. As I show in Section 4.3, this resulted in a restructured set of lists and the Initial Elements of the Arrangement. From there I explore the various facets of the Arrangement in operation—its membership, Secretariat, and internal groups—seeing how the lists play into each of them, and how the hierarchical framing is expressed throughout. Since the Arrangement is concerned with not only developing the lists, but reporting on transfers of controlled technology, I briefly outline this latter feature.

4.1 Framing the problem of dual-use technology

The control of trade in militarily significant items has occurred for thousands of years. Likewise, however, there have been international markets for these items, for both their military and non-military uses. The need for export controls has always been balanced between the economic needs for exporting items of military significance and the desire to prevent an enemy from acquiring those same items. This balance leads to two different framings of the problem of dual-use technology: as either a problem of control or a problem of the marketability of technology.

Cupitt (2000, Ch. 2) provides a very engaging account of the early development of export controls, beginning with Pericles of Athens' restriction of trade with the Megarians in 432 BC. The Megarian Decree, as this action came to be known, prevented all exports from Athens to Megara, and is significant because it represents the first such control enforced in peace-time. Cupitt points out that there was a "dearth of multilateral controls" on trade before the 18th Century because most controls were in place to maintain domestic supplies of war materials rather than to prevent foreign supplies or to project foreign policy (p. 34).[1]

In the English-speaking world, the first example of the institutionalisation of export controls was during the reign of King Charles II of Britain, who was granted power under the *Tonnage and Poundage Act* of 1660 to restrict the transfer of gunpowder, arms, and ammunition outside of the kingdom.[2] Later additions to the British controls included 'naval stores'—the substances such as tar and pitch that were not munitions themselves, but were needed to maintained the wooden sailing ships that formed the might of the British military (Atwater, 1939). The British *Exportation of Arms Act* of 1900 and its extensions at the outbreak of World War I were also clearly in this line of protecting domestic supply, extending the control of exports to cover all technology and food if the monarch so wished.[3]

[1] The latter two, the argument goes, generally require participation from multiple countries unless a monopoly on the controlled item is held by the exporting country.

[2] See 12 Charles II, cap. 4 (Great Britain, 3 Stat. at L, p.4). There were apparently earlier examples of the practice of export control: Cupitt (2000, p. 34) traces it back to Queen Elizabeth I in 1574, but I was unable to verify that account.

[3] Customs (Exportation Prohibition) Act of Aug. 28, 1914. 4 and 5 Geo. V, ch. 64 (52 Law Reports, Statutes, p. 378); and the Customs (Exportation Restriction) Act of Nov. 27, 1914, 5 and 6 George V, ch. 2 (53 Law Reports, Statutes, p. 9).

Even in these early stages of development, however, there was also recognition that the need to control trade had to be balanced with the need for markets in the things to be controlled. Moravcsik (1991) provides a very engaging account of the early stages of this relationship, and the early dominance of economic concerns over military concerns. "Military planners," he argues, recognised that a nation cannot be self-sufficient in obtaining military technology, and they "have often supported freer trade in arms, in the hope thereby of securing greater quantities of superior weaponry either through their own increased production or by purchase abroad" (p. 23). For instance, saltpetre, a crucial component of gunpowder, was a very scarce resource in the 14th & 15th Centuries and widely traded (Braudel, 2002/1981, p. 387). Tall straight pine and fir trees, the trunks of which formed the masts for most European navies, had by the 17th Century all but disappeared from these countries' forests (Bamford, 1956, p. 206–208). The British were able to exploit their American colonies, but the French and Spanish often had to rely on obtaining their masts from countries around the Baltic Sea, acquiring them at significantly increased prices (thus forming a lucrative trade for the exporting countries).

Another example of the problem of dual-use technology is the development of the British cannon industry in the 17th Century (Cipolla, 1965; Clark, 1958; Hale, 1985). British cannon were at the time considered the best in Europe, and there was therefore a large market for them abroad. Charles II, as we noted above, tried to curtail the export of this technology through the *Tonnage and Poundage Act*, but there was a catch. In order to maintain the knowledge and capacity to create these advanced cannon, the companies making them needed to sell them, but the English market only provided enough work for a few weeks of production. While the export of cannon was legally controlled, if requests for licenses were not expedient enough or were not approved, the law was largely ignored.

Using the theory of sociocultural viability, we can use the examples above to outline two framings of the problem of dual-use technology. One of the propositions of this theory is that the discourse on dual-use technology actually reflects a much deeper debate among different world-views and value systems. Each framing has a preferred definition of the problem of dual-use technology, and this definition is related to much more fundamental preferences of that framing on institutional structure, mode of transaction, conception of risk, and driving values.

Hierarchical framing: a problem of control

The framing that has dominated the problem of dual-use technology for the last hundred years sees it as a problem of *control*. This framing sees the ambiguity of a technology's militarily significance as something to be resolved. It can be resolved by systematically developing a classification of technology as either military, dual-use, or neither, and then employing a set of routines and procedures (a bureaucracy) to ensure that technology which should be controlled, is controlled. This is exactly what was done with the development of the classification of 'contraband', which we will look at in the next chapter. Contraband, it was thought, was something that could be measured, and an enforceable line was drawn defining it apart from other things.

The best way for any framing to gain power is for its preferences to be institutionalised. The preferred institutional style for the hierarchical framing, unsurprisingly, is hierarchical. The focus is on nested, bounded groups of individuals each performing their own specialised task under the direction of a common policy. Such an institutional form thrives on the creation of routines and procedures, of rules for when and how everything within the institution gets done. As long as these rules are adhered to, the status quo will be kept, and the appropriate technology will be controlled.

Export controls by their very name are about controlling the international flow of technology. The hierarchical framing has, at least since WWII, established itself as holding the 'hegemonic myth' of the problem of dual-use technology.[4] Hegemonic myths, the reader will recall from Section 2.4, "describe fundamental propositions or assumptions that are unquestionable within the context of a particular discourse" (Rayner, 1994, p. 15). This myth is based on three assumptions about export controls:

1. That it is possible to control the flow of dual-use technology;
2. That it is possible to know from whom dual-use technology should be kept;
3. And that it is possible to define what is and is not dual-use technology.

These assumptions underpin all attempts at developing export control systems, from Charles II in 1660 through to the present-day work of the Wassenaar Arrangement. Saying that the hierarchical myth is hegemonic does not mean that this framing of the problem of dual-use technology has triumphed over all the others (cf. Haas, 1990). Rather, any actor who wishes to become involved in the discourse on dual-use technology must adopt the rhetorical style of the hegemonic framing, if only then to undermine that framing by pointing out how the myth does not relate to actual events.

It is important to disassociate the legitimacy of the myths from the legitimacy of the institutions that are formed around those myths. Showing how an institutional structure of export controls is not adequate is not necessarily a direct attack on the myth that control over dual-use technology is possible. The *Declaration concerning the Laws of Naval War*, which established one of the first multilateral lists of controlled goods in 1909, served a purpose: to enable common policy on shipping goods in times of war. By the end of WWII that purpose was complete, and it fell by the wayside and a different institutional structure was put in place. The *Declaration* became a de facto embargo on the Axis powers, and when the Axis ceased to exist, the *Declaration* fell into disuse.

[4]Recall that myths, within the social science literature, are not mystical tales. Rather, they are stories that embody fundamental assumptions about everyday or scientific reality (Thompson & Rayner, 1998, p. 283).

This does not suggest that control of dual-use technology is not possible. The institution was seen as no longer adequate, but the framing was still entirely adequate, and was used as a basis for future institutional structures.

It is possible, however, for the legitimacy of the myth to be called into question as well as the institutions. As an example, take the problem of defining dual-use technology from within a hierarchical framing. It is a matter of deciding on a parameter that is controllable and then negotiating the value of that parameter. 'The best' parameter for this framing is one that is both important for an item's military use and is controllable. It is no use, for instance, controlling computers based on processor speed if someone can buy two computers below the speed threshold and link them together to get a combined speed above the threshold. If they cannot find a controllable parameter, but the technology is still considered to be militarily significant, then it is the myth—and therefore the framing itself—that is seen as no longer legitimate, rather than just the institutions it has created. This poses a much more serious problem for actors that adhere to the hierarchical framing because of the uncomfortable knowledge that it generates. I will address this point in detail in the case studies in Chapter 6.

Framings are espoused by actors, be they individuals or organisations. The two main ways that a framing becomes de-institutionalised are by 1) actors institutionalising alternative framings and 2) events not playing out as the myth of that framing would expect. These two points are often interconnected. If an actor were, for instance, to start a business in another country producing a technology similar to technology which is under control in order to capture a new market, the competitive framing would be further institutionalised on the international level. This could lead to the technology no longer being controllable because it could be bought from outside the area of control. There would therefore be a weakening of institutional structures that embody the hierarchical framing.

The controllability of a technology is not an objective fact, but determined through a series of interactions (both between actors and between actors and the technology) where the technology is enacted as being either controllable or not. This is often the case, for instance, when comparing the export control systems of different countries.[5] The ability, for instance, of the United States to monitor its borders and check all exports—thus controlling technology flow—is often much more advanced than that of other countries.

Critiques of the hierarchical framing

There have been several critiques of the current institutionalisation of the hierarchical framing, which I briefly outline here. Predominantly, they centre on the first two assumptions of the myth of this framing: that it is possible to know at whom controls are directed, and it is possible to control the transfer of technology. Research that questions at whom controls should be directed was prevalent at the end of the Cold War, when the Soviet Union dissolved, but such critiques also existed prior to then, mostly in the legal literature (e.g. Adler-Karlsson, 1968; Berman & Garson, 1967; Bertsch & McIntyre, 1983; Rubin, 1967–1968). However, there was a significant study by the US Defense Science Board in 1976, often called the 'Bucy Report', which called for the drastic reduction of controlled items, placing an emphasis not on the export of *things*, but on the export of *knowledge* (Defense Science Board Task Force on Export of U.S. Technology, 1976). This distinction, which can be understood as being between tangible and intangible technology, is one that has been a perennial problem for export controls, as will be analysed in Chapter 7.

At the end of the Cold War, many researchers argued that CoCom's purpose had been served and it should be disbanded (e.g. Bailey, 1991; Raanan, 1991; van Ham, 1990), though there were strong arguments for the continued need of CoCom and other multilateral export control arrangements as well (e.g. Karp,

[5] On comparing export control systems, see the series of country reports from the University of Georgia's Center for International Trade and Security: http://www.uga.edu/cits/

1993). Those who are not members of these regimes have also made arguments that such directed controls are unfair and hinder technological development (Mallik, 2004). More in-depth analysis of the points raised by these researchers will take place alongside analysis of the Wassenaar list modification process in the following chapters.

Questioning the second assumption—how to (and whether an organisation or state can) prevent states or people from getting technology—has received the bulk of attention from the research community. There is work that argues for a shift in focus from only controlling the export of technology to also controlling the import of technology into states of concern (Yuan, 2002). Other work points to the fact that technology has been disseminated so widely that controls are futile, and rather than seeking to prevent the target of controls from getting all technology, the goal should be to put in place as many impediments as possible to a target getting the most advanced technology.

Much of the literature is on the prevention of proliferation of weapons of mass destruction (WMD) and their delivery systems (e.g. Cupitt et al., 2001; Hofhansel, 1993; Smith, 1987), though there is the occasional mention of conventional weapons and dual-use technology. Gahlaut (2006) makes several arguments in this regard: there are the problems with controlling trade internal to multilateral companies; the development of new technology with military potential is more often coming from civilian efforts rather than governmental ones; existing capacity for military technology pressures companies to export as defence budgets shrink; and proliferation is more likely now to occur on a black market, even between states. These points are echoed in a major publication by the University of Georgia's Center for International Trade and Security (CITS), *Roadmap to reform* (Gahlaut et al., 2004). The report also points out what its authors see as several problems with current attempts at international coordination of export controls: that consensus voting rules present in multilateral export control arrangements allow a single member to prevent agreement; that implementation of controls is left to national discretion; and that there is an unnecessary degree of redundancy between the regimes (see also Beck, 2000; Beck et al., 2002; Beck & Gahlaut, 2003; Cupitt, 2001).

Anderson & Sarup (2005) point to the need for Wassenaar to improve its information exchange, harmonise licensing procedures of participating states, engage in extraordinary review of the lists of technology, and promote closer cooperation with industry.[6] Latham & Bow (1998) and Roberts (1993) describe the challenges in proliferation between North and South. Joyner (2004) and Dursht (1997) argue for the development of a 'World Trade Organisation'-style multilateral export control arrangement, and Klaus (2004) argues for the need to institute dual-use free trade agreements instead of export controls. Jaffer (2002) argues for the need for denial consultations in Wassenaar to prevent 'undercutting', which is when one state makes a sale that other states have denied (or would deny).

Analysing the third assumption of this myth, that it is possible to define the technologies to be controlled, is one of the main purposes of this thesis, and an area that has not received significant attention from the literature to date, as I noted when looking at the critiques of the concept of dual-use technology above in Section 2.2.

Competitive framing: a problem of marketability

Since the hierarchical framing of the problem of dual-use technology is currently hegemonic, the other framings must be defined in relation to it as well as standing on their own. This is in line with the theory of sociocultural viability's argument that each framing is defined in counter-distinction to the others (Thompson et al., 1990). Slightly different rhetoric will be employed in each case. The competitive framing defines the dual-use problem as one of marketability of the technology, rather than one of controlling it. When standing on its own, such as when a company has markets only within a single country, dual-use technology is seen as either 'spin-off' or 'spin-on' technology.

[6] For another critique, see Gärtner (2008).

As discussed in the Literature Review (p. 43 above), spin-off technology is technology that was developed primarily for military purposes, but has since found a market in non-military purposes. Spin-on is the opposite, where technology mainly developed for non-military applications finds military uses. In both of these cases, the more advanced technology in one area can be used to create a market niche in the other area if someone has the motivation, resources, and networks to make the transition.

The preferred institutional structure for the competitive framing is network-based. People and institutions strengthen and weaken links to others when and where they need to in order to achieve their goals, rather than having a hierarchical (and much more rigid) structure for interaction. Routines and procedures are often seen as things that stifle the creation of new ideas and 'thinking outside the box', so the preferred transactional mode is instead competitive. In competitive transactions, the key to success is remaining innovative and timing the entrance to market well enough to create a niche. Always seeking to expand, the actor that employs this framing will constantly be looking for how new technologies can cross boundaries in the established classification system. The largest risk perceived in this framing is the failure of a market, which would mean the collapse of the environment within which competition is possible.

When addressing the problem of dual-use technology, the myth of the competitive framing is that a market exists and that, if an actor meets or develops a new need in the market for a technology, that technology will be taken up, as long as it is priced appropriately and is perceived as 'better than' any competitors. The parameters of the technology that are important depend on the buyers of the technology, and are therefore revealed through market uptake of one technology over another.

The rhetoric an actor would develop as it strengthens the competitive framing of the dual-use problem depends on what the hegemonic myth (if any) is in a particular context. If the other actor is also employing a competitive framing, the discourse will likely be about such things as market shares, efficiency, and the pace of change in the market. If, however, the hegemonic myth is hierarchical—as it is in the context of international harmonisation of export controls—an actor wishing to strengthen a competitive framing must first destabilise the hegemonic status of the hierarchical framing. The rhetoric of the competitive framing must employ the terminology of the assumptions of the hierarchical myth rather than its own. Thus, instead of talking about market shares, the discussion must centre on whether the technology is controllable.

When controls hinder the marketability of a technology (or are at least perceived to), there are several avenues of recourse for the competitive framing. One can argue 1) that similar technologies are available from beyond the purview of current controls, or 2) that the technology is not really in need of control (e.g. it is not 'really' militarily significant), or 3) that it is not possible to control the technology (too easily disseminated or unable to find a controllable parameter). We will explore these in more depth in Chapter 6 when discussing anomaly-handling strategies.

Dual-use technology as a simple wicked problem

While the myth of control may currently be the hegemonic one for the problem of dual-use, there has always been a battle between the hierarchical and competitive framings. A prime example of how the competitive and hierarchical framings are interconnected is the British cannon industry in the 17th century, described above. The hierarchical framing had not yet developed an institutional structure to enforce its routines and procedures of control, and therefore could not control, even though control was important. Such an institutional structure began to be established with things like governmental awards for scientific and technological innovations and the rise of the professional army over mercenaries, both of which allowed more governmental control over which technologies were developed and who had access to them. The hierarchical framing was also further institutionalised by the development of international agreements on controlling technology and lists of what technology to control.

That these two framings have been in contention with each other for several centuries suggests that the problem of dual-use technology is at least a simple wicked problem. There is much else to support this claim. The problem is certainly persistent. Each of the framings of the problem has its own preferred solution: the hierarchical framing seeks to establish institutions of control, whereas the competitive framing seeks to create market share. The myths upon which each framing is based often spawn contradictory certitudes about what to do about the problem, i.e. the hierarchical framing may argue for more control while the competitive argues for less, though both are completely rational. The problem of dual-use technology is intimately tied to problems of access to resources—both natural and in terms of knowledge—and the establishment of a vibrant economy, both of which could be considered wicked problems in their own right. Trying to change the structure of the institutions designed by one framing often means that framing will lose power within the discourse. As international efforts to strengthen export controls have advanced, the ability of companies to export as they please to whom they please has been curtailed, sometimes dramatically affecting that company's viability. These points give weight to the argument that the problem of dual-use technology is a simple wicked problem.

I argue that this continual contention between the hierarchical and competitive framings is something to be fostered. When the competitive framing becomes over-institutionalised, as was the case with the Krupp family being the primary supplier of weapons technology to many European countries on all sides of wars from the Thirty Year's War in the 17$^{\text{th}}$ Century through World War II (Manchester, 1968), access to that technology becomes cheap (due to market forces) and it spreads accordingly. While this may level the playing field—or rather, the warring field—it also may make it more likely for hostilities to escalate once they begin. If there is too much institutionalisation of the hierarchical framing, markets are likely to suffer from an inability to compete internationally. But are these the only two framings taking part in the discourse?

Egalitarian framing: a problem of open access

While much of the history of dual-use technology falls into a debate between hierarchical and competitive framings of the problem, there is another framing that has recently been strengthening. This framing sees the problem of dual-use technology as a problem of too narrow a focus. Of course any technology may have military uses, but the military applications should not be given precedence over all of the other applications such technology may have.

A computer, for instance, could be used in missile guidance systems, or for sequencing the genome, or for creating a stable banking system that could compete in—or at least interact with—the global market, to name but a few uses. Privileging the military applications is tantamount to saying that killing people with guns is not acceptable, but killing them by, for example, preventing access to vaccination technology is fine. The knowledge upon which military technology is based is the same knowledge that is employed in many non-military areas, and aggregating all of these different areas under one label ('non-military', or 'civilian') is an injustice. If the problem is that there is too narrow a focus, then the solution is to broaden that focus by integrating export controls with work on, for example, international development and other transnational problems like climate change, human migration, epidemics, and resource management.

The myth that this framing develops is the myth of equality, and in particular that military policies should be seen on an equal footing with all of the other policies that drive a society. One of the primary ways that such broadening can occur is through basic scientific research, which develops the underlying knowledge for future technology development in all areas, as long as such research is available to all.

When an actor wishes to strengthen this framing from within a context where the hierarchal framing is hegemonic, the rhetoric will be concerned with showing all of the perspectives on a technology that a focus on control leaves out. In my research, I have found this framing emerging along two very different lines. One, developed for instance in the work of Mallik (2004), argues that multilateral export control arrangements are hindering development of countries who are not members of those arrangements. The other, taken up by academics performing basic scientific research that may, sometime in the future, have some military application, argues that the current export control system and proposed future developments, are likely to overly stifle the collaborative and international nature of academic research. I explore this framing in Chapter 7 in the work of the US Deemed Export Advisory Committee and its successor, the Emerging Technology Research Advisory Committee.

The preferred mode of transaction within the egalitarian framing is one of cooperation, where information is freely shared, be it between policy areas or between academics in countries around the world. The most common risk for this framing is that we may lose the small window of opportunity we have to make a difference in other areas of society because we are too focused on the military/non-military classification system for technology.

While this framing has yet to be institutionalised significantly within export controls, we can look at another very similar area where it is making headway, namely international efforts at regulating intellectual property. I will draw out this connection in Chapter 7 when looking at the Trade-Related aspects of Intellectual Property (TRIPS) agreement within the World Trade Organization and how it relates to current developments within Wassenaar Participating States on controlling intangible technology.

Should this framing be further institutionalised within the dual-use discourse, it is likely that what has for centuries been a simple wicked problem may become a complex wicked problem. Such a shift would bring out the fundamental assumptions that have supported the hierarchical-competitive dichotomy, one of which is that all technologies can be considered to be excludable goods. By bringing this assumption into question, it is possible that the entire apparatus of export controls may need to be rethought—a point that I also touch on briefly at the end of my analysis.

Equipped with three possible framings of the problem of dual-use technology, we are now ready to go into some detail on the development of the Wassenaar Arrangement. We saw from the discussion above that early attempts at export controls had to contend with a hegemonic framing that was competitive instead of hierarchical. In the next section, I point out how the development of CoCom in 1950 saw a significant shift in the balance of the framings, with the hierarchical framing becoming hegemonic.

4.2 The Origins of Wassenaar

This section provides a history of multilateral export control development, a very brief history of Wassenaar's predecessor CoCom, and of the Arrangement's founding period. This period is covered extensively by Mastanduno (1992), Noehrenberg (1995), and Lipson (1999). In describing the period below, I therefore focus on identifying the centrality of the lists in the structure and processes of CoCom and Wassenaar. In doing so, I draw out the many ways that the hierarchical framing of the problem of dual-use technology has become institutionalised, thereby establishing its myth as the current hegemonic myth.

At the beginning of the 20^{th} Century, multilateral efforts to harmonise the types of technology that were allowed to be controlled in international trade resulted in the 1909 *Declaration concerning the Laws of Naval War*, which I will analyse in the next chapter. With this development and the subsequent events of World War I, countries began to shift their understanding of the purpose of export controls. In addition to *ensuring domestic supply* of the things that a country would need to wage war, the controls started to be used more for other purposes, namely *foreign policy* and *preventing foreign supply.* We can see this change in the British position as witnessed by Atwater (1939, p. 299):

> [The export licensing system] had been used during the war with respect to virtually all goods as a means of providing flexibility in the administration of the general export prohibitions, preventing strategic goods from reaching the enemy, and in some instances influencing neutral governments to adopt policies favorable to Great Britain and her Allies.

The United States underwent a similar transition. Early (failed) attempts at export controls occurred in 1807 with the Embargo Act against Britain and France. Institutionalised export control policy first began in 1917 with the *Trading with the Enemy Act.*[7] The US developed a licensing system between the World Wars,[8] and in the early post-war period export controls became fully established as a function of government through the *Export Control Act of 1949.*[9] This Act had three objectives: to reduce continuing national shortages of critical materials; to aid the President in implementing foreign policy; and to control items deemed critical to US national security.[10]

The international harmonisation of export controls further developed out of World War II with the establishment of CoCom (the Coordinating Committee for Multilateral Export Controls) in 1950. CoCom focused on drawing together like-minded states ('the West') to control the flow of technology to a common adversary ('the communist bloc').[11] We can see that the original purpose of

[7]Ch. 10, 6 Stat. 411 (1917), as amended, 50 U.S.C. App. Sec 1-44 (1964).

[8]This was done through the *Neutrality Act of 1935*: 49 stat. 1081 (1935); 22 U.S.C. 441 note

[9]Ch. 11, 63 Stat. 7, as amended, 50 U.S.C. App. Sec 2021-32 (1964).

[10]For a thorough review of the development of US export control policy until the 1990s, see Committee on Science Engineering and Public Policy (U.S.) (1991).

[11]While CoCom never published any documents of its own, it was generally agreed that it was directed at Communist states, as highlighted by the following quote:

> An examination of the lists of proscribed destinations by British, Dutch and US authorities, however, indicated that the targets of COCOM controls in the mid-1980s were Afghanistan, Albania, Bulgaria, Cambodia, Czechoslovakia, Cuba, the German Democratic Republic, Hungary, Laos, Mongolia, North Korea, the Peoples Republic of China, Poland, Romania, the Soviet Union and Vietnam (Cupitt & Grillot, 1997, p. 364).

export controls—to ensure domestic supply—has now completely left the scope of discussion. Instead, export controls were developed as a tool of foreign policy through their ability to prevent certain technologies from reaching certain destinations.

The 1970s saw the formation of the Zangger Committee (ZC)[12] and the Nuclear Suppliers Group (NSG)[13] to control the spread of nuclear technologies and related dual-use items.[14] Primarily in response to the use of chemicals in the Iran-Iraq War, the Australia Group (AG)[15] was formed in 1985. Its aim is to prevent the flow of dual-use technologies that could be used for chemical and biological weapons and weapons-programmes. Finally, in 1987 an informal political arrangement called the Missile Technology Control Regime (MTCR)[16] was formed to control missile and unmanned air vehicle systems capable of delivering weapons of mass destruction (WMD). The ZC, NSG, AG, and MTCR are still in operation today.[17] CoCom was disbanded in 1994 (British Government, 1993*b*) and replaced by the Wassenaar Arrangement in 1996.

Lists of items to control are the basis of any hierarchical framing, and are central to all of these organisations except the Nuclear Suppliers Group, which uses the lists developed by the Zangger Committee. The lists for the ZC, AG, and to a lesser extent the MTCR remain relatively static. CoCom had phases where the lists changed significantly, while in Wassenaar, there are usually dozens of changes every year. This difference reflects the types of lists that each maintains. The Zangger Committee maintains a 'Trigger List' of items that, if exported, would require safeguards enforced by the International Atomic Energy Agency (IAEA). There are a limited number of ways to develop nuclear

[12]website: http://www.zanggercommittee.org

[13]website: http://www.nuclearsuppliersgroup.org

[14]The Zangger Committee maintains the 'Trigger List' of 'especially designed or prepared equipment or material for the processing, use or production of special fissionable material', as noted by the Nuclear non-Proliferation Treaty, Article III.2(b). The NSG only maintains a set of *Guidelines for Nuclear Transfers* and *Guidelines for Nuclear-Related Dual-Use Equipment, Materials, Software and Related Technology.*

[15]website: http://www.australiagroup.net

[16]website: http://www.mtcr.info

[17]For a comparative list of member states for each regime, see Appendix F.

weapons, and thus there is little (or infrequent) need to redefine the stage of technological development where controls are needed. The Australia Group maintains six control lists: Chemical weapons precursors; Dual-use chemical manufacturing facilities and equipment and related technology; Dual-use biological equipment and related technology; Biological agents; Plant pathogens; and Animal pathogens. The AG's concern in monitoring international trade to prevent the ability to produce chemical or biological agents in sufficient quantity for incorporation into weapons. Again, there is a limited number of methods of production, and the possible agents of concern do not change very often. That said, at least some of the lists have changed on an almost yearly basis since 2002, but because of their narrow focus, they remain small. The MTCR is concerned specifically with delivery systems for WMD. These systems develop on a more regular basis, and as a result there are more discussions around the lists. Together, these regimes cover the bulk of the technologies needed to develop weapons of mass destruction.

There is at least one significant difference that sets these regimes apart from CoCom and the Wassenaar Arrangement. The impact on a country's economy of export controls of most WMD-related technology is marginal.[18] Many of these technologies, if exported at all, are done so in small quantities. Controlling knowledge about how to design, produce, and use these technologies has wide acceptance from most if not all of those who are affected by the controls. In contrast, the impact from conventional dual-use technology—that covered by CoCom and Wassenaar—has a major effect on national economies, because the text of the lists can be interpreted as covering significant proportions of the number of items exported generally from a country. Due to this impact (perceived or actual) on the economy, we can expect a competitive framing to have some form of institutionalisation within CoCom and the Wassenaar

[18] Controlling biological dual-use technologies may have more of an impact on the economy, especially as this area continues to develop. There are arguments now being presented that labelling it in the same category as nuclear and chemical technologies is a misnomer (McLeish, personal communication).

Arrangement. An early indicator of the presence of a competitive framing is that CoCom and Wassenaar are the only regimes that take significant numbers of items *off* of their lists.

CoCom

At the end of World War II, there was initially no consensus on whether further institutionalisation (or even maintaining the current level) of export controls was necessary. Yasuhara (1991) provides a detailed account of this period.[19] Within the Department of Commerce, for instance, when the war finished decontrol became the 'fixed policy' (US Congress, 1947, p. 1813). The US military, however, saw things differently and sought "permanent legislation for export controls both to meet a national emergency and to prevent the increase of the warmaking potential of a foreign nation 'inimical to US interests'[20]" (Yasuhara, 1991, p. 129). Yasuhara draws out in detail how the US moved between 1945 and 1950 from an institutional form that focused on controlling technology to ensure domestic supply to one controlling a technology's foreign availability. Myriad events colluded to produce this shift. For instance:

> When the news of the coup in Czechoslovakia [in 1948] arrived, demand for tighter trade controls gained further impetus in the United States. Among those actively advocating tighter controls were longshoremen, Catholics, and veterans (Yasuhara, 1991, p. 131).

The dilemma in starting CoCom was that the US wanted to export technology to Europe to help it rebuild under the Truman Plan after WWII, but it needed to ensure that those exports, as well as other exports from Europe, did not continue on to Communist countries (Yasuhara, 1991, p. 132).

Initially, CoCom had two lists: List I was composed of items to be embargoed unconditionally, and List II contained items for which members agreed

[19] See also Adler-Karlsson (1968).

[20] JCS 1561, Appendix 'A', Draft Memorandum for the Secretaries of War and the Navy, 18 January 1946, in JCS 1561/4, CCS 091.31 (9-28-45), sec. 1. RG 218, Records of the US Joint Chiefs of Staff, National Archives, Washington, DC.

they would restrict their exports to the Soviet Union and Warsaw Pact to 'reasonable' levels and exchange information on what was exported (Mastanduno, 1992, p. 80). They were still shifting between the understanding of export controls as ensuring domestic supply and as preventing foreign supply. With the 1954 list review, however, these lists were replaced by the following, which remained similar in structure until 1991: the Munitions List, covering conventional arms; the Atomic Energy List, covering technologies needed for both nuclear energy and weapons production; and the Industrial List (IL), which covered technologies that had military significance, but were not weapons themselves. The items on CoCom's lists were subject to a blanket denial if they were going to certain countries, and approvals for 'exceptions to export' from one member country had to be approved by a consensus vote by all members.

CoCom had about seven founding members,[21] though within a few years it had grown to fifteen, and by the time it was disbanded in 1994, there were seventeen members, representing the major non-Communist producers of technology: Australia, Belgium, Canada, Denmark, France, Germany, Greece, Italy, Japan, Luxembourg, Netherlands, Norway, Portugal, Spain, Turkey, United Kingdom, United States.[22] "The target countries of CoCom for most of the organization's existence were all of the former Warsaw Pact countries, as well as Albania, Mongolia, Cambodia, North Korea, Vietnam, and the People's Republic of China" (Noehrenberg, 1995, p. 38).

[21]Exactly who were the founding members of CoCom is a matter of debate. The US Office of Technology Assessment (1979, p. 158) states them as Belgium, France, Italy, the Netherlands, Luxembourg, the United Kingdom, and the United States, but a more detailed analysis by Yasuhara (1991) shows that there were several other states that participated in some of the meetings that established CoCom, and some of those listed were not at all of the meetings. Since there was never an official document launching CoCom, there is no established date for its beginning, and therefore no meeting that unambiguously states who the founding members were. I place the founding in 1950 as that is when the lists were agreed to.

[22]This was often described as "all NATO members minus Iceland, plus Japan and Australia" (British Government, 1990; Price, 1987; US White House, 1991, p. 195).

It was run out of the US Embassy in Paris[23] and had three main purposes: to establish and review the lists of technologies; to review and approve licenses to export controlled items; and to co-ordinate national enforcement of export controls (Mastanduno, 1992, p. 7). All of the activities at CoCom used as their foundation the construction and maintenance of the lists. "Deciding which technologies were on the lists was the major task of CoCom and was the one which caused the most disagreements among members" (Noehrenberg, 1995, p. 46).

Some of the drivers behind the development of the lists are noted by Noehrenberg (1995, p. 46):

> The members of CoCom, aside from the US, tried to keep the lists shorter and more narrowed for ease of administration and enforcement, as well as for increasing the opportunities for profitable trade. The US, on the other hand, generally had less interest in trade with the East and had more of a rivalry with the USSR than the Allies had. Therefore, the US placed more emphasis on security considerations than on benefits from trade compared to the Allies and was the major force in CoCom for strengthening controls.

We can begin to see suggestions here of how different members preferred different framings during the list modification process. The focus on administration and enforcement, and the corresponding desired list style—narrowed and focused—suggests that the non-US members of CoCom were arguing from a hierarchical perspective. However, the goal of such a style of administration was to allow more trade, which meant removing or preventing the addition of all but the most important items to the lists.

That the US, and in particular the military, saw itself in a rivalry with the Soviet Union seems a clear sign of the competitive framing, but it is im-

[23] According to Mastanduno (1990), this was in an annex to the Embassy at 58 Rue La Boetie. The building was seen as being highly inadequate for the task at hand. The technical meetings were held in a "cramped, L-shaped room" in the 2nd floor of the annex (Kempe & Lachia, 1984), its budget was only a million dollars at the time of disbanding (Price, 1987), and it lacked "secure communications, and, ironically, [ ] access to modern data processing equipment. CoCom reportedly relied on a hand-cranked mimeograph machine until the [US Department of Defense] donated a photocopier in 1983" (Mastanduno (1992, p. 275) citing Perle (1984)). See also Kempe & Lachia (1984).

portant to point out that this rivalry was not around the problem of dual-use technology, but around another wicked problem, which might be described as the problem of international anarchy (Wendt, 1992). This separate, but very interconnected, problem is about the nature of the international system and how states should act within it, and has been a major focal point for much of the research in international relations. While the US military may develop a competitive framing when viewing their work as addressing this problem, when they view their work as instead addressing the problem of dual-use technology, the issue at hand is not a competition among rivals. It is a matter of *control*. This is a delicate, but important, point for my argument.

We could think of the international development of export controls as a result of the clash of two competitive framings of two different problems: economy and international anarchy. Just as the competitive framing of economy is concerned with market failure, the competitive framing of anarchy is concerned with the failure of the state. While employing the same rhetorical style, these framings would reach polar opposite stances on whether technology should be traded. When addressing the economy problem, the wider technology is distributed, the better. When addressing the anarchy problem, the less access to technology the enemy has, the better. In order to have any dialogue among these problems, a new—wicked—problem was formed: the problem of dual-use technology.

By institutionalising the hierarchical framing of a new problem, the competitive framings of the economy and the anarchy problems now had a common topic of interaction. Each of them needed to adopt the rhetoric of the hierarchical framing to push its own views, be it either that the controls were too weak (anarchy) or that they were too strong (economy). It was the job of the newly created hierarchical framing to decide what constituted an *adequate* level of control. Put another way, CoCom and Wassenaar are seen from the hierarchical framing as being about neither the problem of anarchy nor the problem of economy, but about the problem of determining a balance between the two.

A 'good day at the CoCom office' for an actor strengthening the hierarchical framing was not a day where more or less technology was controlled, but a day where agreement—whatever it may be—was reached.

CoCom had four types of meetings: licensing meetings, Executive Committee meetings, working groups, and High Level Meetings. All of these were concerned in some way with the lists, and most often with the Industrial List (the predecessor to the Wassenaar Dual-Use List). The licensing meetings were attended by licensing experts from various delegations—usually from their Paris embassies—and were held once a week.[24] They focused on licensing issues, and the perception that they were unable to process exceptions applications fast enough was a factor in the 'Core List' revision in 1990–1991.[25]

The Executive Committee was made up of policy level officials and met twice yearly "to consider broad policy issues and to establish or review the progress of CoCom's ad hoc working groups" (Mastanduno, 1990, p. 76). This is sometimes referred to as the Consultative Group (Defense Science Board Task Force on Export of U.S. Technology, 1976; Yasuhara, 1991). Working groups contained mostly technical experts and considered issues such as "trade among CoCom members, the streamlining of the control lists, and the harmonization of national enforcement procedures" (Mastanduno, 1990, p. 76–77), and thus either used or modified the lists.

The High Level Meetings (HLM) began in 1982, and were attended by subcabinet level delegates. Their purpose was to "inject political vigor into and develop political support for the multilateral control process" (Mastanduno, 1990, p. 77), and thus represent a clear strengthening of the hierarchical framing, with its emphasis on further institutionalising the idea that control was the appropriate framing of the dual-use problem. The 1982 HLM, at least from the US perspective, had three initiatives: the expansion of the lists, improvements

[24]On Tuesdays, at least in the late 1980s, according to Mastanduno (1990, p. 76).

[25]For example, the United States requested 1150 general exceptions in 1982, and 3790 in 1985 (table in Ross, 1986, p. 30, citing the US Department of Commerce).

in enforcement, and the strengthening of CoCom's institutional structure (Mastanduno, 1992, p. 268). The 1990 HLM had four initiatives, three of which involved the lists directly: to override the list review process in place at the time; to remove entire categories of technology from the lists; to replace the Industrial List with a much more selective Core List; and to change from viewing Eastern Europe as a target of control to viewing it as a collaborator in controlling (Mastanduno, 1992, p. 333–335). Much of this was a direct result of the fall of the Soviet Union and the Warsaw Pact.

As we can see, the lists played a central role in CoCom. An analysis of the way these lists changed over CoCom's life occupies the next chapter. Through the creation of CoCom and its establishment of routines and procedures for export control, we can see how the problem of dual-use technology came mainly to be seen as a problem of control. CoCom had created a space for the discourse on dual-use technology, and as such it also set the terms of the debate. By focusing on the lists, it created a common discourse whereby framings of other problems, such as the economy or international security, could interact constructively. Each actor in the discourse had to adopt the rhetoric of the hierarchical framing of the problem of dual-use technology, which it could then use to further its own goals, be they more or less stringent controls, or a further strengthening of the hierarchical framing itself. Thus, while the hierarchical framing may be dominant, it exists in part through allowing space for the other framings to engage in debate. By allowing space for other framings of the problem to engage in the debate, we can argue that there was recognition in CoCom of the wickedness of the problem of dual-use technology. The problem, however, was only wicked in a simple way, as the balance to be struck was only between the competitive and hierarchical framings. We now continue on to see how the hierarchical framing was further institutionalised during the New Forum and the development of the Wassenaar Arrangement.

New Forum

Between 1994 and the end of 1995, the members of CoCom—plus Austria, Finland, Ireland, New Zealand, Sweden, and Switzerland, and, by 12 September 1995, Russia, Hungary, Poland, and the Czech and Slovak Republics—set about to rethink how to co-operate on international export controls. They held a series of meetings, called the New Forum, that turned into "a bit of a 'talk about export controls and see the world' sort of organisation, really."[26]

The discussions in the New Forum were broken into different 'working groups', each of which looked at the different aspects of what the members wanted from an export control regime: Group 1 developed the goals, rules, and procedures for the new arrangement; Group 2 developed the lists of technologies to be controlled; and Group 3 was set up to deal with organisational matters (Wassenaar Arrangement, 2008*b*). Each of these groups, then, was working on the assumptions that control was still feasible and that it was possible to have a list of technologies to be controlled—assumptions that underlie the hierarchical framing of the problem of dual-use technology. The complexity of this process was noted in one of my interviews:

> It takes time to develop [those documents] because every word is weighed. It's tested. And then it's translated. You have to remember that every word that is there has to work in the 33 countries.[27]

The modification of the lists in the New Forum was a long and difficult process. As with the 1990–1991 'Core List' revision (see Chapter 5), Working Group 2 took everything off the lists. However, they seem to have kept the reworked structure of the lists. In the process, they noted a number of areas of technology that were deemed to be 'sensitive', including stealth, underwater equipment, night vision, and encryption.[28] This process of modification took

[26]Interview with British Government Officials A & B, 9 February 2007.
[27]Interview with Swedish Former Government Official, 6 January 2006.
[28]Interview with Swedish Government Official, 27 March 2007.

much longer than expected, and time became a critical factor, as one official[29] noted:

> The New Forum was an *extremely* interesting but frustrating time. We spent weeks and weeks in Paris going through each item, all with our own agendas, and it came down to the last three days, which was just before Christmas in 1995. The main players simultaneously received telegrams from their capitals. We actually had one direct from [the Prime Minister], telling us nothing but nothing was going to get in the way of us reaching agreement by the end of the week. So at that stage, bearing in mind that we had a lot of controls on the table which were meaningless and out-dated, no reason for being there, you name it, we had to give in. And as I say, about three days before, we started doing the last round of every single subject, and the US and Britain—basically the two protagonists at the time—were just lifting our reserves, and accepting what was on the table, because we had to have an agreement.

This can be seen as a key point in institutionalising the hierarchical framing's myth of control as the hegemonic myth for the Wassenaar Arrangement. Even though there was significant unresolved debate about the adequacy of the lists, if agreement was not reached, there would be no lists at all. Even if the lists were not perfect, at least the basic premise on which they were founded—that it is possible to define the technology to be controlled—was still intact. This strong relationship to a particular classification system represents a strong collective identity (high-group). The belief that anomalies can be accommodated through a process of adjustment of category definitions, or through the creation of new categories and sub-categories, suggests a high-grid predilection. Both are characteristics of a hierarchical framing.

The review process in the New Forum was certainly a learning experience for those involved, and later on it led to the reformatting of the MTCR and NSG lists as well, which were undertaken in part by the same people who participated in the New Forum.[30]

[29] Interview with British Former Government Official, 8 March 2007. Emphasis original.
[30] Interview with German Government Official, 27 March 2007.

Finally, in the little town of Wassenaar outside of the Hague in The Netherlands on 19 December 1995, agreement was reached to start the Wassenaar Arrangement, and on 11–12 July 1996, after a postponed Plenary on 2–3 April, agreement was reach on the 'Initial Elements', and Argentina, Bulgaria, the Republic of Korea, Romania, and Ukraine had by this time been brought in as founding members (Wassenaar Arrangement, 2008*b*).[31] Why the name Wassenaar? As the member of one delegation[32] said to me in an interview, "I think everyone thought that New Forum was an awful name, and that Wassenaar was far better, and no more cryptic."

4.3 The Wassenaar Arrangement

The Wassenaar Arrangement is just that, an *arrangement* among Participating States. While I may speak of it occasionally as an organisation or a regime, it is technically a political forum for states to get together for one purpose or another. States do not have to follow through on any of the decisions reached at Wassenaar. Yet many of them do. More importantly, many of them spend significant resources in trying to improve Wassenaar one way or another. Of the people I interviewed who were or are directly involved in the proceedings of the Arrangement, quite a few speak of it in language one would use to describe a pet project, with hope and pride.

In reviewing the basic structure of the Wassenaar Arrangement, I will once again be highlighting the centrality of the lists to the functioning of the Arrangement. The Arrangement has two main lists—the Dual-Use List and Munitions List—and two subsets of the Dual-Use List: the Sensitive List (SL) and the Very Sensitive List (VSL). These are arranged hierarchically by the level of control each warrants, with the Munitions List having the most control, then the VSL, SL, and common Dual-Use List, as shown in Table 4.1.

[31]For a list of countries and when they became members, see Appendix F.
[32]Interview with US State Department Official A, 28 September 2006.

Table 4.1: *Hierarchy of Wassenaar lists*

non-military items	least control
common dual-use items	|
Sensitive List items	|
Very Sensitive List items	|
Munitions items	most control

Initial Elements

The *Initial Elements*, or *Guidelines & Procedures, including the Initial Elements* as they were renamed in 2003, form the basic outline of the functions of the Arrangement.[33] They are separated into nine sections: I. Purpose; II. Scope; III. Control Lists; IV. Procedures for General Information Exchange; V. Procedures for Exchange of Information on Dual-Use Goods and Technology; VI. Procedures for the Exchange of Information on Arms; VII. Meetings and Administration; VIII. Participation; and IX. Confidentiality.

The purpose of the Arrangement is clearly laid out in section I.1:

> The Wassenaar Arrangement has been established in order to contribute to regional and international security and stability, by promoting transparency and greater responsibility in transfers of conventional arms and dual-use goods and technologies, thus preventing destabilising accumulations.

It does so by focusing on enhancing cooperation to prevent the "threats to international and regional peace and security which may arise from transfers of armaments and sensitive dual-use goods and technologies where the risks are judged greatest" (I.2–3). In stark contrast to CoCom, it is not directed at "any state or group of states and will not impede bona fide civil transactions." This statement shows the first explicit recognition by the Arrangement that there is a balance to be struck between the security and economic concerns of dual-use technology.

[33] This and other publicly available documents, including the lists, are on the Wassenaar Arrangement website: http://www.wassenaar.org. All of these except the lists have also been published in a regularly updated compilation volume (Wassenaar Arrangement, 2008*c*).

To carry out its purpose, Wassenaar Participating States (as they are officially called) meet on a regular basis (II.1 and VII.1–2), exchanging, on a voluntary basis, information that will enhance transparency (II.2), including information on transfers and denials to transfer (II.3–4). They also continually assess the overall functioning of the Arrangement (II.6)[34] and develop guidelines and procedures for Participating States to use in various aspects of export controls (II.5,7). In doing so, all decisions are reached by consensus (VII.5).

States, except for the Russian Federation, France, and Ukraine, have agreed to control all items on the List of Dual-Use Goods and Technologies and Munitions List, which will be reviewed regularly "to reflect technological developments and experience gained by Participating States" (III).[35] All Participating States agree to exchange general information on the risks associated with transfers of conventional arms and dual-use goods and technologies (IV), and specific information on the denial of licenses of dual-use items and the approval of items on the Munitions List (V–VI).

The Arrangement maintains that it is open to any state that may wish to join, though admission is based on consensus of all current members (VIII). Finally, Article IX states that "Information exchanged will remain confidential and be treated as privileged diplomatic communications. This confidentiality will extend to any use made of the information and any discussion among Participating States."

Wassenaar is currently composed of forty Participating States.[36] I have de-

[34]This has taken the form of Assessment Years, which occur every four years and at which any aspect of the Arrangement can be put on the table as in need of reform. There have been three Assessments so far: 1999, 2003, 2007.

[35]Russia, France, and Ukraine "view this list as a reference list drawn up to help in the selection of dual-use goods" (III*n*), though their national controls do reflect—and often go beyond—the Wassenaar Lists.

[36]The Participating States as of December 2006 were: Argentina, Australia, Austria, Belgium, Bulgaria, Canada, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Latvia, Lithuania, Luxembourg, Malta, Netherlands, New Zealand, Norway, Poland, Portugal, Republic of Korea, Romania, Russian Federation, Slovakia, Slovenia, South Africa, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom, United States. For a list of dates on which each joined, please see Appendix F.

signed a graphical representation of these States, shown in Figure 4.1. As can be seen, with the addition of South Africa in 2006, "the Arrangement now enjoys representation from all continents" (Wassenaar Arrangement, 2006). However, that representation is heavily skewed. What is immediately obvious with this map is that there are no Participating States within the Tropics of Cancer and Capricorn.[37] Likewise, one can easily see the lack of participation from Asia, most notably China. Countries with significant exports of controlled items that are not members of the Arrangement include Brazil, China, India, and Israel.[38]

Secretariat & building

The Secretariat is based a block from the Oper in the centre of Vienna, on [redacted] Mahlerstraße, and is made up of around a dozen staff, Redacted at request of the British Government [redacted][39]

This is different from all of the other current multilateral export control arrangements, which do not have a secretariat. It is also a strong institutionalisation of the hierarchical framing, since there are people whose sole job is to ensure that the rules and procedures of the Arrangement are adhered to. The Secretariat exists for several reasons. Historically, CoCom also had a Secretariat. In fact, some of the furniture in the rooms of the Arrangement came from the CoCom rooms in the US Embassy in Paris. The Secretariat is also

[37] The tips of Argentina, Australia, and South Africa cross the Tropic of Capricorn, but the majority of these States lie further south. Similarly with Hawai'i for the United States.

[38] Israel implements the Wassenaar lists even though it is not a member for political reasons.

[39] Interview with Wassenaar Secretariat Official A & Wassenaar Secretariat Official B, 1 March 2006. The other information in the next few paragraphs also come from this interview.

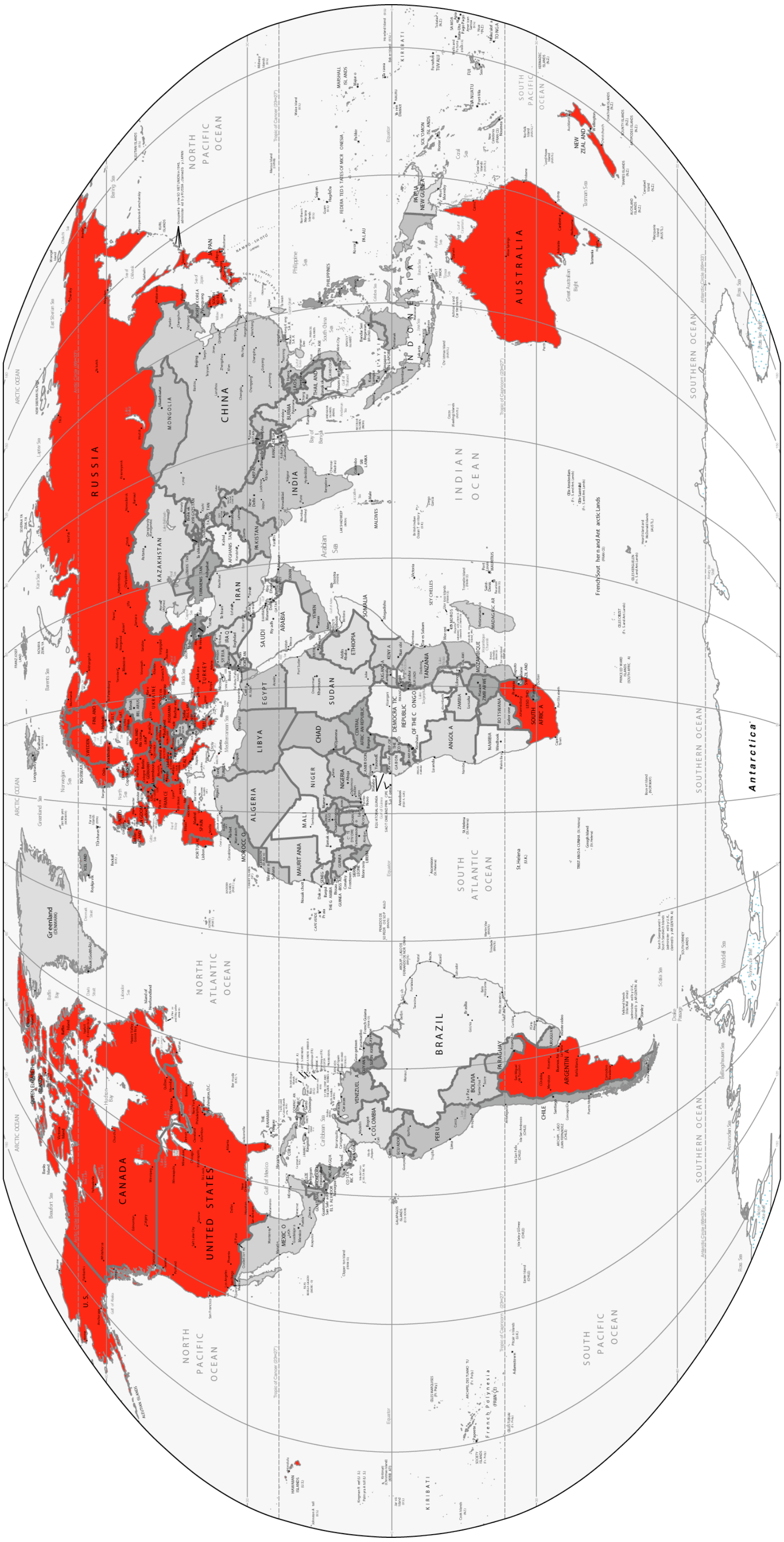


Figure 4.1: *Participating States of the Wassenaar Arrangement, shown in red, as of December 2006 (modified CIA Political Map)*

needed to coordinate the information exchange (described below). A third reason is that a Secretariat is needed to organise the many meetings that take place in a given year for Wassenaar. Unlike the NSG, AG, and to a lesser extent the MTCR, the Wassenaar lists change significantly every year. This is because, rather than trying to control a narrow pathway to a particular end product—say a nuclear bomb—Wassenaar tries to control all technology that may have a potential military use that is not controlled by the other regimes. In this way, it could be thought of as the 'residual' category in the work of Bowker & Star (1999).

All decisions regarding the running of the Wassenaar Arrangement, and also decisions on procedure and changes to lists, are made by Participating States on a consensus basis. The Secretariat advises, but has no vote, in this process. [redacted] The Secretariat functions as a historian for the lists, providing information on why and when list definitions were developed and other decisions reached. [redacted]

[redacted] Redacted at request of the British Government

[redacted] Redacted at request of the British Government [redacted]

[redacted]

The layout of the rooms in the Secretariat enables and constrains the types of interactions the members of delegations can have with one another, both socially and in terms of constructing the list text.[42] There is a main meeting room that is used for the main sessions of the EG and GWG, and for the VPoC.[43] It has an oval table that is just big enough to fit at least the primary member of each delegation at the table, the rest sitting on the chairs against the wall.

This equal placement of delegations around the table suggests that an egalitarian framing has been institutionalised, but I caution the reader in assuming that it is an egalitarian framing of the problem of dual-use. More likely, it is an egalitarian framing of the problem of international anarchy mentioned above. All states are treated as equals. This is mirrored by the institutionalisation of a veto power for each state in any discussion.

In 2005 the Arrangement upgraded their presentation equipment in this room. This was not a trivial matter and has had a significant effect on operations, particularly the EG.[44] Instead of having a projector at one end of the room which not everyone could see, they now have a series of recessed monitors in the middle of the oval. This allows everyone to see the changes to the actual text in real-time, eliminating much of the need to take long breaks while the changes were made and photocopied for all at the meeting.

Another time-saving feature of the Arrangement is that all discussions are held in [redacted]

[42] This information comes from a tour of the building that I was given.

[43] The Plenary is too large to be held in the Secretariat, so they usually rent someplace else.

[44] Interview with British Former Government Official, 8 March 2007.

[redacted]

Redacted at request of the British Government [redacted]

Outside of the main meeting room, there is Redacted at request of the British Government [redacted] a set of computers where, during the breakout session of the meetings, members from delegations can discuss items with each other, correspond with their capitals, and talk to other delegations. Beyond that, there is one smaller room, big enough for about 10 people comfortably, though it can hold "up to 50 in a pinch",[46] and is used particularly for the EG breakout sessions.[47] All of these features of the building allow for more debate to occur on what constitutes an adequate level of control, and therefore strengthen the hierarchical framing.

Functioning bodies

Having an overview of the membership and the Secretariat, we now turn to the functioning bodies of the Arrangement. There are five main bodies that are made up of delegates from the Participating States and that meet on a regular basis in Vienna: the Expert Group; the General Working Group; the Plenary; the Licensing and Enforcement Officers Meeting, and the Vienna Points of Contact. Each of these is described below.

Expert Group

The Expert Group (EG) is the body within Wassenaar that does most of the negotiation with regards to the modifications made to the Munitions List and Dual-Use List. Its nearest parallel in CoCom was the working groups that used to review the lists. During the course of a year, the EG usually meets in two

[46] Interview with British Former Government Official, 3 Jun 2008.

[47] This is compared to the small and cramped quarters of CoCom described above. While the people I interviewed provided small complaints about the rooms being too hot in the summer, there seemed to be few other negative aspects of the current set-up.

formal sessions—in March-April and September—and one informal session in June-July.[48] The sessions are usually two weeks long, and can involve anywhere from a half dozen to all of the Participating States. The informal sessions are strictly that, informal; they are not administered by the Secretariat, and there is a 'no-tie' policy.[49]

The EG is chaired by a representative of a Participating State, selected on a rotating alphabetical basis. Some countries decide to pass on chairing the EG, as a technical background and a command of technical English are seen as necessary in aiding understanding when discussion moves too far off topic.[50] Informally, the Chair is asked to serve for two years as opposed to the one year term for Chairs of the GWG and Plenary. This is because many Chairs learn a lot in their first year that they can then apply to making their second year run more smoothly. "It's a far tougher job [than the chair of the GWG or Plenary], and it's a job that requires all of the diplomatic skills of the others, but substantive technical skills as well."[51]

Countries send varying numbers of delegates to the EG meetings. Some rarely send any, such as Belgium, Latvia, Luxembourg, and Malta. Others, like Canada and Sweden, send one or two, occasionally supplemented by more when they are submitting a proposal. Large delegations, typically the US, Britain, and Russia, will send 10 or more delegates.[52] These delegates usually come from the Ministries of Defence, Trade, or Foreign Affairs, depending on the country. There are also delegates from industries, but they are always brought in as part of a State delegation, and must as such represent the interests of

[48]Interview with Swedish Former Government Official, 6 January 2006. There is often more than one informal session if specific proposals warrant further discussions. Discussions also occur in ad hoc fashion between small numbers of states.

[49]Interview with British Former Government Official, 8 March 2007. Initially they were not even held at the Secretariat.

[50]Interview with US State Department Official A & US State Department Official B, 11 September 2006.

[51]Interview with US State Department Official A, 28 September 2006.

[52]This information comes from informal discussions with members of various delegations at EG meetings, supplemented by a copy of the List of Participants for the 19–29 September 2005 Expert Group Meeting that I received from a source who wished to remain anonymous.

the State rather than their company. It should be pointed out that if the industry representatives are at a Wassenaar meeting, it is most likely because their company's interests and those of the State line up with one another. This suggests that some states, or parts of state delegations, are trying to strengthen the competitive framing of the problem of dual-use technology. They are seen as technical experts on a particular item under debate and are usually brought in only for the part of the meeting that discusses their technology.

Even given six weeks a year to work through changes to the list, members of the EG find it difficult to get through the average of 60 proposals per year, the vast majority of which concern the Dual-Use—as opposed to the Munitions—List.[53] The typical day of an EG formal meeting sees some of the larger delegations meeting in the morning for breakfast at 7.30, and getting into the Secretariat by 8.30.[54] The first round is supposed to begin at 9.30, though rarely does.[55] There is an introduction to the day, followed by a round table of questions and answers. The delegations then break up into Technical Working Groups (TWGs, pronounced 'twigs')—each of which has a Chair appointed by the Chair of the EG—to discuss specific proposals in more depth. Many TWGs only have a few people, but in a contentious case, there may be 30 people or more in a single TWG.[56] TWGs often extend over the two-hour lunch break.[57] After lunch, the main session of the EG is reconvened and reports are made on the morning's discussion. There is a further round of questions and answers, and then provisional decisions are made about list changes. These decisions are provisional because all 'decisions' are made only at the Plenary each December.

The head of a delegation to the EG has a number of options when it comes to the provisional decision period. A State could choose to go on *Favourable*

[53] Interview with Wassenaar Secretariat Official C, 13 June 2007.

[54] Interview with British Former Government Official, 8 March 2007 and Interview with US State Department Official A & US State Department Official B, 11 September 2006.

[55] Interview with British Former Government Official, 8 March 2007.

[56] Interview with US Defense Department Official A & US Defense Department Official B, 5 February 2007.

[57] Interview with British Former Government Official, 8 March 2007.

Reserve, which means that the State is likely to accept the modification to the list without further revisions. If a State went on *Study Reserve*, it is saying that it needs more time to consider the details of a proposal, but is still considering accepting it. For more contentious issues, States may be on 'study reserve' for years.[58] Finally, a State could choose to go on *Reserve*, which means that there is a problem with the proposal—either political or philosophical—which the State is unlikely to accept.[59] One might think that an easy way to scuttle the hegemonic classification system in use at the Wassenaar would be for a Participating State simply to veto any decision. These vetoes do happen, as we will explore in Chapter 6, but they work against the hierarchical framing of the problem of dual-use technology. A person wishing to go against a hierarchical framing is rarely in the position to veto, which is the reserve of the head of each delegation—a position that often comes well into a career in the civil service, and therefore is likely held by a person who has for many years stated a preference for a hierarchical framing of the problem.

The EG is a social body as well as a working body. On one of the first few days of each formal session, there is a reception hosted by the Secretariat for all of the delegations, as a chance to break the ice with new members of delegations and in general engage with each other in a more conversational way. In addition to this, multiple delegations may meet up on occasion for meals—usually dinner. Such extensive contact between delegations is all meant to help integrate the professionals across national boundaries, and is strong evidence in support of the argument of Lipson (2006*a*) that Wassenaar serves as a 'trans-governmental network' of governmental officials with export control responsibilities (see also Lipson, 2005-2006*b*).

[58]Interview with British Former Government Official, 8 March 2007.

[59]Interview with US Defense Department Official A & US Defense Department Official B, 5 February 2007.

General Working Group

The General Working Group (GWG) is the internal body that discusses matters that are more policy-related. That is not to say that they do not work in technical areas as well, as will be seen in the case study on Intangible Technology Transfers in Chapter 7. They normally meet in May and October for only a few days. GWG meetings are usually attended by higher-level representation than at the EG, but generally not as high as the ambassadorial level of the Plenary.[60] The Chair of the GWG rotates yearly in reverse alphabetical order, thereby preventing a continuous follow-on between the GWG and the Plenary. There was not much interaction between the GWG and EG before the 2003 Assessment Year. They were seen as being separate, with the GWG focusing on political matters and the EG focusing on technical matters. Since then, however, there has been increasing cross-over between the two.[61]

The GWG is the place where much of the groundwork is laid for the other text outputs of the Arrangement, such as the 'Statements of Understandings', 'Elements for…', and 'Best Practices' documents. Statements of Understandings are seen as 'first steps' to either an Elements document or a Best Practice. For example, in 2001 the GWG developed the *Statement of Understanding on Intangible Transfers of Software and Technology*, which stated, in one paragraph, that transfer of controlled technology poses a risk, regardless of the medium of transfer. In 2006, the GWG developed the *Best Practices for Implementing Intangible Transfer of Technology Controls*, which lays out, over the course of two pages, how States should go about trying to control these types of transfers. It is therefore a more complicated document, and is based on the common understanding to which they had previously agreed.[62] While the GWG does not itself make modifications to the lists, it does clarify the

[60] Interview with Swedish Former Government Official, 6 January 2006.
[61] Interview with Swedish Former Government Official, 6 January 2006.
[62] For a full list of the documents produced by the GWG, see Appendix B.

boundaries of the lists by producing a document on 'intangible technology' or a *Statement of Understanding on Control of Non-Listed Dual-Use Items.*

Plenary

The Plenary meets for two days once a year, usually in the first week of December. As noted above, this is where all of the formal decisions for the Arrangement are taken. Everything from budgetary decisions for the functioning of the Secretariat to deciding on the documents that come out of the GWG, to approving the modifications to the lists by the EG, must be squeezed into these two days. Moreover, the people making the decisions will likely not have been involved directly in the EG or GWG. They will have been briefed about the developments over the past year, and may have—such as in the US case—actually been overseeing the entire process, but this will be the first trip of the year to the Secretariat for the majority of them. The purpose of the Plenary is for Participating States to give either their political approval to the work of the EG and GWG, or if a State is not able to give its approval, for it to make a political statement as to why it cannot do so. As will be seen in the discussions below on the proposal process for changing the lists, there is almost an art to deciding which proposals will not result in one State or another having to make a political statement about a list change. *A major unspoken objective of the EG is to sort out all of the political matters regarding a list change before it reaches the Plenary.*

LEOM & VPoCs

There are two other significant bodies of the Wassenaar Arrangement. The first is the *Licensing and Enforcement Officers Meeting* (LEOM). The LEOM is a forum in which licensing and enforcement officers discuss issues which are directly germane to their responsibilities in their State, including how to implement the Elements and Best Practice documents that come out of the GWG. The licensing officers are the people who actually decide whether a technology presented for export has sufficient characteristics to be matched to a piece of text on the Dual-Use (or Munitions) List. The enforcement officers are customs officials who have to make a similar assessment of the characteristic of the technology in order (a) to decide if a license is needed if it does not have one, or (b) to ensure that the license is valid. The LEOM also provides advice to the GWG. The chair of the LEOM does not rotate like the chairs of the other groups, because

> a lot of countries don't seem to have somebody who can deal with that issue well. . . Instead each year we try to recruit someone who is knowledgeable on the substance, who's got leadership skills, and has good English.[63]

The licensing and enforcement officers (LEOs) are an important part of the overall export control system, but their role is not one that I address directly in this thesis other than to point out that there is a direct connection between the texts of the Dual-Use List and the technology that may get exported. As a user of the lists, ability for a LEO to make this connection is an important aspect for the hierarchical framing in the process of list modification. The process of list modification, in this sense, can be seen as 'configuring the user' (Grint & Woolgar, 1997) in the process of inscribing the technology. The 'user' in this case is the LEO who has an established classification system and must become skilled in fitting each technology (or license application) he comes across into that classification system.

Finally, there are the *Vienna Points of Contact* (VPoCs, pronounced 'v-pocks'). These are usually people from the State's Embassy or Mission in Vienna who meet with the Secretariat on a monthly or bi-monthly basis to handle more of the administrative side of the Arrangement, such as budgeting, maintaining the building, etc. These people are, in a way, technical experts of a different nature.[64] Vienna is a city where many international organisations are

[63] Interview with US State Department Official A, 28 September 2006.

[64] Interview with British Government Official A & British Government Official B, 9 February 2006

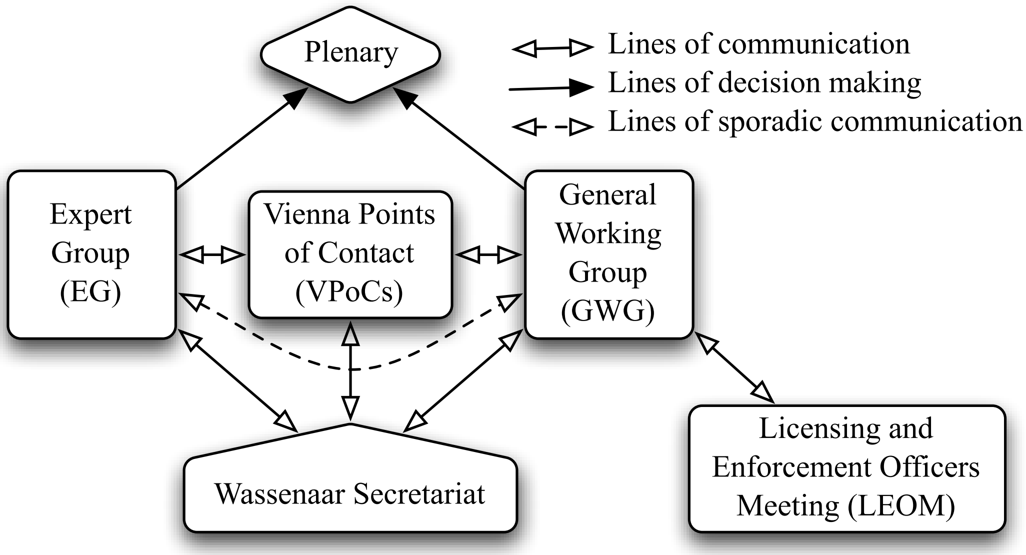


Figure 4.2: *Relation of the internal units of the Wassenaar Arrangement*

based, in particular many international security organisations, such as the International Atomic Energy Agency (IAEA), the Organization for Security and Cooperation in Europe (OSCE), and the United Nations (UN). A single VPoC will likely go to a few if not all of the organisations to perform similar duties, and thus provides a linkage between them. For many of the smaller countries, the VPoC may be the only person who ever attends any of the Wassenaar meetings. For some of the larger countries, such as Russia and Japan, the VPoC serves as the head of delegation to the EG and GWG.[65] The VPoCs also serve as official communication channels with the State, and are used by national delegations to the EG and GWG to get the official line from the State if the negotiating situation changes during a meeting. This is another example of Lipson's (2006*a*) idea that Wassenaar is a 'transgovernmental network' of export control officials. Figure 4.2 provides a graphical representation of the various standing bodies of the Wassenaar Arrangement, as described above.

[65]Interview with Russian Government Official & British Government Official F, 28 March 2007, and Interview with Japanese Government Official, 19 June 2007.

[redacted] & Outreach

There are two other structural aspects of the Wassenaar Arrangement that deserve mention here before we move on to look at the lists themselves. The first is the secure communication system that the Arrangement has developed, [redacted]. This consists of [redacted] a secured line [redacted] The documents [redacted] fall into two broad categories: proposals and reporting. Within the proposal section, there are all of the proposals that States have made over all the years of the Arrangement, both for changes to the lists and for the creation of new documents through the GWG. Within the reporting section, there are the statements from each State about the approvals and denials of licenses they have processed. States are required to notify the Arrangement on the denial of licenses for export of items on the Dual-Use List to non-members twice per year, except for items on the Sensitive and Very Sensitive Lists (SL & VSL), which require notification within preferably 30, but no more than 60, days of the denial. For items on the SL, VSL, and Munitions List, States are required to report on actual transfers every six months.[66] Each State puts its own information [redacted] and also has instantaneous access to all information entered by other States. They are therefore not beholden to the Secretariat to distribute the information from one State to all the others.

The final aspect of the Arrangement we will note here is the Outreach Seminar, which has been held twice, the first on 19 October 2004, and the second on 3 October 2005. The first, called "The Wassenaar Arrangement: Responsibility, Transparency and Security", brought together a wide range of participants from non-governmental organizations, think-tanks, academic institutes, industry and the media, together with representatives from a number of non-Wassenaar countries in order to "raise awareness of the positive con-

[66] These requirements are noted in the *Initial Elements*, V.2–4 and VI.2.

tribution that the Wassenaar Arrangement makes to responsible transfers of conventional arms and dual-use goods and technologies" (Wassenaar Arrangement, 2004*d*). The day allowed a unique interaction between the Arrangement and all of these other bodies, which has not been repeated since. Presentations covered

> the Arrangement's history, method of work, conclusions of the 2003 Assessment of its functioning, including its renewed focus on terrorism, current activities and areas of on-going negotiation. Other topics included the export control lists and how the lists are reviewed, arms brokering, work on small arms and light weapons and its ground-breaking work on shoulder-held anti-aircraft missiles or MANPADS. Participants from leading think tanks and NGOs also contributed their perspectives on arms export control issues, and how the Arrangement and civil society might enhance their cooperation (Wassenaar Arrangement, 2004*d*).

In 2005, the Seminar was repeated, but with much more of an industry focus. This time called "Outreach to Industry", the aim was "to provide for a professional exchange of views and sharing of national experiences with the aim of strengthening the effectiveness of export controls" (Wassenaar Arrangement, 2005*b*). At the time of writing, there were no plans to hold any future seminars. This is seen as unfortunate by some members, because it is one of the few ways that the Arrangement has been able to open up its internal workings to the outside world:

> But there are opportunities there [at the Outreach Seminars] to then fire back their own views, be they positive or negative. That's what we want. Partly to dispel this idea that this is some sort of secret club that engages in black arts. We don't sit around with our trouser legs rolled up and all that sort of thing. It's not true. And to an extent I suppose what I was saying about my frustration of the lack of understanding is a function of this lack of transparency, and this is the thing now that we are trying to address. We're saying, "no this is not secret, it's just that nobody's bothered to come and ask us, and we haven't found the appropriate forum to sit down with everybody and say what we do." So let's do it, and get rid of this idea that we won't talk about what we do. I mean, information

> exchange—sensitive government information—Hell, you've got to keep that secret. But how we do what we do, and why we do what we do, is not a secret.[67]

In terms of the methodology I employ in this thesis, this quote is key. It shows that the way I have defined my thesis questions is compatible with the type of information that the members wish to provide. That is, I want to analyse the relationship between patterns of social relations and the texts of the lists, and doing so does not necessarily require access to current negotiations, which may be too politically sensitive, nor to information about how many exports of controlled items country X licensed or denied. Instead, it requires understanding first what the Wassenaar Arrangement does, and second why each of the people involved in it believes they need to be engaged in the debate. This is precisely the information they are willing to give.

4.4 Conclusion

In this chapter, we have seen how, throughout the last several centuries, the need for export controls has always been a balance between the economic needs for exporting items of military significance and the desire to control who has those items. This balance leads to two different framings of the problem of dual-use technology: either as a problem of control or a problem of the marketability of technology.

If the problem is constructed as one of control, it can be resolved by systematically developing a classification of technology as either military, dual-use, or neither, and then by employing a set of routines and procedures (a bureaucracy) to ensure that technology which should be controlled, is controlled. This framing rests on three assumptions, which form its 'myth of control': that it is possible to control the flow of dual-use technology; that it is possible to know

[67] Interview with British Government Official A & British Government Official B, 9 February 2006.

from whom dual-use technology should be kept; and that it is possible to define what is and is not dual-use technology. It is these assumptions that have largely been institutionalised through the development of international export control systems. While the first two assumptions have recently come under heavy critique, the third has been largely neglected in the academic literature.

This hierarchical framing of the problem of dual-use technology has always had to contend with another framing which views the problem not as one of control, but as one of competition and the marketability of technology. When addressing the problem of dual-use technology, the myth of the competitive framing is that a market exists and that, if you meet or develop a new need in the market for a technology, that technology will be taken up, as long as it is priced appropriately and is perceived to be 'better than' any competitors.

The development of CoCom was, in part, a way for actors espousing two very different competitive framings to come together. The competitive framing of the economy is concerned with market failure, whereas the competitive framing of anarchy is concerned with the failure of the state. While employing the same rhetorical style, these framings would reach polar opposite stances on whether technology should be traded. By making the problem about maintaining lists of controlled technology, CoCom institutionalised a hierarchical framing of the problem, creating a common rhetoric that these otherwise incommensurable views can use to come to agreement.

The New Forum and the establishment of the Wassenaar Arrangement further institutionalised the hierarchical framing of the problem of dual-use technology. Wassenaar, like CoCom, has a permanent Secretariat that organises the meetings of the Arrangement and hosts them in its office space in Vienna. The Arrangement is organically (Durkheim, 1893) structured, with each functioning body addressing a separate part of the problem of dual-use technology, be it the technical side (Expert Group), political side (General Working Group), enforcement (Licensing and Enforcement Officers Meeting), or the day-to-day running of the Arrangement (Vienna Points of Contact).

All discussions at Wassenaar are centred on one primary aspect of technology: its military significance. This is the main criterion for the selection of items for each of its lists,[68] and guides all of the discussions in both the Expert Group and the General Working Group. Within that broad framework, the Arrangement clearly defines the types of knowledge that are relevant for discussions in its *Criteria for the Selection of Dual-Use Items*: foreign availability; the ability to control the item; the ability to clearly and objectively define the item; and whether it is controlled by another regime. Each of these criteria is control-related, and discussion about technology within the Arrangement is usually about negotiating the knowledge of how a technology does or does not meet the criteria. Knowledge about these technologies that is not seen by the hierarchical framing as related to the criteria (e.g. market share, or impact on health, environment, or poverty,. . .) is therefore irrelevant. I am not saying that these areas of knowledge *are* not important, only that, in order for them to be considered within Wassenaar discussions, they must be presented as relating to one of the criteria for control.

Within the Wassenaar Arrangement, the fact that there are lists of controlled items is comfortable knowledge, as is the knowledge about how to establish and run a national export control system. All of the rules and procedures for modifying the lists that we have discussed in this chapter are part of the hierarchical framing's comfortable knowledge. This knowledge is comfortable because it supports the assumption that the wicked problem of dual-use technology can be addressed through control measures.

While these points would suggest that there is only room within the Wassenaar Arrangement for a hierarchical framing, there have also been significant moves by the Arrangement to allow space for competitive framings. Major attempts at this include the two Outreach Seminars that were held in 2004

[68] "Dual-use goods and technologies to be controlled are those which are major or key elements for the indigenous development, production, use or enhancement of military capabilities" (Wassenaar Arrangement, 2005*a*).

and 2005, where industry and academic input was specifically sought on how the Arrangement might be improved. It is also the case, however, that many countries take up a competitive framing of the problem of dual-use technology during debates on specific list modifications, as we will see in later chapters.

The problem of dual-use, we can now see, is a wicked problem. There are multiple framings of the problem interacting on a continual basis within the Wassenaar Arrangement. The problem itself has been around for many centuries, and shows no signs of being soluble. The problem of dual-use technology can be seen as a symptom of other wicked problems, such as the effects of controls on the economy, or the effect of lack of controls on decreased security. The problem, for all of the history of CoCom and most of the history of Wassenaar, has only been a simple wicked problem, however. The discourse has been dominated by a debate between hierarchical and competitive framings of the problem and how to balance the two. This, as we explore in Chapter 7, may be beginning to change with the strengthening of a third, egalitarian, framing of the problem.

We now have an overview of the history of the Wassenaar Arrangement that is remarkably different than those that have been produced before, either for CoCom (Mastanduno, 1992; Noehrenberg, 1995) or Wassenaar (Lipson, 1999, 2006*a*). Instead of focusing primarily on the external environment in which the Arrangement sits, we have focused on viewing the Arrangement as a classification system that builds and maintains lists. Having established the importance of the lists, we now turn to an overview of the lists themselves.

The material culture of bureaucracy and empire is not found in pomp and circumstance, nor even in the first instance at the point of a gun, but rather at the point of a list.

—Bowker & Star (1999, p 137)

5 The Structure of the lists

Contents

Participating States of the Wassenaar Arrangement are supposed to implement the lists of controlled technology in their national export control systems in order to monitor the flow of the items to non-member countries and actively to make decisions on which items they want to export and which they do not. Having provided an overview of the history and structure of the Wassenaar Arrangement in the last chapter, in which we saw how the lists are central to their functioning and to the discourse on dual-use technology, I now turn our attention to the history and structure of the lists themselves. The lists represent the basis of the hierarchical framing and fulfil one of the assumptions of the myth of control: that it is possible to define a list of technology to control. Through an analysis of the history and structure of the international lists of controlled technology, we are looking for clues as to how they incorporate technological ambiguity.

We begin this chapter with a short history from the 16th to 20th Centuries of international lists of items controlled for their military significance. We explore in depth the CoCom lists to see how they developed throughout the life of CoCom. Key in this development is the shift that occurred during the 1990-1991 'Core List' revision. The overall structure of the lists relates to the needs that the lists serve, which in turn relate to how the technologies on the lists are described, or, as I argue, *in*scribed. The structure of the lists between CoCom and Wassenaar changed little, so in turning to the lists as they appear in the Wassenaar Arrangement, we focus on some definitional matters. I conclude with a description of the standard proposal process that Participating States go through when they want to make modifications to the Dual-Use List.

5.1 Lists prior to CoCom

As early as the late 16th and early 17th Centuries, there were international collaborations to control the trade in militarily significant items. The most prominent among these early examples were all bilateral treaties, often involving much more than just the control of goods, such as the treaty of the Pyrenees in 1659 between France and Spain and the treaty of Whitehall in 1661 between England and Sweden (Westlake, 1913, p. 278–280). The items listed were seen as 'contraband', a concept elaborated by Grotius (1625) on his work concerning the classification of goods transferred in times of war. Continuing through the 18th and 19th Centuries, many countries used 'contraband' to refer to things that were controlled in trade (Cupitt, 2000, p. 35–36; Westlake, 1913, ch. X). It is noteworthy that the term was, perhaps intentionally, ambiguous (Latané, 1919, p. 169). Efforts to define contraband reached the United States Supreme Court in its 1866 decision[1] on *The Peterhoff*, a ship that was said to have carried contraband between London and a neutral port during the American Civil War (¶136):

> The classification of goods as contraband or not contraband has much perplexed text writers and jurists. A strictly accurate and satisfactory classification is perhaps impracticable; but that which is best supported by American and English decisions may be said to divide all merchandise into three classes. Of these classes, the first consists of articles manufactured and primarily and ordinarily used for military purposes in time of war; the second, of articles which may be and are used for purposes of war or peace, according to circumstances; and the third, of articles exclusively used for peaceful purposes. Merchandise of the first class, destined to a belligerent country or places occupied by the army or navy of a belligerent, is always contraband; merchandise of the second class is contraband only when actually destined to the military or naval use of a belligerent; while merchandise of the third class is not contraband at all, though liable to seizure and condemnation for violation of blockade or siege.

It is important to note that whether or not something was contraband depended on its *use* in addition to physical characteristics. This is contrasted below (page 194) with the current application of 'dual-use' within the Wassenaar Arrangement, which specifically is not based on use. Use, as we shall see, is notoriously difficult to determine, and the British had decided well before the Peterhoff case that the classification of the good depended instead on its *destination.*[2]

We can also see here the difference between war and peace, which is only one of the ways that the 'dual' in dual-use can be split, as we reviewed in Section 2.2.

[1] This can be found in the files of the Supreme Court under 5 Wallace 28

[2] This was apparently decided in the Prize Court ruling of *Jorge Margaretha* in 1799, though I was not able to locate the original case. See Førland (1993, p. 159), a report on a similar case in 1949 (*The Frankisky (no. 1): Eygpt, Prize Court of Alexandria. July 21, 1949*, 1955, p. 592), and Pyke (1915, p. 119).

Technology, during this era, was controlled only in times of war. The tension with the definition of the term 'contraband' did not ease, and was the subject of much debate at the 1899 and 1907 Hague Peace Conferences. The British made a declaration at the beginning of the 1907 Conference arguing that "profound doctrinal and practical differences exist as to contraband" (Westlake, 1913, p. 287). The difficulty with the concept of contraband, Westlake (1913, p. 288) notes, is:

> that the progress of science has increased the number of things which in certain circumstances are of use in war though not absolute contraband in the strictest sense—that the complaints of neutrals on account of interference with the trade in things of that class have consequently increased—that the complexity of the cargoes carried by modern merchantmen of large size makes the search in them for contraband goods difficult and vexatious—that further difficulties would arise if a ship accused of carrying contraband was allowed to proceed on her voyage, the alleged contraband being transhipped or destroyed—that the destination of contraband to the enemy is often difficult of proof, and that under the doctrine of continuous voyage a belligerent might almost entirely interrupt neutral commerce—that for all these reasons the principle of contraband is the source of great damage to trade in non-contraband goods, and that neutrals demand indemnities so large that prize courts refuse them[. . .] and that to abandon it would be a work of peace and justice.

The rapid development of science, the complaints on the effect on commercial trade, and the difficulty of actually enforcing any control mechanisms are all points that appear time and again within the dual-use discourse, and form part of the rhetoric used by the competitive framing of the problem of dual-use technology. These arguments carried much strength, and while a resolution to accept the British position to abolish the concept of contraband received the support of twenty-five states,[3] it was also opposed by five: France, Germany, Montenegro, Russia, and the United States. Other states had put forward proposals for either abolishing or modifying the concept of contraband, but in the

[3]For a full list, see (Westlake, 1913, p. 288)

end, no agreement was unanimously reached and the matter was passed on to the Conference of London in 1908–9.

This Conference culminated in the *Declaration Concerning the Laws of Naval War* in London on 26 February 1909.[4] This declaration produced the first multilateral lists of controlled items in trade: ‘absolute contraband’, which have a direct use in war; ‘conditional contraband’, which may be used in both war and peace; and the ‘free list’, which contained things that are not contraband and therefore should not be stopped in their international transfer. The list of conditional contraband is in Article 24 (in Table 5.1), and the term is elaborated in Articles 33 & 35:

> Art. 33. Conditional contraband is liable to capture if it is shown to be destined for the use of the armed forces or of a government department of the enemy State, unless in this latter case the circumstances show that the goods cannot in fact be used for the purposes of the war in progress.
>
> Art. 35. Conditional contraband is not liable to capture, except when found on board a vessel bound for territory belonging to or occupied by the enemy, or for the armed forces of the enemy, and when it is not to be discharged in an intervening neutral port.

We can see here how it might be difficult to call the things under control ‘technologies’. Most people, for instance, would not consider food, grain, or gold technologies. We will explore this point more when looking at the development of controls on intangible transfers of technologies in Chapter 7. The 1909 list of contraband quickly grew during the World Wars, as countries moved items from the ‘free list’ onto the ‘conditional contraband’ list, and by the end of World War II there was nothing left on the ‘free list’, thereby making the concept of contraband vacuous, as everything was considered contraband (Førland, 1991, p. 10–11; Mastanduno, 1990, p. 47–48). Little reference is made to the term—as it applies to export controls—after this period.

[4]Available at http://www1.umn.edu/humanrts/instree/1909b.htm

Table 5.1: *Conditional contraband, as defined in the 1909 Declaration concerning the Laws of Naval War*

Art. 24. The following articles, susceptible of use in war as well as for purposes of peace, may, without notice, be treated as contraband of war, under the name of conditional contraband:

1. Foodstuffs.
2. Forage and grain, suitable for feeding animals.
3. Clothing, fabrics for clothing, and boots and shoes, suitable for use in war.
4. Gold and silver in coin or bullion; paper money.
5. Vehicles of all kinds available for use in war, and their component parts.
6. Vessels, craft, and boats of all kinds; floating docks, parts of docks and their component parts.
7. Railway material, both fixed and rolling-stock, and material for telegraphs, wireless telegraphs, and telephones.
8. Balloons and flying machines and their distinctive component parts, together with accessories and articles recognizable as intended for use in connection with balloons and flying machines.
9. Fuel; lubricants.
10. Powder and explosives not specially prepared for use in war.
11. Barbed wire and implements for fixing and cutting the same.
12. Horseshoes and shoeing materials.
13. Harness and saddlery.
14. Field glasses, telescopes, chronometers, and all kinds of nautical instruments.

Instead, CoCom employed the term 'strategic goods' to refer to all of the items on its lists (e.g. British Government, 1954), and the term reflects the larger Cold War bipolar stance of the time. The term never had much use outside of CoCom, however, and in the 1980s the US began referring to the items under control, which were not specifically military, as 'dual-use' (Mally, 1982).[5] The term was concurrently adopted in the academic literature (Mastanduno, 1985; Meese, 1981–1983).

This brief history shows that there has been significant international collaboration on export controls, and specifically on developing lists of controlled technology, for at least the past three hundred years. This process has often incorporated ambiguities into the controlled technology, either through not specifically naming the items controlled or by allowing the lists to shift over time. Neither earlier treaties nor the Declaration of 1909 were seen as carrying much weight, however, as the controls were so difficult to impose.

5.2 The CoCom lists

The CoCom lists were never publicly available, but were "virtually identical to the national lists published by some CoCom members" (US Office of Technology Assessment, 1979, p. 156). All references to the lists in academic literature refer instead to the British lists, published by the Export Control Organisation within the Department of Trade and Industry as a supplement to its trade journal. The members of CoCom themselves often referred to the British lists as well, because they were published in easy to carry booklets.[6] I therefore base this discussion of the CoCom lists on those published by Britain (British Government, 1954, 1958, 1960, 1961, 1962, 1964, 1966, 1969, 1972, 1976, 1980, 1985, 1987, 1989, 1990, 1991*a*,*b*, 1993*a*).

[5] Mally was a Foreign Affairs Officer with the US Arms Control and Disarmament Agency at the Department of State.

[6] Phone interview with Robert Anstead, member of US delegation to CoCom, 24 March 2008.

The US was by far the most dominant player in all of the CoCom meetings, but particularly in the lists meetings, as they had more resources and more people than the other delegations. While decision making occurred by consensus, "CoCom delegations almost never opposed an export of which the US approved during the 1980s" (Noehrenberg, 1995, p. 51). Similarly, "the US was always the instigator for including a technology on the lists. Due to its greater resources, it could investigate, prepare, and argue a case for such inclusion better than any other delegation" (Noehrenberg, 1995, p. 54). The US dominance was not complete, though. From the very beginning of CoCom there were compromises between the US position and that of other countries (Mastanduno, 1992, p. 81).[7] The US position was also not always unified. There were many differences of opinion between the military and the Department of Commerce (Yasuhara, 1991).

While the US continually argued for putting items on the lists, it also—at least until the 1990s—continually vetoed taking items off, even when the technologies became less and less militarily critical due to technological progress (Mastanduno, 1992). This suggests that the US viewed the list less as a system of nested categories and more as a homogenous whole, supporting my point earlier that the concern was less with the problem of dual-use and more with the problem of international anarchy. When in doubt, things go onto the list, though it does not matter where. At the same time, the US very much believed in the need to form the lists and for all to agree to them, thus recognising that the problem of dual-use must also be addressed. Even a preliminary look at the political situation in the late 1940s and early 1950s shows how these views of the lists were mirrored in the social framework the US was using—a competitive framing focused on a rivalry with the Soviet Union and a recognition that that

[7]The US wanted CoCom to be part of NATO, "so that issues of economic security could be treated as part of political and military strategy" (Mastanduno, 1992, p. 81). In a footnote to that sentence, Mastanduno notes, "[t]he US preference that export controls be handled within the context of NATO is expressed in a telegram from Harriman to Hoffman, November 5, 1949, reprinted in *FRUS*, 1949, 5:169–71." I was unable to get access to this telegram.

required the joint effort of many states.

An excerpt from Mastanduno (1990, p. 76) provides some insight into a typical CoCom list review process; as we will see in the case studies in later chapters, this process is largely the same in Wassenaar.

> Several criteria are relevant in this review process, including military utility and significance, and the availability of the item in question from non-CoCom countries. In a typical bargaining sequence, the United States might provide an assessment of a particular item's military utility (e.g. "these machine tools are used in the following way by our Air Force"), while other members might produce evidence that the item can be readily purchased in non-CoCom countries or can be produced by controlled destinations themselves. The review process is tedious and time-consuming. It usually involves a series of proposals and counterproposals based on technical assessments colored by bureaucratic or economic interests. Delegations in Paris frequently must refer back to their home governments for guidance and negotiating instructions. Some of the technologically less advanced members do not participate actively in list reviews, and instead rely on the technical judgements of others. The United States will frequently seek bilateral agreement with certain key member states as a means to facilitate reaching multilateral agreement.

Throughout the life of CoCom there was a series of major list reviews: 1954, 1958, 1978, 1982–1984, and 1990–1991 (the 'Core List' revision). There were also minor list reviews conducted yearly from 1958–1969, and every three years from 1969–1984 (Mastanduno, 1992, p. 110n). From 1985 until 1990, there was a rolling list review, where segments of the lists, rather than the entire list, were up for review each year (Mastanduno, 1990, p. 76).

In the first few years of CoCom, during the Korean War, the lists were broadened beyond items of direct military utility to those with more general economic significance. "This was done on the grounds that Soviet economic and military power were synonymous" (Mastanduno, 1990, p. 77). However, the revisions to the lists in 1954 and 1958 saw significant reductions in the items controlled (British Government, 1954, 1958). They remained relatively short for the next twenty years, but became increasingly controversial among members as global trade grew and requests for exceptions to export mounted (Mastanduno, 1990, p. 77). Here, then, we see the now hegemonic hierarchical framing being challenged by the competitive framing, which argued for doing away with the lists, or at least decreasing the level of control.

In the beginning of CoCom there were two lists. List I contained items that were subject to a full embargo for shipment to the Soviet Union. List II contained items that had quantitative limits of the number of exports (British Government, 1954).[8] List I was broken into Groups A-M. Most of these items were not weapons, but things like machine tools, industrial chemicals, bearings, locomotives, radio equipment, electronic equipment, oils, and rubbers. Group H had atomic materials, and Group M covered conventional, biological, and chemical weapons. List II contained some of the first set of items, but with different specifications. List I was 6 two-column pages, and List II not quite one page.

The 1958 revision saw the 'List' categorisation removed (British Government, 1958). Adler-Karlsson (1968) says that this move came from removing List II (the quantitative control list), which could "almost be regarded as a final revision in the economic warfare, as the CoCom policy hereafter, with few exceptions, was concentrated on commodities which by all participating states were considered to be properly 'strategic'" (p. 96). Another way to view it, however, is the receding of the competitive framing of the alternative framing of the problem of international anarchy, and its gradual replacement with a hierarchical framing of the problem of dual-use technology. However, List II seems to have been incorporated into List I by means of 'Notes', which explicitly said that, at least for Britain, applications for export would be considered for certain items.[9] As of 1958, CoCom was also now directed at the following

[8] Some note a List III, which contained items whose place on Lists I & II was not yet decided (Mastanduno, 1992, p.94n and US Office of Technology Assessment, 1979, p. 155), but it depends on when you place the actual start date of CoCom. I place it when Lists I & II were first finalised (1950), which was when there was no longer a List III.

[9] These 'Notes' were replaced by words in italics in 1972, and greatly expanded.

countries: "Albania, Bulgaria, China, Czechoslovakia, Hungary, North Korea, North Vietnam, Poland, Roumania, The Soviet Union, the Soviet Zone of Germany and Tibet" (British Government, 1958). This represents a strengthening of the competitive framing of the alternative problem of anarchy. The Groups on the lists were labelled as shown in Table 5.2. One of the main things to

Table 5.2: *Categories of the 1958 Industrial List*

Group A	Metalworking Machinery
Group B	Chemical and Metallurgical Plant, Compressors, Furnaces, Pumps, Valves, etc
Group C	Diesel Engines and Electric Generators
Group D	Miscellaneous Goods and Machinery
Group E	Transport
Group F	Electronic Equipment including Communications and Radar
Group G	Scientific Instruments and Apparatus, Servomechanisms and Photographic Equipment
Group H	Metals, Minerals and Metal Manufactures
Group I	Chemicals, Plastics and Synthetic Rubbers
Group J	Petroleum Products, Lubricant and Hydraulic Fluids
Group K	Arms, Munitions, Military Equipment and Machinery etc. Specially designed for their Production

note about these early lists is that most of the items that were on them were easily identifiable as items. That is, they would contain the title of the item and perhaps one or two characteristics. You could easily talk about an item as an 'entry'. Thus, in 1954, Group G contained a single line for computers, shown in Figure 5.1.

1960 saw another reorganisation of the lists (Table 5.3), moving the single paragraph that was all arms and munitions, along with the single sentence

Computors, electronic, other than office calculating machines.

Figure 5.1: *1954 entry for computers (not actual image) (British Government, 1954)*

that was the atomic list, into their own Groups (British Government, 1960). All totalled, it was 9 pages. All of the items now had numbers as well, "as a means of ready identification and reference," instead of the simple itemised list that existed before (British Government, 1960, p.276).

Table 5.3: *Categories of the 1960 Industrial List*

Group A	Munitions List
Group B	Atomic Energy List
Group C	Metal-Working Machinery
Group D	Chemical and Petroleum Equipment
Group E	Electrical and Power-Generating Equipment
Group F	General Industrial Equipment
Group G	Transportation Equipment
Group H	Electronic Equipment including Communications and Radar
Group I	Scientific Instruments and Apparatus, Servomechanisms and Photographic Equipment
Group J	Metals, Minerals, and their Manufactures
Group K	Chemicals, Metalloids, and Petroleum Products
Group L	Synthetic Rubber and Synthetic Film

In the 1966 lists, the Munitions and Atomic Energy Groups fully separated from the others, and each became their own lists (British Government, 1966). The lists were now: Munitions List; Atomic Energy List; Groups A-J (the old

Groups C-L).[10] One point of note here is that the British Government began (with the 1962 edition of the lists) sidelining the changes that were made in the actual text (this process stopped by the 1972 lists). This made it very easy to note where additions were made. Deletions were noted in the beginning of the lists. As a whole, the statement at the beginning of the lists from most years contained some form of the phrase "the net effect is to reduce the scope of the embargo," and yet the lists continued to get longer. In 1966, they were 25 pages. 1966 also saw the introduction of a new paragraph in the preamble to the lists:

> Manufacturers are reminded that the purpose of these strategic controls will be defeated if technical information or technical know-how concerning embargoed equipment is revealed to the above countries. Great care should therefore be taken to prevent this happening. A particular danger arises when technicians or students from these countries are visiting or are being trained at British factories.

This was the first mention of trying to control the intangible transfer of technology. It appeared in all lists after this date. We shall be looking at this issue in depth in Chapter 7.

As the lists became more complex, further qualifications were needed on what constituted an item on the list. Why was this happening? Mastanduno (1992) argues that this was due to conflict between two different perceptions of the relationship between technology trade and (inter)national security (p. 13 & Ch.2). According to one view—'economic warfare'—controls would be broadened to include any technology that would strengthen the economy of an adversary. "The assumption here is that because military power is ultimately dependent on an economic base, quantitatively and qualitatively, trade that significantly enhances the economy of an adversary indirectly enhances its military power and thus should be prohibited in the interest of national security" (p. 13). This was the view that the US took, particularly in the 1949-1958 and

[10] Note that these Group letters equate to the 1958 revision of the lists, minus Group K.

1980-1984 years, when it saw its relationship with the Soviet Union as more politically confrontational.

According to the other view, strategic (security) aims could be met by controlling only the technologies that made a "direct and significant contribution to an adversary's military capabilities" (p. 13). This view would include technologies deemed to be purely 'military', but also those which had commercial as well as specific military uses, and Mastanduno refers to it as a 'strategic embargo'. This was the view preferred by European members of CoCom, Mastanduno argues, because they, unlike the US, did not see themselves in an arms race with the Soviet Union and they had a greater economic interest in East-West trade, and therefore preferred the competitive framing of the problem of dual-use technology. Many European members of CoCom held this view from the beginning, and after 1958 they were able to convince the US to relax the controls, or at least they were able to thwart many attempts to broaden the controls. This often meant that the text on the lists got longer because they were more narrowly focused. As we shall see in the next chapter, such an outcome is the result of the 'monster-adjustment' strategies that the hierarchical framing employs to handle anomalies to the dual-use classification system.

From listing technologies to listing parameters

Rather than listing technologies under control, the CoCom Industrial List, from 1958 onwards, shifted to describing the parameters of a technology under consideration and the value of each parameter. To return to our earlier example of the single line to describe computers, it had by 1976 turned into item *1565* in Group G (actually now combined with Group F) and covered three two-column pages, plus another page and a half for describing *1564*, "Electronic component assemblies, sub-assemblies, printed circuit boards, and microcircuits". *1564* is worth closer inspection to help us understand the changes taking place in the lists. It first appeared in the 1960 lists and occupied seven lines. By the 1972 lists it consisted of the the text shown in Figure 5.2.

1564. Electronic components as follows:

(a) Assemblies and sub-assemblies constituting one or more functional circuits with a component density greater than 75 parts per cubic inch (4.575 part per cubic centimetre);

(b) Modular insulator panels (including wafers) mounting single or multiple electronic elements and specialised parts therefor.

Explanatory Note: Circuit boards and panels which do not contain components described in this list and which do not come within the scope of sub-item (a) above are not covered by sub-item (b) unless they are constructed of insulating materials other than paper base phenolics, glass cloth melamine, glass cloth epoxy resin or of insulating materials with an operating temperature range not exceeding that of the above-mentioned materials.

(c) integrated circuits, i.e. assemblies and sub-assemblies containing one or more functional circuits in which there are both components and inter-connections formed by the diffusion or deposition of materials into or on a common substrate.

Devices described in sub-items (a), (b), (c), provided that the devices have been designed specifically for identifiable civil applications and, by nature of design or performance, are substantially restricted to the particular application for which they have been designed.

Figure 5.2: *1972 entry for item 1564 (not actual image) (British Government, 1972)*

We can see here both the use of the 'Explanatory Note' and the *italicised* text noting items that were more likely to receive a license to export. The next two pages show *1564* as it appeared in the 1976 lists (British Government, 1976, p. 317-318), and using this image of the lists we can ask, 'how many technologies are controlled here?'

quency may reach 1.5 × 10^{10}. For tubes intended for other applications and rated for operation without a grid current, the product of the rated anode dissipation and the square of the maximum frequency may reach 2.5 × 10^8.

(2) Tubes rated only for pulse operation having either of the following characteristics:

(i) above 1,000 MHz at the peak pulse output power; or

(ii) between 300 MHz and 1,000 MHz and for which under any condition of cooling, the product of the peak pulse output power (expressed in watts) and the square of the maximum frequency (expressed in MHz) is greater than 4.5 × 10^{10};

Tubes in which the velocity of the electrons is utilised as one of the functional parameters, including but not limited to klystrons, travelling wave tubes and magnetrons, *except*:

(i) Low power oscillator klystrons designed to operate at frequencies below 13.5 GHz with a maximum rated output power of less than 3 W;

(ii) Fixed frequency and tunable pulsed magnetrons which are in normal civil use in equipment which may be exported under the terms of this List as follows:

(1) designed to operate at frequencies below 3.5 GHz with a maximum rated output power of 1.2 MHz or less;

(2) designed to operate at frequencies between 3.5 GHz and 10.5 GHz with a maximum rated output power of 300 kW or less;

(iii) Fixed frequency continuous wave magnetrons designed for medical use or for industrial heating or cooking purposes operating at a frequency of 2.45 GHz ± 0.05 GHz with a maximum rated output power not exceeding 5 kW or at a frequency lower than 1 GHz with a maximum rated output power not exceeding 25 kW;

Valves designed to withstand acceleration of short duration (shock) greater than 1,000 g;

Valves designed for operation in ambient temperatures exceeding 300°C;

Vacuum tubes specially designed for use as pulse modulators for radar or for similar applications, having a peak anode voltage rating of 100 kV or more; or rated for a peak pulse power of 2.4 MW or more.

Travelling wave tubes and mounts designed to operate at frequencies below 13.5 *GHz for use as the output tube in civil communications, subject to the tube having the following characteristics:*

(i) a saturated output power not exceeding 40 *W at or below* 8.5 *GHz;*

(ii) a saturated output power not exceeding 20 *W between* 8.5 *GHz and* 13.5 *GHz.*

Tubes covered by sub-items (a) and (b) above, specially designed for television purposes and which are to be used in television transmitters, the precise location of which is known, for civil telecasting according to CCIR or OIR standards.

Tubes covered by sub-items (a) and (b) required as replacement parts for specific civilian equipment (for example pulse amplifier klystrons and fixed frequency and tuneable pulsed magnetrons covered by sub-item (b) and needed for civil radar) not exceeding the capability of that which could be exported in the context of other List items, provided that these parts do not upgrade the initial performance of that equipment.

Pulsed amplifier klystrons described in sub-item (b) above designed to operate at frequencies below 3.5 *GHz with a maximum rated peak output power of* 1.6 *MW or less.*

Hydrogen thyratrons rated for a peak pulse power output 5 MW or more.

Explanatory Note: A thyratron is any hot cathode gas-filled tube having 3 or more electrodes in which anode current flow is initiated by a control electrode.

Hydrogen thyratrons required as replacement parts in specific civil radar equipment previously exported, provided that they do not upgrade the initial performance of that equipment.

Capacitors designed for and/or capable of maintaining their electrical and mechanical characteristics during their specified operating lifetime, as follows:

Monolithic ceramic capacitors rated for operation over the whole range of ambient temperatures from below −45°C to above +100°C;

Tantalum electrolytic capacitors rated for operation at ambient temperatures exceeding +125°C, *except* sintered electrolytic types having a casing made of epoxy resin or which are sealed or coated with epoxy resin;

(c) Other capacitors rated for operation at ambient temperatures below −55°C or above +200°C.

Monolithic ceramic capacitors covered by this item which are rated for operation at ambient temperatures within the range from −55°*C to* +125°*C.*

1561. Materials specially designed and manufactured for use as absorbers of electromagnetic waves having frequencies greater than 2 × 10^8 Hz, and less than 3 × 10^{12} Hz.

1564. Electronic component assemblies, sub-assemblies, printed circuit boards, and microcircuits.

I. Defined as follows:

(a) Assembly—A number of components assembled to perform a specific function or functions, replaceable as an entity (and normally capable of being disassembled).

(b) Microcircuit—A device in which a number of passive and active circuit elements are considered as indivisibly associated on or within a continuous structure to perform the function of a circuit.

(c) Monolithic integrated circuit—A microcircuit fabricated as a single component consisting of elements formed in or on a single semi-conducting substrate by diffusion, implantation or deposition.

(d) Film type microcircuit—An array of circuit elements and metallic interconnections formed by deposition of a thick or thin film on an insulating substrate.

(e) Multichip microcircuit—A microcircuit containing two or more monolithic integrated circuit chips bonded to a common substrate.

(f) Hybrid microcircuit—A microcircuit consisting of a combination of film type microcircuits and monolithic integrated circuit elements or combinations of either with discrete components.

(g) Circuit element—A single active or passive functional item in an electronic circuit, such as one diode, one transistor, one resistor, one capacitor.

(h) Discrete component—A separately packaged circuit element with its own external connections.

II. Listed as follows:

(a) High density assemblies, constituting one or more functional circuits, (*except* those with a discrete component density of 15 per cc (246 per cubic inch) or less), having any of the following characteristics:

(1) Consisting of discrete components and integrated circuits;

(2) Incorporating any active discrete component, caught by another item in this schedule;

(3) Designed or rated for continuous operation without derating over the temperature range −55°C to + 85°C;

(4) Designed or rated as radiation hardened circuits;

(b) Printed circuit boards (single sided, double sided, or multi-layer) designed to mount and provide interconnection between electronic components (with or without such components), *except* those mounting no controlled components and manufactured from any of the following insulating materials:

(i) Paper base phenolics

(ii) Glass cloth melamine

(iii) Glass epoxy resin

(iv) Polyethylene terephthalate

(v) Any insulating material with a maximum continuous rated operating temperature not exceeding 150°C;

(c) Microcircuits (monolithic integrated circuits, multichip, hybrid, or film type microcircuits), *except*

(1) encapsulated passive networks formed by thick film deposition techniques; or

(2) encapsulated and tested circuits which are not designed or rated as radiation hardened, which are packaged in TO-5 outline cases (0.305 inch to 0.370 inch diameter) or in non-hermetically sealed cases and which are:

(i) Bipolar types designed for operation as saturated digital logic circuit elements (except Schottky barrier and ECL types), having all rated maximum propagation delays of 15 nanoseconds or more, and all typical digital propagation delays are 7 nanoseconds or more (for devices specified only in terms of clock or toggle rate, the typical value must be 30 MHz or less), encapsulated in a package having 16 terminals or less, and not rated for operation below −20°C or above +75°C;

(ii) Encapsulated and tested circuits which are not designed or rated as radiation hardened, which are packaged in TO-5 outline cases (0.305 inch to 0.370 inch diameter) or in non-hermetically sealed cases and which are:

(1) Bipolar types designed for operation as digital logic circuit elements but limited to gates, inverters, buffers, bilateral switches, drivers, counters, latches, adders, comparators, parity generators, multiplexers, expanders, flip-flops, multivibrators, code converters, registers, decoders, demultiplexers, diode matrices, multipliers and Schmidt-triggers, and having all of the following characteristics:
  - (a) A product of the typical basic gate propagation delay time, in nanoseconds, and the power dissipation per basic gate, in milliwatts, not less than 70 pJ (ie speed-power product/gate not less than 70 pJ);
  - (b) A typical propagation delay time not less than 5 nanoseconds;
  - (c) Not rated for operation below −20°C or above +75°C; and
  - (d) Encapsulated in a package having 16 terminals or less.

(2) (a) Non-reprogrammable P-channel MOS circuits specially designed for, and which by virtue of circuit design, content and lay-out are limited to use for, simple manually operated calculators which provide no more than the following six operational functions; addition, subtraction, multiplication, division (including percentage and reciprocal), squaring, square root; and are not rated for operation below −20°C or above +75°C;
  - (b) P-channel MOS circuits, specifically designed as, and which by virtue of circuit design, content and layout are limited to use as, digital shift registers with a maximum clock rate of 2 MHz, a maximum number of bits per package of 256 and are not rated for operation below −20°C or above +75°C;

(3) Non-reprogrammable types specially designed for, and which by virtue of circuit design, content and lay-out are limited to use only for, functional purposes in the electrical systems of automobiles or trucks.

(4) (a) Untuned AC amplifiers having a bandwidth of less than 1 MHz and a maximum rated power dissipation of 5 W or less at a case temperature of 25°C;
  - (b) Audio amplifiers having a maximum rated power dissipation of 25 W or less at a case temperature of 25°C;

(5) Operational amplifiers, having all of the following characteristics:
  - (a) A typical unity-gain open-loop bandwidth of not more than 5 MHz;
  - (b) A typical open-loop voltage gain of not more than 100,000 or 100 dB;
  - (c) A maximum intrinsic rated input offset voltage of not less than 5 mV;
  - (d) A slow rate not exceeding 1 Volt/microsecond;
  - (e) Not rated for operation below −20°C or above +75°C;

(6) Voltage regulators, having all of the following characteristics:
  - (a) A rated nominal output voltage of 40 Volts or less;
  - (b) A maximum output of current of 150 mA or less;
  - (c) A rated maximum power dissipation of 1.5 W or less, at a case (or mounting base) temperature of 25°C;
  - (d) Not rated for operation below −20°C or above +75°C;

(7) Voltage comparators, having all of the following characteristics;
  - (a) A maximum input of offset voltage of not less than 2 mV,
  - (b) A typical switching speed or typical response time of not less than 30 nanoseconds;
  - (c) Not rated for operation below −20°C or above +75°C;

(8) Types specially designed for civil uses as frequency modulation stereo multiplex demodulators, television synchronisation signal processors, and not rated for operation below −40°C or above +85°C;

(9) Bipolar memory devices, having all of the following characteristics:
  - (a) A maximum number of bits per package not exceeding 64;
  - (b) A typical access time not less than 50 nanoseconds;
  - (c) Not rated for operation below −20°C or above +75°C; and
  - (d) Encapsulated in a package having 16 terminals or less;

(10) Non-reprogrammable, non-imaging types specially designed for use in unembargoed cameras (including cine cameras) and medical pacemakers, and which by circuit design, content and lay-out are normally limited to such use;

(11) Bipolar types designed for operation as electronically controlled switches (inductive, magnetic, optical) or threshold value switches, with switching times of 7 microseconds or greater, designed for civil uses and not rated for operation below −20°C or above +75°C.

Explanatory Note: Nothing in the above shall be construed as sanctioning the export of technology for manufacture of any assembly, sub-assembly, microcircuit (monolithic integrated circuit, multichip hybrid, or film type microcircuit) or circuit element referred to in this item. For manufacturing equipment see Item 1355 and/or Item 1356.

Devices described in sub-items II (a), (b), (c), provided that the devices have been designed specifically for identifiable civil applications and, by nature of design or performance, are substantially restricted to the particular application for which they have been designed.

Devices covered by sub-items II (a), (b) and (c) above when they consist of, or are incorporated in, plug-in printed circuit boards or plug-in modules for use in equipment which is not caught in this schedule, or for use in specifically identified equipment previously exported, and which do not upgrade the initial performance of that equipment, provided that the plug-in printed circuit boards or plug-in modules cannot operate independently from the equipment to which they are to be connected or inserted.

Integrated circuits covered by sub-item II (c) above only by virtue of being encased in hermetically sealed dual-in-line packages provided that the exporting government is satisfied that the stated legitimate civil end-use requires such a package. Devices covered by sub-item II (c) above which are designed specifically for use in clocks and watches and by design or performance restricted to such use.

P-channel MOS circuits qualified for release under sub-item II(c)(ii)(2)(a) above except by virtue of the temperature limits therein, provided they are not rated for operation at temperatures below −40°C or above +85°C.

Explanatory Note: This item is not intended to cover any of the following:

- (i) Non-coherent light-emitting alpha-numeric displays (see also Item 1544);
- (ii) Any display as in (i) above which incorporates an integrated circuit (not rated for operation below −20°C or above +75°C) used for controlling and/or driving that display, provided that the integrated circuit is not integral with the actual display device;
- (iii) Simple encapsulated photo coupler (transoptor) assemblies with electrical input and output and which incorporate non-coherent light-emitting diodes.

1565. Electronic computers and related equipment, as follows:

- (a) Analogue computers designed or modified for use in airborne vehicles, missiles or space vehicles and rated for continuous operation at temperatures from below −45°C to above +55°C and equipment or systems incorporating such computers;
- (b) Other analogue computers capable of accepting, processing and putting out data in the form of one or more continuous variables

One answer to 'how many technologies are on the list?' is that there are four, as noted in the title of *1564*: *electronic component assemblies; sub-assemblies; printed circuit boards; and microcircuits.* But are these technologies, or are they categories of technology, a container for more defined items that might be presented in an export license request? There were many different items which may have been presented for export which could all have had the label 'microcircuit', and there were many items which did not fall under the label because they did not meet the further elaborated criteria.

If we look a level down then, we find that *1564(c) 'microcircuits'* is actually four different things: monolithic integrated circuits; multichip microcircuits; hybrid microcircuits; and film type microcircuits. If we accept that 'microcircuits' is a category of technology composing these four items, then might each of these be considered a technology which could be controlled? They might, but only if they did *not* fall into one of the further sub-categories, sub-subcategories, or sub-sub-subcategories, all of which are covered in an exception clause. But even if it did fall into one of those sub-sub-subcategories, it still might not be controlled if it had certain characteristics. Thus *1564(c)(2) encapsulated and tested circuits* which are *1564(c)(2)(ii) encapsulated and tested circuits*[11] that are *not* designed or rated as radiation hardened and that *are* packaged in TO-5 outline cases or non-hermetically sealed cases, would only be controlled if they could *not* be considered *(5) operational amplifiers* that met characteristics (a) through (e).

We are almost there. We have now reached the Explanatory Notes and the *italicised* notes, which as noted above describe items that were likely to receive a favourable license application review. Thus, given all of the above, our 'technology' on the Industrial List seems to have become entirely ambiguous. The 'interpretative flexibility' of the lists, to use Bijker's (1993) terminology, has been narrowed, but at the same time it is clear that the technologies to which the broad categories of text refer (e.g. 'computers') are no longer the

[11]Yes, the exact label is applied to both *1564(c)(2)* and *1564(c)(2)(ii)*.

"robust pockets of interpretation in a sea of interpretively flexible texts" that Woolgar notes technologies usually are (Woolgar, 1991, p. 39).

How many technologies are controlled? It is impossible to say for several reasons. First, by using an exception clause, *1564* controls everything but a small section of 'microcircuits'. This is like asking, "how many widgets are in the box?" and getting the answer, "no widgets that are blue are in the box."

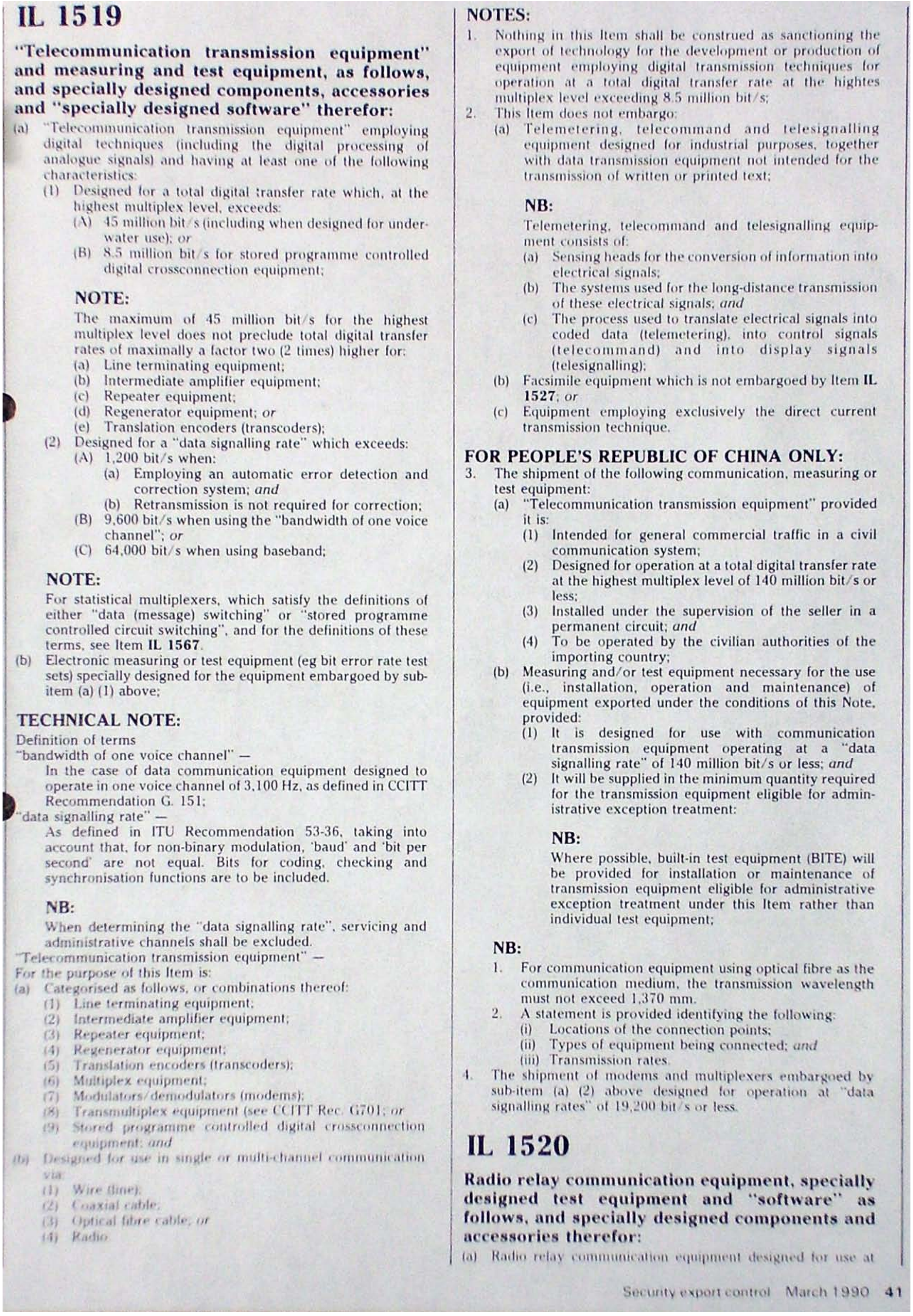
A stronger argument for why we cannot count how many technologies are on the lists is that 'technology' is actually a container phrase. It does not refer to an artefact or set of practices so much as it refers to a set of characteristics that those artefacts or practices (or indeed knowledge) might embody. As the lists get more complex and items on the lists become more defined, what we are seeing is a negotiation that involves finding a characteristic of a technology which satisfies the different framings of the problem of dual-use technology. Rather than defining a technology that is controlled, the actors making the changes to the lists are creating a new container, a new collection of characteristics. They are *inscribing* the technology, rather than describing it. In so doing, they are trying to decide between the many characteristics that might be included. That is, *they are working with the ambiguity of technology.* Which characteristics are finally inscribed are ones that allow enough ambiguity to remain in the technology so that each of the framings is heard and responded to (see Schwarz & Thompson, 1990).

The 1980s saw a major expansion in the text of the lists, particularly in electronics, where *IL 1565*—computer controls—had not changed in nearly a decade (British Government, 1985, 1987). And by 1990, the lists had grown both lop-sided—with extensive control text on some Groups and virtually none on others—and still out-dated. The rolling review process adopted in the second half of the 1980s was moving too slowly for many members who wanted to see more technologies removed (Noehrenberg, 1995, p. 78–79).

There are several points about these lists that deserve mention here. First, the numbering of the Industrial List (IL), generated in a time when the list was still largely a list of technologies, was by now seen as inadequate, because CoCom members were trying instead to list parameters of technologies. The IL was broken into eight Groups, each with 100 possible divisions (i.e. from 1000–1099 for Group A). Not all of these divisions were used. When the numbered divisions were first introduced, the gaps between them seemed highly arbitrary and likely reflected either the perception of future needs to control technology which might have fallen in between two divisions, or else were the result of an initial culling of the lists that were used to generate the first CoCom lists (Yasuhara, 1991). Within each division, technologies and parameters were listed in the order in which they were added to the list. As the list shifted to describing parameters of technologies, it was no longer adequate just to have a standardised organisation of the Groups and the divisions (numbers) within Groups. There needed to be more organisation.

Secondly, the IL was by now riddled with Notes, Technical Notes, and N.B.s. For instance, Figure 5.3 shows *IL 1519*, which is only 21 lines long without the Notes. These notes, combined with the layout of the pages, make it difficult to understand where one is in the lists—particularly when a division may go on for pages—and the precise classification an item would have to come under in order to be controlled (or licensed for an exception to a control). More importantly, there was not a consistent pattern of when each type of note was used.

Another point of note, as also shown by Figure 5.3, is that, as of March 1990, the IL was massively lop-sided. Many divisions had been deleted. Group B, for example, had only *IL 1110*, *IL 1129*, *IL 1131*, and *IL 1145*. Similarly, some divisions had grown enormously long, such as *IL 1565*, which laid out the characteristics of computers that were controlled. Most of the IL Groups were under 10 pages each—Group B was under one page—while Groups F & G '*Electronic equipment including communications, radar, computer hardware and software*' were combined and totalled 56 pages. This lop-sidedness demonstrated that different types of technologies were of strategic value in the 1980s



IL 1519

"Telecommunication transmission equipment" and measuring and test equipment, as follows, and specially designed components, accessories and "specially designed software" therefor:

(a) "Telecommunication transmission equipment" employing digital techniques (including the digital processing of analogue signals) and having at least one of the following characteristics:
  (1) Designed for a total digital transfer rate which, at the highest multiplex level, exceeds:
    (A) 45 million bit/s (including when designed for under-water use); *or*
    (B) 8.5 million bit/s for stored programme controlled digital crossconnection equipment;

NOTE:
The maximum of 45 million bit/s for the highest multiplex level does not preclude total digital transfer rates of maximally a factor two (2 times) higher for:
(a) Line terminating equipment;
(b) Intermediate amplifier equipment;
(c) Repeater equipment;
(d) Regenerator equipment; *or*
(e) Translation encoders (transcoders);

  (2) Designed for a "data signalling rate" which exceeds:
    (A) 1,200 bit/s when:
      (a) Employing an automatic error detection and correction system; *and*
      (b) Retransmission is not required for correction;
    (B) 9,600 bit/s when using the "bandwidth of one voice channel"; *or*
    (C) 64,000 bit/s when using baseband;

NOTE:
For statistical multiplexers, which satisfy the definitions of either "data (message) switching" or "stored programme controlled circuit switching", and for the definitions of these terms, see Item **IL 1567**.

(b) Electronic measuring or test equipment (eg bit error rate test sets) specially designed for the equipment embargoed by sub-item (a) (1) above;

TECHNICAL NOTE:
Definition of terms
"bandwidth of one voice channel" —
In the case of data communication equipment designed to operate in one voice channel of 3,100 Hz, as defined in CCITT Recommendation G. 151;
"data signalling rate" —
As defined in ITU Recommendation 53-36, taking into account that, for non-binary modulation, 'baud' and 'bit per second' are not equal. Bits for coding, checking and synchronisation functions are to be included.

NB:
When determining the "data signalling rate", servicing and administrative channels shall be excluded.
"Telecommunication transmission equipment" —
For the purpose of this Item is:
(a) Categorised as follows, or combinations thereof:
  (1) Line terminating equipment;
  (2) Intermediate amplifier equipment;
  (3) Repeater equipment;
  (4) Regenerator equipment;
  (5) Translation encoders (transcoders);
  (6) Multiplex equipment;
  (7) Modulators/demodulators (modems);
  (8) Transmultiplex equipment (see CCITT Rec. G701; *or*
  (9) Stored programme controlled digital crossconnection equipment; *and*
(b) Designed for use in single or multi-channel communication via:
  (1) Wire (line);
  (2) Coaxial cable;
  (3) Optical fibre cable; *or*
  (4) Radio

NOTES:
1. Nothing in this Item shall be construed as sanctioning the export of technology for the development or production of equipment employing digital transmission techniques for operation at a total digital transfer rate at the hightes multiplex level exceeding 8.5 million bit/s;
2. This Item does not embargo:
  (a) Telemetering, telecommand and telesignalling equipment designed for industrial purposes, together with data transmission equipment not intended for the transmission of written or printed text;

NB:
Telemetering, telecommand and telesignalling equipment consists of:
(a) Sensing heads for the conversion of information into electrical signals;
(b) The systems used for the long-distance transmission of these electrical signals; *and*
(c) The process used to translate electrical signals into coded data (telemetering), into control signals (telecommand) and into display signals (telesignalling);

  (b) Facsimile equipment which is not embargoed by Item **IL 1527**; *or*
  (c) Equipment employing exclusively the direct current transmission technique.

FOR PEOPLE'S REPUBLIC OF CHINA ONLY:
3. The shipment of the following communication, measuring or test equipment:
  (a) "Telecommunication transmission equipment" provided it is:
    (1) Intended for general commercial traffic in a civil communication system;
    (2) Designed for operation at a total digital transfer rate at the highest multiplex level of 140 million bit/s or less;
    (3) Installed under the supervision of the seller in a permanent circuit; *and*
    (4) To be operated by the civilian authorities of the importing country;
  (b) Measuring and/or test equipment necessary for the use (i.e., installation, operation and maintenance) of equipment exported under the conditions of this Note, provided:
    (1) It is designed for use with communication transmission equipment operating at a "data signalling rate" of 140 million bit/s or less; *and*
    (2) It will be supplied in the minimum quantity required for the transmission equipment eligible for administrative exception treatment:

NB:
Where possible, built-in test equipment (BITE) will be provided for installation or maintenance of transmission equipment eligible for administrative exception treatment under this Item rather than individual test equipment;

NB:
1. For communication equipment using optical fibre as the communication medium, the transmission wavelength must not exceed 1,370 mm.
2. A statement is provided identifying the following:
  (i) Locations of the connection points;
  (ii) Types of equipment being connected; *and*
  (iii) Transmission rates.

4. The shipment of modems and multiplexers embargoed by sub-item (a) (2) above designed for operation at "data signalling rates" of 19,200 bit/s or less.

IL 1520

Radio relay communication equipment, specially designed test equipment and "software" as follows, and specially designed components and accessories therefor:

(a) Radio relay communication equipment designed for use at

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Figure 5.3: *IL 1519 (British Government, 1990)*

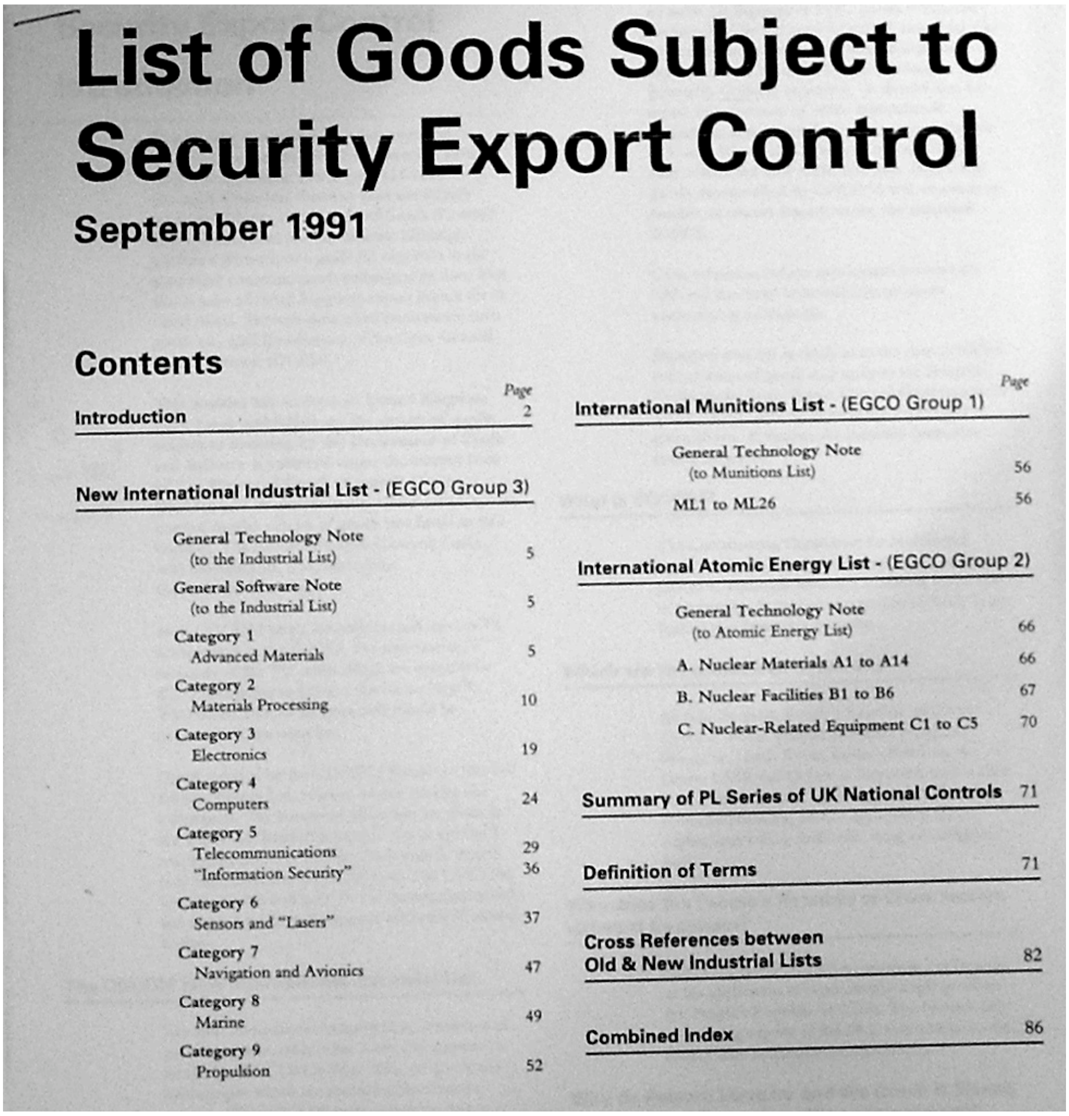
and 1990s from those in the 1950s. It also showed cracks in the underlying system of classification.

The Core List revision

In 1989–1990, there were growing concerns about the credibility of CoCom, voiced by CoCom members themselves, as a result of the end of the Cold War and the rapid transformation occurring in East-West relations. The US attempted to appease these concerns by offering to ease licensing for many technologies on the lists, but this offer was met by resistance by West Germany and other West European members (Mastanduno, 1992, p. 332), who were arguing for more drastic revisions of the lists (Magnusson, 1990). In June of 1990, such drastic revisions began to occur with the 'Core List' revision, where members started with no technologies on the lists and had to justify any item that they wanted to include, rather than starting with the current lists and placing the burden of justification on those who wanted to take items off. They also threw out the old structure of the lists.

"The very idea of controlling a short list of only the most sensitive items was not new," Mastanduno (1992, p. 334) notes. "It had been the 'ideal' preference of West European governments in CoCom, particularly the French, for at least a decade." The new 'Core List' can be seen in the September 1991 publication by the British Government (1991*a*), shown in Figure 5.4. Its structure, completely revamped, resembles much more closely the structure of the Wassenaar lists than the previous CoCom lists.

Throwing out the old lists can be seen as a major coup for the competitive framing, as it showed the anomalous status of many of the items on the Industrial List. However, this framing was not able to seat its myth—the open market solution (Rayner, 1994, p. 20–21)—as the hegemonic one, nor did it necessarily want to. From the perspective of this framing, the view of a single classificatory scheme for all technology (and correspondingly all patterns of social relations) is anathema. The role of the competitive framing will be



List of Goods Subject to Security Export Control

September 1991

Contents

Figure 5.4: *Table of Contents from British Government (1991*a*)*

explored in more detail when we look at specific list changes in the following chapters.

We can now see that the lists have a rich history in CoCom. They began as simple alphabetical lists of technologies and changed over the course of forty years to be highly structured lists of parameters of technology. This change can be seen as representative of the hegemonic institutionalisation of the hierarchical myth of control. Throughout this time, though, the competitive framing was continually competing for power.

While there are significant differences between the overall structure of CoCom and Wassenaar as organisations, as we saw in the last chapter, the lists with which Wassenaar started are essentially the ones with which CoCom ended. What the New Forum provided was a chance once again to reassess the lists, but also to clearly define their structure and content. It did so by creating the *Guidelines for the Drafting of Lists* and by defining many of the common terms they used in the lists. I incorporate a discussion of these aspects of the lists into the overview of the Wassenaar lists below.

5.3 The Wassenaar lists

While the Wassenaar Arrangement has two main lists of controlled items that came out of the New Forum—the Munitions List and the Dual-Use List[12]—it also has a set of auxiliary documents attached to the lists. These consist of: a list of definitions of common terms in the lists that have specific meanings; a table of acronyms and abbreviations; and a collection of *Statements of Understandings* and *Validity Notes*. *Statements of Understandings* are "aimed at providing common ground for the understanding of the issue and at providing guidance to Participating States" (Wassenaar Arrangement, 2008*d*, p. 4). *Validity Notes* are "agreement[s] by Participating States to review a certain list entry before the end of a specific period of time, in the light of experience gained and technological developments" (Wassenaar Arrangement, 2008*d*, p. 4). If they do not review the text before the validity note runs out, then the text automatically reverts to the previous addition.[13] This is a key way that the debate between views about the definition of text can be maintained while still modifying the lists. It is therefore a signifier of anomalies that are having difficulty being incorporated into the classification system, which means that the other framings are trying to use the technology in question to point out the

[12]The Atomic Energy List was subsumed by the Zangger Committee.
[13]Interview with British Former Government Official, 3 June 2008.

inadequacy of the system as a whole. This is a way of holding the dominant framing to account.

Unlike CoCom, these lists are implemented only at national discretion. France, Russia, and the Ukraine actually view the list, not as a control list, but as a reference list, as shown in Figure 5.5.[14] One methodological point needs to be mentioned here. I have chosen to provide figures of key pieces of text rather than copy the text because the configuration of the text on the page also is significant in much of my analysis. For example, the use of a footnote here instead of an in-text note suggests that this behaviour has only mild approval. It is also worth noting that the Arrangement lacks a directed focus for

* France, the Russian Federation and Ukraine view this list as reference drawn up to help in the selection of dual-use goods which could contribute to the indigenous development, production or enhancement of conventional munitions capabilities.

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Figure 5.5: *Dual-Use List as 'reference list' rather than 'control list' (Wassenaar Arrangement, 2007*b*)*

the controls, thereby making a 'strategic embargo' such as existed in CoCom more difficult. The lists can no longer be tailored to a particular threat, but must instead address the more general threat of 'destabilising accumulations' of technology.

The Munitions List

The Munitions List (ML) is fairly straightforward, consisting of 22 categories and covering 24 pages. Some categories, such as *ML16*, are only a few lines long, others are a few pages. There are typically a handful of changes to the ML each year. There are a few 'Notes' and very infrequent specification of parameters in this list. It is therefore still largely a list of technologies.

[14]All figures are from the 2007 Corrected version of the Dual-Use List unless otherwise noted.

These technologies include aircraft, ships, and land vehicles; guns and their attachments; explosives and propellants; fire control equipment; chemical and biological agents; electronic equipment; armour; military training equipment; imaging and countermeasure equipment; directed energy weapons; and 'superconductive' equipment. Most of these technologies, in order to fall in the Munitions List, need to be 'specially designed for military use'. However, they do not have to be 'finished products' (*ML16*). In addition to those technologies of direct use in military operations, the Munitions List also controls:

> **ML17.** Miscellaneous equipment, materials and libraries, as follows, and specially designed components therefor: ...
>
> **ML18.** Equipment for the production of products referred to in the Munitions List, as follows:
>
> **a.** Specially designed or modified production equipment for the production of products controlled by the Munitions List, and specially designed components therefore;
>
> **b.** Specially designed environmental test facilities and specially designed equipment therefor, for the certification, qualification or testing of products on the Munitions List.
>
> ...
>
> **ML21.** "Software" as follows: ...
>
> **ML22.** "Technology" as follows: ...

ML21 and *ML22* will be discussed below when talking about the more general meaning of those terms. *ML17* contains a random assortment of technologies that do not fit neatly into the other categories. Again, this is another example of a 'residual category' (Bowker & Star, 1999). Watching this category's size is therefore a useful way to judge the adequacy of the structure of the list—if *ML17* becomes the longest category, it will likely be time to modify the categories themselves. *ML18* is an extremely broad category, covering any tool specially designed to produce any technology that is listed on the list. While these technologies may have non-military applications, if they are 'specially designed' to produce technologies controlled by the Munitions List, then they are controlled. What constitutes being specially designed for military use is an interesting question, but is not the focus of this thesis. It is enough here to note that when something is considered specially designed for military use, it no longer falls in the 'dual-use' category. This provides a clear boundary in the overall classification system (recall Figure 4.1).

Table 5.4: *Categories of the Dual-Use List*

Category 1 – Advanced Materials
Category 2 – Materials Processing
Category 3 – Electronics
Category 4 – Computers
Category 5 – Part 1 – Telecommunications
Category 5 – Part 2 – "Information Security"
Category 6 – Sensors and "Lasers"
Category 7 – Navigation and Avionics
Category 8 – Marine
Category 9 – Aerospace and Propulsion

Table 5.5: *Sections of the Dual-Use List Categories*

A – Systems, Equipment, and Components
B – Test, Inspection, and Production Equipment
C – Materials
D – Software
E – Technology

The Dual-Use List

The Dual-Use List, however, is much more complex. As shown in Table 5.4, it is composed of the categories agreed to for the September 1991 CoCom list. As noted above, a key aspect of the revised list is that it has a more complex structure. Each Category is now divided into five Sections, as shown in Table 5.5.[15] Later categories are also meant to build on earlier ones. Thus,

[15]These are reproduced in Appendix B for ease of reference in later chapters.

Category 9 (Aerospace & Propulsion) may control an 'unmanned aerial vehicle', but the gyroscope in it may be controlled in Category 7 (Navigation and Avionics), and the circuitry used to make the gyroscope may be controlled in Category 3 (Electronics).[16] The list also has two sub-lists: the Sensitive List and the Very Sensitive List. The Sensitive List is for "key elements directly related to the indigenous development, production, use or enhancement of advanced conventional military capabilities whose proliferation would significantly undermine the objectives of the Wassenaar Arrangement" (Wassenaar Arrangement, 2004*a*). The Very Sensitive List has almost the same requirements, "key elements *essential for* the indigenous development, production, use or enhancement of *the most* advanced conventional military capabilities whose proliferation would significantly undermine the objectives of the Wassenaar Arrangement" (emphasis added, Wassenaar Arrangement, 2004*b*).

The balance between competing framings of the problem of dual-use technology over the Dual-Use List definitions, and the hegemony of the hierarchical framing, is clearly present in the following quote:[17]

> What do [Participating States] see as [the Wassenaar Arrangement's] purpose and how do they internally work at it? As X commented a minute ago, for the United States, I think it's pretty much a balance between- the purpose of it is national security. For us there's no ambiguity about that. For us it's national security. But, we strive in what we're doing to find a balance between national security and commercial interests. Our perspective is very much driven by the notion that you have controls on technology- limiting who can get access to technology is the national security purpose of Wassenaar. At the same time, whenever you're doing that, you have to recognise that you are creating impediments, grit in the system, for regular commerce. And that regular commerce- United States leadership in regular commerce, United States leadership in commercial technologies, their development, their production, etc, is also a national security interest.

[16]Specific example used in Interview with Wassenaar Secretariat Official C, 13 June 2007.

[17]Interview with US State Department Official A & US State Department Official B on 11 September 2006. I have changed the name of the interviewee referred to in the quote to 'X'.

Multiple words, multiple meanings

We will get into more detail about the structure of the lists in the specific case studies in following chapters. Here, we pause to consider some definitional issues. Up until this point, I have used the word 'technology' in its common usage definition. One would imagine that an organisation focused on defining dual-use and military technology would have a definition of technology itself, and it does. However, as shown in Figure 5.6—and as I first pointed out in Chapter 2 when discussing the concept of technology—this definition only pertains to a fraction of the items on the lists.

GTN & Both Lists "Technology"

Specific information necessary for the "development", "production" or "use" of a product. The information takes the form of technical data or technical assistance. Controlled "technology" for the Dual-Use List is defined in the General Technology Note and in the Dual-Use List. Controlled "technology" for the Munitions List is specified in ML22.

Technical Notes

1. *'Technical data' may take forms such as blueprints, plans, diagrams, models, formulae, tables, engineering designs and specifications, manuals and instructions written or recorded on other media or devices such as disk, tape, read-only memories.*
2. *'Technical assistance' may take forms such as instruction, skills, training, working knowledge, consulting services. 'Technical assistance' may involve transfer of 'technical data'.*

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Figure 5.6: *Definition of 'technology' (Wassenaar Arrangement, 2007b)*

In Wassenaar discussions, therefore, 'technology' only refers to a small part of the things controlled. In particular, it refers to *information* in the form of 'technical data' and 'technical assistance'. This is the 'knowledge' aspect of the rough definition of technology that I employ in this thesis: any human construction coupled with the practices and knowledge of how to engage that construction towards a particular end. The 'technology' that is controlled is defined in the list itself, but there is also a definition of 'controlled technology' in the General Technology Note (Figure 5.7), which comes at the beginning of the Dual-Use List. We will return to why the Wassenaar Arrangement chose to

GENERAL TECHNOLOGY NOTE

The export of "technology" which is "required" for the "development", "production" or "use" of items controlled in the Dual-Use List is controlled according to the provisions in each Category. This "technology" remains under control even when applicable to any uncontrolled item.

Controls do not apply to that "technology" which is the minimum necessary for the installation, operation, maintenance (checking) and repair of those items which are not controlled or whose export has been authorised.

Note *This does not release such "technology" controlled in entries 1.E.2.e. & 1.E.2.f. and 8.E.2.a. & 8.E.2.b.*

Controls do not apply to "technology" "in the public domain", to "basic scientific research" or to the minimum necessary information for patent applications.

Figure 5.7: *Definition of 'controlled technology' (Wassenaar Arrangement, 2007b)*

have such a narrow definition of technology in a moment, but for now we must ask, "If 'technology' is so narrowly defined, then what are all the other things on the list called?" The answer is that there is no single name for them. Having used the term 'technology', it appears that the list refers to everything else using a variety of terms, namely 'goods', 'systems', 'equipment', 'components', 'materials', 'software', 'products', and 'items'. Let us see if there is any order behind which term is used when.

The most obvious place that the term 'goods' occurs is in the name of the organisation: The Wassenaar Arrangement for Export Controls on Conventional Arms and Dual-Use *Goods* and Technologies. That, however, is virtually its sole occurrence. The term is used once in *1.A.2.'Note 2'* to describe 'sporting goods' and in four other places in the list where it refers to the list as a whole (*2.A.'N.B.'*, *2.B.4.'N.B.'*, *6.A.5.f.'N.B.'*, and *9.A.'N.B.'*).[18] The latter

[18]For help on locating references to the list, please see Appendix B.

instances are of note in their own right as they are part of a clarification on the purpose of the lists.

As can be seen in Figure 5.5, 'goods' occur in a footnote to nota benes in the text, making clear that France, the Russian Federation, and Ukraine see the list as a 'reference' "to help in the selection of dual-use goods". A 'good', then can be understood to mean anything that is on the Dual-Use List that is not 'technology'.

'Systems', 'equipment', 'components', and 'materials' refer to subsections of Dual-Use List categories, as does 'software'. 'Software', however, also has its own definition, as shown in Figure 5.8.

Both Lists	"Software" A collection of one or more "programmes" or "microprogrammes" fixed in any tangible medium of expression.

Figure 5.8: *Definition of 'software' (Wassenaar Arrangement, 2007*b*)*

For 'products' and 'items', the analysis becomes more difficult. When referring to things commonly known as technology, the term 'product' appears about a dozen times in the lists. In all occurrences apart from ML16 and ML18, 'product' is always found in a Note or a definition.[19] The definitional occurrences appear in 'development', 'required', 'space-qualified', and most interestingly, 'technology'. Returning to Figure 5.6, we notice that 'product' is the thing that 'technology' is used to 'develop', 'produce', or 'use', and thus should refer to other things on the list.

The most explicit term used to describe things on the lists, however, is 'item'. It first occurs in the Table of Contents referring to each section of the Munitions List ("Items 1 to 22…"). It then occurs in the General Technology

[19] The non-definitional occurrences are *1.C.'Technical Note', 4.A.3.c.'Note 2', 5.'Part 2'.'Note 2', 9.A.4.'Note'.'N.B.', ML8.c.'Note 1', ML16, ML18.a, ML18.b*, and *ML18.'Note'.f*

Note in a similar capacity to 'product'.[20] It appears in a number of Notes,[21] in the Munitions List a few times[22], and in the definition of 'nuclear reactor'. It also occurs four times in the Statements of Understanding and Validity Notes, which are appended on to the end of the lists. It refers to both 'goods' and 'technology'. But what gives this term the most weight is its use outside of the lists. It occurs over a hundred times in the *Basic Documents* compilation, including extensively in the *Initial Elements* (Wassenaar Arrangement, 2007*a*), and is also the only one of these terms used in the original *Guidelines for the Drafting of Lists* document, where it is defined as "anything which may be presented for export" (Hathway, 1996, p.12).[23] I will therefore now use the term *item* whenever I refer to the 'containers of parameters' on the lists. I will continue to use technology as I defined it before, namely as any human construction coupled with the practices and knowledge of how to engage that construction towards a particular end. When I need to refer to 'technology' as defined in the lists, I will enclose the word in single quotes.

Guidelines for the Drafting of Lists

When deciding how to structure the lists during the New Forum, the Drafting Group came up with a set of guidelines. These *Guidelines for the Drafting of Lists*[24] were revised in 2007-2008 (Wassenaar Arrangement, 2008*d*), and I have included an exact reproduction of both versions in Appendix G.[25] I encourage the reader to take a moment to browse through them before continuing, as a working knowledge of them will greatly aid in following the technicalities of the list modifications I analyse in the next chapter.

[20] See Figure 5.7.

[21] *1.A.2.'Note 2', 2.D.'Note 2', 3.A.1.b.4.'Note 2', 5.'Part 2'.'Note 3', 5.'Part 2'.'Note 3'.e, 6.A.3.b.4.'Note 3'.c.'Note', 6.A.3.b.4.'Note 4'.'Note'.*

[22] *ML4.a, ML4.b, ML5.c, ML5.d, ML7.'Note 2', ML.8.'Technical Notes'.1, ML.8.'Technical Notes'.2, ML17.n, ML17.'Technical Notes'.2, ML22.a, ML22.b.1, ML22.'Note 1', ML22.'Note 2'.a.*

[23] Unfortunately, this definition disappeared in the revised version of the *Guidelines*.

[24] Hereafter referred to as *Guidelines*.

[25] This is the first time either version of the *Guidelines* has been made public.

The *Guidelines* document itself is very structured, with the revised version having its own table of contents and hierarchical numbering system. The first thing to note about the current version of the *Guidelines* is Section III.1, the 'General Principle' used in drafting control text. It begins by laying out the difference between the Dual-Use List and the Munitions List:

> There is a difference in approach to controls specified in the Dual-Use List from those specified in the Munitions List. Controls in the Dual-Use List rely on greater specificity for the controlled items and are evaluated against the agreed selection criteria. The nature of military goods requires less specificity.

This clearly shows the boundary between dual-use and military items. Military items are ones that do not require the negotiation between different framings of technology in order to be inscribed on the Munitions List. Establishing that they are 'specially designed for military use' is sufficient to override any other parameter of the technology. The ambiguities of the technology are not of concern, and therefore the item does not need as much specificity.[26]

Dual-use items, on the other hand, do not have this overriding parameter, and as such their ambiguities must be negotiated with more 'specificity' in order to find 'criteria' that each framing can 'agree' to. Section III.3. of the *Guidelines* describes in some detail the need for clarity in the Dual-Use List, which further supports this claim.

> For the Dual-Use List, clear and objective specifications should include control parameters known by industry and associated control thresholds or technical characteristics/performance. Control text should break out the overall specification into clearly identified characteristics and the combination in which they are to be met. A combination of parameters may be designated using the terms *and* or *or*. *And* is used when more than one parameter must be met to satisfy the conditions for control and *or* is used when there are different alternatives for satisfying the conditions for control. At times *and* and *or* may be used in combination to clearly specify the items to be controlled. However, such complex combinations

[26]The rest of the *Guidelines* therefore focuses mainly on the structure of the Dual-Use List.

> are not always possible, especially where technology or software is concerned.
>
> Wherever possible the use of decontrol Notes and illustrative lists of controlled items should be avoided. On a case by case basis they may be used when necessary.

This is a clear statement of the dominance of a highly structured and tightly bound classification of technology, marking it high on both the grid and group axes, and therefore representative of the hierarchical framing.

Finally, this section argues that "[s]ubjective controls, which are based on end-use, should be avoided. A subjective control is a control that treats an item differently if it is used for a different purpose." This is essentially negating the 'designed for a purpose' parameter that delimits dual-use and munitions items. By delegitimising any criteria based on use, the *Guildelines* are constraining the ambiguity of the technology. An entire class of ambiguities, the *use* of the technology, is eliminated except for 'military use'. However, there are exceptions to every rule, and the *Guidelines* provide an example of what not to do that is taken from the actual Dual-Use List, as shown in Figure 5.9.

> Subjective controls, which are based on end-use, should be avoided. A subjective control is a control that treats an item differently if it is used for a different purpose.
>
> Example:
>
> 3. A. 1. a. 2. "Microprocessor microcircuits", "microcomputer microcircuits", …
>
> *Note 3.A.1.a.2. does not apply to integrated circuits for civil automobile or railway train applications.*

Figure 5.9: *Constraining ambiguity by disallowing subjective controls (Wassenaar Arrangement, 2008*d*, p. 5)*

The *Guidelines* then continue by describing the structure of an individual entry, as shown in Figure 5.10. An 'entry' may be found generally in the third, fourth, and occasionally fifth levels of the list, i.e. an entry could have sub-entries which in turn could have sub-sub-entries. It begins with a 'chapeau',[27] which is a container for all the items to be controlled:

[27]'Chapeau' is French for 'a hat'. This nicely supports my argument that entries are containers rather than technologies.

Chapeau the entry

Sub-entries consisting of either further entries or characteristics of the entry

Note used to clarify what is or is not included in the control. "A Note must not expand the scope of control"

Technical Note used to: clarify meaning; provide test methods; define alternative terms; or provide local definitions.

Nota Bene usually references another Category or item, "which should also be reviewed to determine control status."

Figure 5.10: *Individual entry structure in Guidelines. (not actual image) (Wassenaar Arrangement, 2008*d*)*

> The chapeau may introduce control parameters but more detailed parameters may be listed in sub-entries. Where the controls for a particular entry can be written without ambiguity in a single paragraph, it should stand alone in the form of a chapeau. When a sub-entry is required, the chapeau identifies the items to be controlled in any associated sub-entry. It is essential that the chapeau covers all items intended to be controlled by a given entry (III. 2. a.).

This structure is very clearly followed in the lists. There are of course exceptions. In my discussions with one of the leaders of the revision of these *Guidelines*, he pointed out how hard it was actually to find a piece of text on the lists that was a perfect example of how the list should be written. The trend, however, has been a yearly reduction of the exceptions, rather than an ever-increasing number of them, as had been the case before the 1990-1991 CoCom list revision. The year 2008 was the first where Wassenaar used the revised *Guidelines*. One will be able to tell how much these *Guidelines* are adhered to by monitoring the types of changes on the lists. It is important to note that the *Guidelines* lay out the structure of the lists, but they do not lay out how to *change* that structure. Major changes to the list, such as the possibility of creating a Category 10 for terrorism technology, do not as yet have an established procedure for discussion or implementation.

This analysis of the *Guidelines* has shown that the Dual-Use List of the Wassenaar Arrangement clearly controls parameters of technology rather than technology itself. It has also shown the degree to which the hierarchical framing has embedded itself as the hegemonic myth. We now turn to a brief discussion of the proposal process used to make changes to the lists.

The proposal process

In order to make changes to the lists, Participating States of the Wassenaar Arrangement engage in a proposal process that takes at least one year. There are many ways that ideas come for proposing changes to the lists, as will be shown in the following chapters. Here, we will only look at the logistics of the process, as the detail will be addressed in the following chapters. The process typically begins in winter with the identification of items that a State would like to change and the development of a proposal. The proposal itself has thirteen sections covering the desired changes to the text, the background for the change, a justification, the satisfaction of the *Criteria for Control* (described below), other changes that are needed, and any other information. A typical proposal is provided below.[28]

[28] The name of the country has been 'X'ed out

WA-EG (07) XX 010
[redacted]

WASSENAAR ARRANGEMENT EXPERT GROUP - PROPOSAL

Submitting country	**XXX**
Title of Proposal	Fibre Lasers
Current text	6.A.5.a. Non-“tunable” continuous wave “(CW) lasers”, having any of the following: 1. … 2. … 3. … 4. … 5. … 6. An output wavelength exceeding 975 nm but not exceeding 1,150 nm and having any of the following: a. A single transverse mode output having any of the following: 1. A wall-plug efficiency exceeding 12% and an output power exceeding 100 W; or 2. An output power exceeding 150 W; or b. A multiple transverse mode output having any of the following: 1. A wall-plug efficiency exceeding 18% and an output power exceeding 500 W; or 2. An output power exceeding 2 kW; <u>Note</u> *6.A.5.a.6.b. does not control multiple transverse mode, industrial "lasers" with output power exceeding 2 kW and not exceeding 6 kW with a total mass greater than 1,200 kg. For the purpose of this note, total mass includes all components required to operate the "laser", e.g., "laser", power supply, heat exchanger, but excludes external optics for beam conditioning and/or delivery.* 6.A.5.b. Non-“tunable” “pulsed lasers”, having any of the following: 1. … 2. … 3. … 4. … 5. … 6. An output wavelength exceeding 975 nm but not exceeding 1,150 nm and having any of the following:

	a. A "pulse duration" of ……… b. A "pulse duration" exceeding 1 ns but not exceeding 1 µs, and having any of the following: 1. A single transverse mode output having any of the following: a. A "peak power" exceeding 100 MW; b. An "average output power" exceeding 20 W limited by design to a maximum pulse repetition frequency less than or equal to 1 kHz; c. A wall-plug efficiency exceeding 12% and an "average output power" exceeding 100 W and capable of operating at a pulse repetition frequency greater than 1 kHz; d. An "average output power" exceeding 150 W and capable of operating at a pulse repetition frequency greater than 1 kHz; or e. An output energy exceeding 2 J per pulse; or
Proposed text	6.A.5.a. Non-"tunable" continuous wave "(CW) lasers", having any of the following: 1. … 2. … 3. … 4. … 5. … 6. An output wavelength exceeding 975 nm but not exceeding 1,150 nm and having any of the following: a. A single transverse mode output having any of the following: 1. A wall-plug efficiency exceeding 12% and **[a. A bandwidth not exceeding 100MHz and an output power exceeding 5 W; or** **b. A bandwidth exceeding 100MHz and]** an output power exceeding 100W; <u>or</u> 2. An output power exceeding 150 W; or b. A multiple transverse mode output having any of the following: 1. A wall-plug efficiency exceeding 18% and an output power exceeding 500 W; or 2. An output power exceeding 2 kW; <u>Note</u> *6.A.5.a.6.b. does not control multiple transverse mode, industrial "lasers" with output power*

	exceeding 2 kW and not exceeding 6 kW with a total mass greater than 1,200 kg. For the purpose of this note, total mass includes all components required to operate the "laser", e.g., "laser", power supply, heat exchanger, but excludes external optics for beam conditioning and/or delivery. 6.A.5.b. Non-“tunable” “pulsed lasers”, having any of the following: 1. … 2. … 3. … 4. … 5. … 6. An output wavelength exceeding 975 nm but not exceeding 1,150 nm and having any of the following: b. A "pulse duration" exceeding 1 ns but not exceeding 1 µs, and having any of the following: 1. A single transverse mode output having any of the following: a. A "peak power" exceeding 100 MW; b. An "average output power" exceeding 20 W limited by design to a maximum pulse repetition frequency less than or equal to 1 kHz; c. A wall-plug efficiency exceeding 12% and **[1. A bandwidth not exceeding 100MHz and an “average output power” exceeding 5W; <u>or</u>** **2. A bandwidth exceeding 100MHz and]** an "average output power" exceeding 100 W and capable of operating at a pulse repetition frequency greater than 1 kHz; d. An "average output power" exceeding 150 W and capable of operating at a pulse repetition frequency greater than 1 kHz; or e. An output energy exceeding 2 J per pulse; or

Background	Additional control parameters in items 6.A.5.a.6.a.1, 6.A.5.a.7.a, 6.A.5.b.6.b.1.c, 6.A.5.b.6.c.1.b, 6.A.5.b.8 of the long term fix for very narrow bandwidth lasers in the 975-1555nm bandwidth. The change from a technology based control to a parameter based control system necessitates the control of any new technology with military utility based on the parameters of the laser. Fibre lasers have developed apace and in late 2006 narrow bandwidth fibre lasers capable of efficient frequency doubling became commercially available.
Technical justification	Due to their low weight, small size and high efficiency (battery operated) the lasers present a viable method for producing a credible man-portable laser dazzle weapons. Dazzle for magnifying sights and image intensifiers would be greater and to greater ranges. Hazard distances to the unaided eye would be hundreds of metres to kilometres range for the powers available.
Major/key element	New technology allows portable, efficient fibre lasers to be used as dazzle sources.
Foreign Availability	Currently only available in the USA.
Controllability	These lasers have only recently become available (Oct. 2006) so numbers are currently unknown.
Controlled in another regime?	No
Consequential changes?	No other changes are necessary.
Proposed Review Date	
Other information	www.ipgphotonics.com/products_1micron_lasers_singlefrequency_ylr-lp-sfs.htm

The first four sections are self-explanatory, though it is interesting to note that the 'Title of the Proposal' uses a term that appears nowhere on the list. This is further evidence that the list controls parameters, not technologies. The 'Background' section provides the accepted rationale for proposing the change. Note here too, that in this case, this proposal explicitly states there is a "change from technology based control to a parameter based control system." In a proposal arguing to increase the scope of control, such as this one, the 'Justification' is usually based on the security need. In a proposal arguing for a decrease in the scope of control, the 'Justification' is usually based on the current text not meeting one of the four *Criteria of Control* listed next. These criteria come from the *Criteria for the selection of Dual-Use items* (Wassenaar Arrangement, 2005*a*), shown in Figure 5.11.

As we can see, in this case the Participating State is arguing that the item is a "key element for the indigenous development, production, use or enhancement of military capabilities," that it is not available outside Participating States, that it is likely that they can control it, and that it is not controlled by another regime (such as the ZC, AG, or MTCR).[29] Finally, there is a proposed review date and any other information needed (i.e. the 'residual category').

The proposal is usually uploaded onto the [redacted] in early March, which gives the other countries time to develop their positions on it by the first Expert Group (EG) meeting. At the first EG meeting, proposals are divvied up and Technical Working Groups (TWGs) are formed. Counter-proposals may also be offered. In an average year there are roughly 60 proposals.[30] On some of them agreement is reached quickly and there is no need to form a TWG. Why this agreement is so quick for some and not for others will be the topic of analysis for Chapter 6. At the

[29]The other criterion of control is "the ability to make a clear and objective specification of the item," which is done in Sections 3 and 4.

[30]Interview with Wassenaar Secretariat Official C, 13 June 2007 and Interview with British Former Government Official, 8 March 2007.

CRITERIA FOR THE SELECTION OF DUAL-USE ITEMS

(as updated at the December 2005 Plenary)

Dual-use goods and technologies to be controlled are those which are major or key elements for the indigenous development, production, use[1] or enhancement of military capabilities[2]. For selection purposes the dual-use items should also be evaluated against the following criteria:

- Foreign availability outside Participating States.
- The ability to control effectively the export of the goods.
- The ability to make a clear and objective specification of the item.
- Controlled by another regime[3].

1 Use means operation, installation (including on-site installation), maintenance (checking), repair, overhaul and refurbishing.
2 Controlled by the Munitions List.
3 An item which is controlled by another regime should not normally qualify to be controlled by the Wassenaar Arrangement unless additional coverage proves to be necessary according to the purposes of the Wassenaar Arrangement, or when concerns and objectives are not identical.

Figure 5.11: *Criteria for the Selection of Dual-Use Items*

end of the first two-week-long EG meeting, a poll is taken, as described above, to determine each state's stance on each proposal.

Over the course of the Summer, States engage in informal meetings of the EG and bilateral relations to negotiate the text in an attempt to find parameters and values of those parameters that satisfy each framing. This work culminates in the Autumn EG meeting, also two weeks. If agreement is reached in the EG, i.e. a 'conditional agreement' is reached, then the changed text is sent to the Plenary for ratification. If agreement is not reached, the States decide whether to throw the proposal out or to continue reviewing it again the next year. There is an unspoken rule that a proposal can only be on the table for three years, after which it must be taken off and reformulated.[31]

Once the Plenary agrees to a change in the text of the lists, States must implement that change in their national controls. The time needed to do this varies from instantaneous, for countries that simply use the Wassenaar lists, to almost a year because the text needs to be translated into a different list structure or language. Thus, the time from the beginning of a proposal to its implementation in export control systems is at least one year, and often much longer. As a result, members of the EG must not only be aware of the current state of technological development, but also where it is likely to go in the time between the present and the actual implementation of the controls. In some categories, this is not too difficult, but in others, where technology is advancing generations in a few years, this can be a source of many difficulties in the Arrangement, as will be shown in the next chapter when we look at controls on computers.

5.4 Conclusion

International collaboration on export controls, and specifically on developing lists of controlled technology, has been ongoing for at least the past three hundred years. Early lists had many things on them that we may not consider technology, such as food, grains, and gold. The first significant multilateral initiative to harmonise national lists of items controlled for their military significance was the 1909 *Declaration Concerning the Laws of Naval War*, but it steadily grew less useful to countries and was abandoned, along with the concept of contraband, at the end of the Second World War.

It was replaced by the Coordinating Committee for Multilateral Export Controls, a group of seventeen countries that met regularly in the US Embassy in Paris from 1950 through 1993. CoCom had three lists, of which the Industrial List was the one that changed most often. As the text on the lists steadily grew

[31] Interview with US Defense Department Officials A & B, 5 February 2007.

over the life of CoCom, the scope of the controls generally became narrower. In the beginning of CoCom, the lists could be said to describe technologies under control, such as 'computers'. With time, the lists began instead to define the parameters of controlled technology rather than the technology itself. That is, the technologies under control became more qualified, more finely defined, and therefore there were fewer technologies that were likely to meet the specifications of control.

Along with more specification, there were numerous exemptions on the lists, which made it impossible to say exactly how many technologies were controlled. These exemptions and the ambiguity in the definitions themselves, I have posited, are the outcomes of multiple framings of the problem of dual-use technology interacting with each other over extended periods of time.

The Core List revision saw a shift in the institutional structure of CoCom from being in a default position of control (i.e. when in doubt, the technology is under control), to being in a default position of decontrol. The New Forum reworked the lists again, but maintained the revised CoCom structure.

The Wassenaar Arrangement has two primary lists, the Munitions List and the Dual-Use List. The Munitions List is clearly separated from the others by covering all technologies designed for military use. It defines technologies rather than parameters of technologies, much as the early CoCom lists did. This is because the single criterion of 'use' is sufficient for any item to get onto the list.

The Dual-Use List, in contrast, is much more complex and logically structured than the Munitions List and early CoCom lists. It is difficult to speak of all of the things on the list as 'technologies', since 'technology' has a very specific use within Wassenaar, only referring to the "specific information necessary for the 'development', 'production' or 'use' of a product" (Wassenaar Arrangement, 2007*b*, p. 203). Instead, the best term to use to describe the things on the lists is to speak of them as 'items'. This goes very well with viewing the Wassenaar Arrangement as primarily a classification system, and also appropriately blurs the line between technologies and the texts that define them.

The Wassenaar Arrangement makes yearly modifications to the control lists, but these modifications often take significant amounts of time between proposal inception and implementation in export control laws of the forty Participating States of the Arrangement. Still, the lists represent the basis of the hierarchical framing of the problem of dual-use technology, and fulfil one of the assumptions that underlie export controls: that it is possible to define a list of technology to control.

We now turn our attention to specific attempts to make changes to the Dual-Use List. In Chapter 6, I analyse how anomaly-handling strategies compete in the process of list modification. This enables us to see in further detail how attempts are made to unseat the hierarchical framing, and how ambiguity is maintained in the final definition that the list-making process produces. The final analytic chapter is Chapter 7, in which I will look at how discussions around intangible technologies have mainly taken place in the GWG instead of the EG, and how that relates to the divide between social and technical worlds.

There is no simple solution to this quandary: splitting a dual-use item such as a sophisticated computer into its 'military' and 'civilian' parts is like King Solomon dividing the child.

—Førland (1993, p. 160)

6 Anomaly-handling & the Dual-Use List

Contents

We now have an understanding of how the Wassenaar Arrangement plays a part in addressing the wicked problem of dual-use technology. The wicked problem can be defined in many ways, and while the current hegemonic framing sees the problem as one of control, there are other framings that define the problem as one of competition or of inequality. Each of these framings is valid, though none of them is able completely to encapsulate the wicked problem. By analysing the history and structure of the Arrangement, I showed that while the hierarchical framing is hegemonic within Wassenaar, the other framings—and in particular the competitive framing—are also present in the debates. This chapter addresses the technical side of the Arrangement to show how it is dynamic and constantly evolving. While the hierarchical framing is still hegemonic, actors expressing it constantly have to reassert it as the lists are shown to be inadequate in some way. This inadequacy is expressed by pointing out *anomalies* in the classification system which, if not resolved, can lead to *uncomfortable knowledge* for the hierarchical framing.

The first section looks at the first of the anomaly-handling strategies, monster-adjustment. When the monster-adjustment is done with minimal contention with the other framings, as was the case with the quantum cryptography debate, we find that the anomaly is easily situated within the now-expanded classification system and the hierarchical framing's preferred form of organisation is strengthened. This is what happens with most of the modifications to the Dual-Use List of Wassenaar.

When the adjustment involves greater amounts of contention than experienced with quantum cryptography, as when addressing the topic of thermal imaging (Section 6.2), compromises must be made which force actors expressing the hierarchical framing out of their comfort zone. In this case, we can see a mixture of monster-adjustment and exception-barring strategies. To control more technology in one part of the list, exceptions have to be made in another part of the list.

The third section of this chapter provides an example of when actors expressing the hierarchical framing predominantly employ the exception-barring strategy to handle an anomaly. By doing so, the scope of the classification system is made narrower in order to maintain control. Within the Wassenaar Arrangement, this is generally done through decontrolling items on the lists, and we look at the case of decontrolling computers. By barring exceptions—in this case the knowledge that computers cannot be controlled based on their level of performance, interconnect, or memory—an actor expressing the hierarchical framing accepts that, while the anomaly is relevant to its framing of the wicked problem, it is not resolvable within the current classification system. Moreover, continued irresolution actually undermines the hierarchical framing as a whole—thus creating uncomfortable knowledge—because it shows that while control is desirable, it is not possible.

In the final section, we explore how the Wassenaar Arrangement can be thought of as an incompletely theorised agreement, where actors supporting different framings of the problem of dual-use technology are able to agree on particular list modifications even though they hold widely different and even contradictory views on what the technology is and the role it plays in society.

Questions asked in the proposal process

It is useful here to break the process for modifying the lists into a series of questions—using the analytic framework devised in Chapter 3—the answers to which will provide evidence for the type or types of anomaly-handling strategies employed. All proposals need to start with an actor determining that the topic of the proposal is relevant to the Wassenaar Arrangement. While this may seem obvious to some, determining something to be relevant can lead to significant amounts of uncomfortable knowledge for the hierarchical framing if that thing subsequently cannot be adequately controlled, and therefore there might be more to be gained (in terms of the framing's internal stability) by deeming the topic to be irrelevant.

Following on from the question of relevance is a determination of what type of proposal needs to be made: for tightening controls, which would incorporate more technology into the lists; relaxing controls; or 'cleaning' the text with no substantive change. When tightening controls, the proposal must justify how the proposed addition to the lists meets all of the criteria set out in the *Criteria* *for the Selection of Dual-Use Items*. Arguments for this type of proposal often use the monster-adjustment strategy, as they are trying to show how items that were previously not in the classification system can easily find a place there. When relaxing controls, the proposal needs to justify how the current item on the lists no longer meets at least one of the criteria. Arguments for this type of proposal can be monster-adjustment as well if the argument is that the item is no longer militarily significant (i.e. relevant), but most often the exception-barring strategy is employed, arguing that the item cannot be controlled for some reason. 'Cleaning' the text often involves reformatting items so that they are in line with the *Guidelines for the Drafting of lists*, but is not supposed to involve a change on the level of control. This was the major concern of the Wassenaar Arrangement's 2007 Assessment Year task group on list clean-up.[1]

In most cases, a proposed list modification will have economic implications, and many Participating States solicit opinions from industries about the impact a proposal may have. It is also the case that many proposals, especially to relax controls, originate from industry. Industry representatives usually seek to strengthen a competitive framing of the problem of dual-use technology, focusing on expanding the marketability of the technology. The weight given to the economic impact varies from case to case and depends on several factors, including the economic benefit of relaxing controls or—if there is an established market—when tightening controls, but is generally seen as something that must be balanced with the perceived military significance of the item. Getting all Participating States to agree on the level of military significance of an item, however, is sometimes a very difficult task.

There are also political and logistical considerations to take into account. Negotiations at Wassenaar form part of a State's overall presence on the international stage, and negotiations in another area of international politics may impact upon a State's decision to put forward or oppose a particular proposal. Logistically, the terminology in the proposal must be able to be translated into

[1] Interview with US State Department Official B, 19 January 2007.

the dozens of languages used by Participating States, and it often takes significant time during the Expert Group meetings to find terminology that works for all. Another logistical factor is the question of how many proposals a State is submitting in a particular year, and the fact that there are only so many hours of meetings for the Expert Group. States may hold off submitting too many proposals that are likely to be contentious in order to get agreement on at least one of them.[2]

One of the key questions that States address in determining if a proposal should be submitted to Wassenaar is if 'the time is right' for this tightening/relaxing of controls. "Often the most difficult decision to take in putting forward proposals... is to try not to control something too early because it's still in academia, and then missing the chance of it being put in the public domain when you can't control it anymore."[3] This is a clear example of Collingridge's (1980) 'control dilemma': Participating States do not want to control something that does not yet exist, but at the same time, they want to make sure that, once something does exist and is deemed in need of control, it is controlled.

Each of these questions can play not only into the decision as to whether or not a proposal should be put forward, but also into the technical specifications of the item in the proposal. Having a technology become labelled as 'dual-use' is the result of all of these factors, and undoubtedly more.

6.1 Quantum cryptography

An historical context

Cryptology—the art of writing and solving codes—is an ancient science. It is composed of two parts. The first, cryptography, is the design and employment of methods (called 'ciphers') for processing plain text through an algorithm

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[2]This primarily happens with the larger delegations, as many States only submit a few, if any, proposals in a given year.

[3]Interview with British Former Government Official, 8 March 2007.

('encrypting' it) such that only the intended recipient can read it (by 'decrypting' it). The information the recipient needs to decrypt the cipher text is called the 'key'. The second part of cryptology is cryptanalysis, the art of decrypting cipher text without knowledge of the key (also called 'cracking' the cipher).

There has always been an interest in secret communication from both military and non-military actors. Books specifically on cryptology date back to at least 900 AD (Al-Kadit, 1992), and one of the most famous ciphers, which uses permutations, is named after Julius Caesar as it was used in many of his official communications.[4] The Julius Caesar cipher takes the alphabet and transposes it by a set number of places. For example, transposing by 5 would mean that what was an 'a' becomes a 'f', a 'b' becomes a 'g', etc.

The Julius Caesar cipher takes the alphabet and transposes it by a set number of places. A transposition of 5 would produce the following cipher text:

plain text:
Beware the Ides of March
cipher text:
Gjbfwj ymj Nijx tk Rfwhm

Figure 6.1: *Example of the Julius Caesar cipher*

The security of a cipher is determined by the ability of an enemy either to acquire the key and perform the decryption using the key, or to crack the cipher without the key.[5] Some ciphers, such as the Julius Caesar cipher, are relatively easy to crack, especially with today's computing power. Others, such as the Enigma cipher used by the Germans in World War II, are much more difficult. Enigma relied on a machine like a typewriter with multiple rotors (and later a plugboard) that allowed complex substitution ciphers, and a handbook that told the operator where to set the rotors for each day. Attempts to crack this code involved both the stealing of the machines and handbooks and the creation of a machine that could work through all of the permutations and select the ones most likely to be correct.

[4]See, for instance, his account of using the cipher in the *Gallic Wars*.

[5]The enemy can acquire the key either by cryptanalysis or by finding where the recipient stores the key and stealing it.

Both the Julius Caesar and Enigma ciphers were military creations for military use. Cryptography can have a much wider aim than that, however. Al-Kadit (1992), in a landmark study of the history of Arab cryptology, discusses its use in translation. The Arab culture was rapidly expanding in 700–1000 A.D, acquiring texts from all their neighbouring civilizations. Often lacking a translator, they relied on cryptanalytic techniques to understand the structure of the language and thereby the contents of the texts. Religious leaders also have need for cryptography, and the Catholic Pope's communications from the Renaissance onwards have been the subject of much study (Alvarez, 1993; Meister, 1906; Pasztor, 1984).

It wasn't until the advent of computers, however, that the ability (and need) to encrypt information was more widely accessible. In 1974, International Business Machines (IBM) responded to a call[6] by the US government to produce a standard encryption algorithm "that could satisfy a broad range of commercial and unclassified government requirements in information security" (Burr, 2001, p. 250). The algorithm became the *Data Encryption Standard* and spurred much interest in deploying encryption in all business transactions. Today, everything from personal emails to online banking to telephone conversations and, of course, state secrets, can be encrypted to levels that make the data very difficult to read, even for the most advanced cryptanalytic government units.[7]

Almost all of the ciphers that have been created to date are susceptible to some form of cryptanalysis; that is, they can be cracked. There is at least one cipher, however, that is theoretically uncrackable without the key, and it is this cipher that is used in quantum cryptography. It is called the 'one-time pad'

[6] The call was first sent out in *Federal Register* (May 15, 1973), and sent out again in *Federal Register* (August 17, 1974).

[7] There was much debate in the late 1990s over how secure personal communications should be (e.g. Anonymous, 1998; D'Amico, 1998; Hogg, 2000; Madsen, 1999; Shehadeh, 1999). While this debate did reach Wassenaar discussions and are a cause for many people initially learning about and trying to influence the Arrangement, I decided not to analyse this particular debate because I was unable to reach many of the primary sources and a proper treatment of the case would likely be a book in its own right.

and was developed by Gilbert Vernam around 1919[8] and proved uncrackable by Claude Shannon (1949).[9] The one-time pad consists of a key that is a string of binary text (0 and 1's, called 'bits') at least as long as the message to be sent. The sender (whom we shall call Alice) and receiver (Bob) both have a copy of the key. Alice has a plain text in binary form[10] and adds it using binary addition to the key to get the cipher text.[11] Alice then sends the cipher text to Bob via an unencrypted channel. Bob performs the binary addition of the cipher text with the key to get the plain text back. This process is shown in Figure 6.2. Since the key is random, an eavesdropper is unable to retrieve any useful information from the cipher text. This cipher depends entirely on the secrecy of the key, which has to be changed after every message, hence calling it the 'one-time pad' cipher. The difficulty of securely transmitting a key between the sender and receiver has meant this cipher has been used relatively little, except for situations where the highest levels of secrecy were demanded.

The difficulty of key transfer is what quantum cryptography claims to overcome (e.g. Sergienko, 2006). Quantum cryptography is therefore more usefully called 'quantum key distribution' (QKD). If Alice is able to give Bob a key in such a way that she knows if anyone has looked at it during the transfer (thus compromising it), then she can use the key as a one-time pad cipher and can securely transfer information to Bob knowing that the mathematical properties of the one-time pad ensure that no one can crack her cipher text. The properties of quantum bits, or 'qubits', allow the key exchange to occur in such a way that, in theory, any eavesdropping can be detected. This theoretical capability has given quantum cryptography a lot of public attention and a fair degree of sensationalisation (see Anonymous, 2003; Markoff, 2002; Marks, 2007; Singh, 1999). Currently, there are at least three companies that claim to

[8] US Patent number 1,310,719, issued 22 July 1919.

[9] At the present time, it is the only cipher to be mathematically proven uncrackable.

[10] This is not difficult, since all computer languages are based on a binary system.

[11] The cipher text is therefore simply a statement of whether the plain text bit is the same or different than the key bit.

sell quantum cryptographic systems, Magiq Technology,[12] BBN Technologies,[13] and Id Quantique.[14] It is important to note that, while quantum cryptography may be in principle a perfectly secure way to transfer a key, to ensure complete secrecy would require a perfectly noiseless communication channel. Since such channels do not exist, error correction and noise cancelling algorithms must be employed as well, which make the system no longer 'perfectly' secure. The amount of noise in a communication channel is the primary limiting factor in current attempts to employ quantum cryptography.

While this is a very brief overview of quantum cryptography, it should give the reader enough knowledge to understand the debate within the Wassenaar Arrangement. We now turn to the proposal process for this list modification.

The proposal process

As with most debates at the Wassenaar Arrangement, this one started with a proposal for a list change, this time from the British government, and specifically from the Communications-Electronic Security Group (CESG) at the Government Communication Headquarters (GCHQ). The text of any proposal has the potential to become anomalous, undermining the classification system as a whole. While the proposal offered a specific change—the text to go on the list—the process of accepting the proposal was one that involved discussion on both what the technology was, and whether it was anomalous. Those in the debate had to decide whether the technology was actually a form of cryptography, and, if it was, whether or not it was covered under the current controls. In creating the final text of *5.A.2.a.9*, they further had to decide how specified (and conversely how ambiguous) the text should be. We will look at each of these aspects in turn.

[12] http://www.magiqtech.com
[13] http://www.bbn.com/
[14] http://www.idquantique.com/

The one-time pad cipher adds each bit of a plain text to a corresponding bit of a key to get the cipher text:[a]

plain text:		010111001010
key:	+	110111101101
cipher text:		100000100111

To get the plain text back, one need only add the key to the cipher text:

cipher text:		100000100111
key:	+	110111101101
plain text:		010111001010

[a]In binary addition, 1+1=0. Essentially, the cipher bits are therefore just statements of whether the key bit and the plain bit are the same (cipher bit = 0) or different (cipher bit = 1).

Figure 6.2: *Example of the one-time pad cipher*

Is quantum cryptography a form of cryptography? It has the label of 'cryptography', and for some, that is enough for them to consider it a cryptographic system. But what does a cryptographic system do? Does it transfer information securely, or does it *allow* for information to be transferred securely? The former is a more widely accepted definition, but quantum cryptography falls more into the latter. Recall that quantum cryptography can more accurately be called 'quantum key distribution'; it transfers the key that is used in the one-time pad cipher, but does not actually encrypt the message itself. This is why one member of a delegation, when I mentioned quantum cryptography, replied, "It's now controlled. And we had an interesting debate on that because it's not really cryptography, it's quantum key distribution."[15] And indeed, when we look at the text of the list, there is a Technical Note after 5.A.2.a.9 that says, "'Quantum cryptography' is also known as quantum key distribution (QKD)." This is further supported by the definition of quantum cryptography provided in the list (Figure 6.3).

Recall that a cryptographic system is composed of an encryption and decryption algorithm and a key. The algorithm used in quantum cryptography—the one-time pad—is very simple and widely known. Trying to control the

[15]Interview with US State Department Official A & US State Department Official B, 11 September 2006.

Cat 5P2 "Quantum cryptography"
A family of techniques for the establishment of a shared key for "cryptography" by measuring the quantum-mechanical properties of a physical system (including those physical properties explicitly governed by quantum optics, quantum field theory, or quantum electrodynamics).

Figure 6.3: *Definition of 'quantum cryptography'*

international dissemination of the algorithm, then, is not an option for the Arrangement. Controlling the knowledge of and technology for producing and transferring the key, however, is an option, and in this way Wassenaar can in effect control the whole quantum cryptographic system. This process of identifying the best point of control is common in the list modification process, as one participant noted:

> [People working on our delegation are aware of] what's being developed, what's being used, what is an enabling technology or a key enabling technology for a given military system. And when that's identified, we say, "ok. Can we control it and where can we control it? What's a critical choke point that needs to be controlled? Is it the software? Is it the materials? Is it the manufacturing technology for it, which is just a know-how beyond the software?"[16]

When quantum key distribution is viewed as a 'critical choke point' for the application of a quantum cryptographic system, we can understand why the proposal placed this text within Category 5 – Part 2: it is, for the purposes of control, cryptography. This was succinctly stated by a member of the British delegation:

> Interviewee: From my angle it [quantum cryptography] was a very very simple thing, and the least controversial of all the topics going forward. It was CESG's proposal. There was no reason from any angle why a new form (or new to us anyway) of encryption should not be added to the control, particularly because it seemed to us to be quite important. So in practical terms the proposal went forward. The interested parties were shut in a room upstairs in Wassenaar to really make sure that everybody understood what it was that we wanted to control.

[16] Interview with US Defense Department Official A, 8 August 2006.

> SE: Which is not at all clear on the actual lists. It says that you control 'quantum cryptography'.
>
> Interviewee: I think that was deliberate, at the end of the day, as a lot of the Cat 5 controls are. They are open to interpretation. It's not something that I ever felt very happy about, but one couldn't change overnight controls that had been there for a long time.[17]

Quantum cryptography was therefore established by at least one delegation as being a *relevant* technology for the purposes of the Wassenaar Arrangement. The next step in the proposal process was to determine if the technology was already controlled in Category 5 – Part 2.

It is useful here to recall that, if such a proposal had come up in 1980, it is very likely that no one would have seen the need to add text to the list because *IL 1527* (*5.A.2*'s predecessor) covered "Cryptographic equipment and ancillary equipment... designed to ensure secrecy of communications..." When the quantum cryptography proposal was submitted in 2004, however, the then-current control text was the chapeau[18] for *5.A.2.a*, shown in Figure 6.4.

5. A. 2. SYSTEMS, EQUIPMENT AND COMPONENTS

a. Systems, equipment, application specific "electronic assemblies", modules and integrated circuits for "information security", as follows, and other specially designed components therefor:

Figure 6.4: *Chapeau for 5.A.2.a (Wassenaar Arrangement, 2004*c*)*

This chapeau does not actually control any technology itself. The "as follows" denotes that items to be controlled are only specified in the sub-entries. This chapeau was created in the Core List revision of 1991, when *IL 1527* became Category 5 – Part 2. With that move there was an important shift in the structure of the controls. *IL 1527* controlled all cryptographic equipment

[17]Interview with British Former Government Official, 8 March 2007.

[18]Recall that the *Guidelines for Drafting the lists* states that entries are to be broken down into chapeaux, sub-entries, Notes, Technical Notes, and Note Benes, in that order. Refer to Appendix G.

and components, whereas *5.A.2.a.* only controls that equipment specified in the sub-entries. What was a blanket control text became a blanket *decontrol* text. This supports the remark that the 1991 Core List revision was a shift from controlling all technology with specific decontrols, to only controlling the most important technologies (see page 182). This shift tends to create more anomalies because a more fine-grained classification system will leave more technology out than in. As a very simple analogy, the old CoCom lists would control 'blocks', whereas the post-1991 lists would control 'blocks meeting any of the following criteria: red; square; smaller than 2 metres on any side'. For something to be controlled under the former classification system, it would only have needed to be understood as a block, but under the latter system, many things which are blocks would not fall under control. The former system is designed to prevent many anomalies by having a broad characteristic that covers a large range of technology. The latter system will generate more anomalies because it tries to control only specific instances of a general category.

Whether a system is broad or fine-grained is, of course, a relative matter. One could say that calling something a block is more fine-grained than just calling it a 'shape'. Returning to the Wassenaar lists, they could be very simple and just control 'technology' instead of having so many categories and items. Such a system would likely have few anomalies arising from something not being controlled but, as we shall see below, many more anomalies arising from contestations over whether technologies under control *can actually be* controlled. For now, it is sufficient to say that within *5.A.2.a* there was no text under which the participants thought quantum cryptography could be placed, and therefore new text needed to be created. This solidified quantum cryptography as an anomaly within the dual-use classification system, which meant an anomaly-handling strategy was now necessary.

We can now see that the team that put together the proposal on quantum cryptography positioned it to be relevant to the Arrangement and not currently under control. Moreover, we have the beginnings of the next part of the proposal process—determining whether the technology *can* be controlled. Implicit in any proposal to add a technology to the list is the assumption that such technology can be controlled. This is a clear statement of the monster-adjustment strategy:

1. A technology is relevant

2. It is not currently under control

3. It can easily be controlled by a modification of the current text

Having established that quantum cryptography is relevant, is not already controlled, and can be controlled, Britain then submitted the proposal to the Wassenaar Arrangement, where the other Participating States had an opportunity to comment on it and debate whether the modification should actually be made to the list. The discussions to make the list change for quantum cryptography were typical in that there was little debate over whether the technology should be controlled. There were also characteristics of the discussions typical specifically of changing Category 5 – Part 2.[19] They were conducted in a Technical Working Group (TWG) in a room on the upper floor of Wassenaar, at the same time of day as the Expert Group (EG) main meeting in the room downstairs. The meeting was composed mostly of members of national delegations from their respective intelligence ministries. When this group—sometimes called the 'security & intelligence experts subgroup'[20]—proposes a change, it is usually accepted without debate by the main EG. With quantum cryptography, however, there were a lot of people in the room who would not necessarily be thought of as security and intelligence experts, and were there more to find out about this new technology that they did not know about than to help establish controls.[21]

[19] Interview with British Former Government Official, 8 March 2007.
[20] Personal correspondence with US State Department Official A, 23 October 2008.
[21] Interview with British Former Government Official, 8 March 2007.

This raises an important point about how specific the control text becomes in a list change. While there is the official specification that the text must be a "clear and objective specification of the item" (Wassenaar Arrangement, 2005*a*), there is also the concern of *giving away too much information*. The lists, in other words, are not meant to be blueprints and procedure manuals for technology.

But why state the text of the list as simply controlling 'quantum cryptography' with no parameters other than that it is also known as 'quantum key distribution'? They could have been more specific, for instance by breaking it down into arial systems and optical-fibre systems. They could have included parameters for the number of qubits per second that could be transferred, or the distance over which the system could work. One answer could be that the artefacts which currently exist are still more at the theoretical stage than the production stage. Until the technology is more developed, a person employing the monster-adjustment strategy would be satisfied with a broad level of control.

There are several analytic points that come to light here. First is that the text functions *as* the technology under control. Providing information about the technology for the purposes of control is itself an uncontrolled transfer of knowledge about the technology. This leads to the second analytic point, which is that the decisions on the text involved decisions on creating strategic ignorance (McGoey, 2007) for potential adversaries by purposefully building ambiguity into the definition of dual-use technology. There is as much interest in what is *not* used to define quantum cryptography as what *is*. Finally, a third analytic point is that the decision on how specific to make the definition was also a matter of finding parameters acceptable to all, getting agreement where possible and leaving the rest alone. This point will be addressed in detail when we discuss the Wassenaar Arrangement as an 'incompletely theorised agreement' in Section 6.3.

How could this proposal have been defeated? Those actors expressing the competitive framing could have used the point that the text is very broad to argue that the item should not be controlled because the text was not a "clear and objective specification of the item," and could not be because the technology is still in the early stages of development (including the development of the global market for the technology). Another point that could have been raised by this framing at the national as opposed to international level is that the controls would have put too heavy a burden on industry, or that the controls would significantly hinder competition on the global marketplace. To my knowledge, however, these arguments were not made. One reason may be that actors expressing the competitive framing were placated by actors expressing the hierarchical framing early on. "Nobody's saying they are going to be stopped from using [quantum cryptography]. The only factor that I perhaps put into [the design of the proposal] was that it didn't seem to me to be any burden on UK industry whatsoever."[22] Another reason may be that significant potential uses of this technology were already specifically decontrolled. Banking and financial transactions were decontrolled by *5.A.2.'Note d'*, and mass market uses were decontrolled with *5.'Note 3'.* The competitive framing therefore was assured that marketing the technology would not be subject to undue hindrance from export controls. Agreement was therefore reached with little dispute and the avoidance of all uncomfortable knowledge. And thus, *5.A.2.a.9* was inscribed and the anomaly was successfully resolved into the now-expanded classification system.

6.2 Focal plane arrays

The focal plane array debate was very different from the case of quantum cryptography, although both ended with the resolution of the anomaly. 'Focal

[22]Interview with British Former Government Official, 8 March 2007.

plane arrays'—covered in section *6.A.2.a.3*—are technologies for thermal sensing, and one of the most recent modifications to this section of the Dual-Use List was very contentious. In analysing this case study, we are looking for the reasons why this modification was so contentious while our previous case was not. As with my analysis above, we begin here with a brief history of thermal sensing and the closely-related technology of night-vision equipment, and then turn to the proposal process.

An historical context

All of the categories of the Wassenaar Dual-Use List are permeable. Some technologies may be able to fit into multiple categories, and the technologies within any of the categories may have very little to do with one another. Category 6 represents a broad container for technologies that can be classified as either 'sensors' or 'lasers'. But this is a relatively new container; along with the other categories, it was devised in the Core List review of CoCom in 1990-1991.

I noted in Chapter 4 that the CoCom lists had become significantly lopsided in the 1970s and 1980s, particularly with reference to Groups F & G 'Electronic equipment including communications, radar, computer hardware and software'. Electronics, which were only just gaining prevalence at the end of WWII, had by then become a major component of both military and economic viability. During the Core List revision in 1990–1991, these groups—items with numbers in the *1500s*—were split up into several different categories, and other categories were mixed with items in these groups. This was particularly the case with the new Category 6 – 'Sensors and "Lasers"', which contains items from most parts of the old Groups F & G, but also parts of Group C 'Electrical and power generating equipment' (the *1200s*), Group D 'General industrial equipment' (the *1300s*), and Group I 'Chemicals, metalloids, and petroleum products' (the *1700s*).[23] Space does not permit me here to delve into the specific reasons why the category of 'Sensors and "Lasers"' was seen

[23]See Appendix C for a full listing of the CoCom origins of the items in Category 6.

as a more appropriate container than the old groups, but it is important to note that, within the world of export controls, the development even of these broad categories is not a clear-cut process with a single definitive outcome.

Category 6 – 'Sensors and "Lasers"' is divided, as the other categories are, into five sections (see Appendix B). *6.A* is further divided into subsections as shown in Table 6.1. Focal plane arrays are placed into *6.A.2* 'Optical Sensors' and are defined as shown in Figure 6.5.

Table 6.1: *Subsections of 6.A.*

6.A. Systems, Equipment and Components
6.A.1. Acoustics
6.A.2. Optical Sensors
6.A.3. Cameras
6.A.4. Optics
6.A.5. Lasers
6.A.6. Magnetic and Electric Field Sensors
6.A.7. Gravimeters
6.A.8. Radar

Cat 6 "Focal plane array"

A linear or two-dimensional planar layer, or combination of planar layers, of individual detector elements, with or without readout electronics, which work in the focal plane.

Note *This definition does not include a stack of single detector elements or any two, three or four element detectors provided time delay and integration is not performed within the element.*

Figure 6.5: *Definition of 'focal plane array' (Wassenaar Arrangement, 2007*b*, p. 190)*

The chief characteristic of focal plane arrays that Participating States consider to be of military significance is their ability to sense infrared light, and to do so quickly, with high resolution, at a significant distance, and/or be lightweight, robust, and durable. Why these features are desirable, and the parameters of each which all can agree to be 'militarily significant', are, as we might expect, a matter of debate within the Wassenaar Arrangement. It is the sensor characteristic that the States used to place focal plane arrays in Category 6—'Sensors and "Lasers"', while the characteristic of it detecting light (electromagnetic radiation) instead of sounds (acoustical vibrations) places it in *6.A.2* as opposed to *6.A.1*.

Focal plane arrays provide a detectable change in electric properties due to absorbed thermal radiation. 'Thermal' imaging means looking at how hot or cold an object is in relation to its surroundings. Key military activities that use thermal imaging include heat-seeking missiles and vision systems in no-light conditions.

The ability to see in the dark is one of the military technologies that Participating States believe provide a key advantage to the development of military capabilities generally, and is thus controlled on the Sensitive List as well as the Dual-Use List.

> Why are they important? They first of all generate night vision capability. And night vision has been shown by our Army and all the other forces (Air Force, Navy, what have you) as a critical enabler for the success of your operations. That's the long and short of it. So it does have a strong military utility.[24]

Early work on technology to aid sight in darkness began at the end of World War II and focused on image converters. Image converters produce images through the use of photocathodes, which sense near-infrared light and produce an image on phosphor that a person can view through a lens. Drawbacks of this technology are seen to include the requirement of a near-infrared light source, a low quantum efficiency of the photocathode, and no internal amplification of the signal produced by the photocathode (Wood et al., 1992).

These perceived drawbacks were addressed through the development of 'image intensifiers' that do not need an integrated infrared light source, as they

[24]Interview with US Defense Department Official A & US Defense Department Official B, 5 February 2007.

are sensitive enough to produce a readable display using reflected moonlight or airglow (a glow in the night sky caused by radiation from the upper atmosphere) (Inoué & Spring, 1997). First generation (Gen I) intensifiers were employed by the US in the Vietnam War, and use electrostatic focusing and electron acceleration to produce a brighter display (Anonymous, 2008). Perceived problems with Gen I intensifiers include image distortion, short-lived components, and large size (Anonymous, 2002). Second generation (Gen II) intensifiers developed in the early 1970s make use of a 'microchannel plate', which multiplies the number of electrons that impact the phosphorous display as well as accelerating them (Inoué & Spring, 1997, p. 336). These intensifiers have a higher resolution, are smaller, and produce less image distortion (Wood et al., 1992). Third generation (Gen III) intensifiers added a gallium arsenide (GaAs) coating to the photocathode, which makes them 2–3 orders of magnitude more sensitive to ambient light (Anonymous, 2002). While Gen I intensifiers needed the equivalent light source of a full moon to produce a image deemed useable, Gen III could do the same in heavily overcast situations.

Image intensifiers are used widely by militaries today, as well as by commercial security systems, police, hunters, and the media. You can tell an image that is produced this way because it is only in shades of green (a result of the phosphor, which only emits green light). Early types of image convertors were covered in Group F of the 1954 CoCom lists, "Electronic vacuum tubes or valves of the following descriptions: [. . .] (g) Image convertors and electronic storage tubes, except television camera tubes other than photoconductive camera tubes" (British Government, 1954, p. 785). In the 1958 lists, this became *IL 1555*. They are currently controlled under *6.A.2.a.2* of the Wassenaar Dual-Use List, of which *6.A.2.a.2.a* and *6.A.2.a.2.b* are also controlled on the Sensitive List.

Instead of taking ambient visible or near-infrared light (electromagnetic radiation with wavelengths of roughly 400 nm to 700 nm) and magnifying it, thermal sensing detects electromagnetic waves in the infrared spectrum, with wavelengths generally agreed to be between 750 nm and 1,000,000 nm (1 mm, or 1,000 microns (μm)).[25] An object's emission of infrared light is often linked to its temperature relative to the ambient temperature. Thus, generally speaking, hot things (relative to their environment) emit more infrared photons than cooler ones around them. As an example, if you were able to see in the infrared spectrum, it could be pitch black in a room and you would be able to see humans and other animals, an electric hob turned on, and gaps in the walls that are letting in cold air. Moreover, certain bands of infrared radiation have certain properties that visible light does not, one of which is the ability to penetrate common types of fog and smoke.

In theory, "all physical phenomena in the range of about 0.11 eV can be proposed for IR detectors" (Norton, 1999). These phenomena include:

> thermoelectric power (thermocouples), change in electrical conductivity (bolometers), gas expansion (Golay cell), pyroelectricity (pyroelectric detectors), photon drag, Josephson effect (Josephson junctions, SQUIDs), internal emission (PtSi Schottky barriers), fundamental absorption (intrinsic photodetectors), impurity absorption (extrinsic photodetectors), low-dimensional solids (superlattice (SL) and quantum well (QW) detectors), different type of phase transitions, etc. (Rogalski, 2002, p. 188).

The oldest CoCom lists available (1954) define controls for infrared detection in Group F as a sub-item of "Electronic vacuum tubes or valves" (Figure 6.6).[26]

By 1960, advances in bolometers and thermocouples were seen by the members of CoCom as warranting separate controls from 'photo-electric' and 'photo-conductive' cells, which had by then become *IL 1548*. These technologies were instead defined by their ability to sense 'thermal' energy, as shown by *IL 1550* (Figure 6.7), first found on the lists in 1960.

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[25] There is no scientific consensus on where the visible light portion of the electromagnetic spectrum ends and the infrared portion begins. Different groups of scientists use different methods for drawing the line. Meteorologists, for instance, divide the infrared portion according to how the light is absorbed by different molecules, while engineers tend to draw the lines based on the the absorption capabilities of different detector materials. Generally, this is taken as evidence that the electromagnetic spectrum is, as thought, continuous rather than discrete.

[26] 12,000 Angstrom units = 12 μm

(h) Photo-electric cells of the following descriptions:

1. Photo-electric cells with a peak sensitivity at a wavelength longer than 12,000 Angstrom units;...

Figure 6.6: *Early infrared detection controls (British Government, 1954, p. 785) (not actual image)*

1550. Thermal detecting cells, i.e. bolometers and thermocouple detectors, radiant energy types only, with a response time constant of less than 10 milliseconds measured at the operating temperature of the cell for which the time constant reaches a minimum.

Figure 6.7: *The first appearance of IL 1550 (British Government, 1960, p. 282) (not actual image)*

IL 1550 disappeared in the 1980 CoCom lists, and while it may appear that 'thermal detecting cells' are no longer controlled, there is also evidence to suggest that they were instead no longer seen as in Groups F & G (then called 'Electronic equipment including communications, radar, computer hardware and software'), but instead as part of Group C 'Electrical and power-generating equipment'. In particular, *IL 1205(b)(1–3)*, which covered 'photo-voltaic cells', later became *6.A.2.a.3* after the Core List revision, as shown in the Cross Reference Index.[27] These 'cells' were controlled based on their 'power output', rather than by the wavelengths they absorbed. I choose to use the word 'absorb' here rather than 'detect' as that seems more in keeping with the mindset of viewing the cells as power-providers rather than radiation-detectors.

6.A.2.a.3, which was the topic of the debate at Wassenaar in 2002–2004 that I analyse in this section, does not solely owe its existence to *1205(b)(1–3)* as the

[27] See Appendix C.

Cross Reference Index suggests. When *6.A.2.a.3* first came into existence in 1991, it had the chapeau 'Non-"space-qualified" linear or two dimensional focal plane arrays'. The term 'focal plane array', however, first appeared in *IL 1548* in 1985 (British Government, 1985, p. 29), and the parameters used to define the technology in *6.A.2.a.3* were not those of *IL 1205* (i.e. 'power output'), but rather the wavelengths of radiation that the material could detect/absorb, which were the parameters used by *IL 1548*. As we can see, then, *6.A.2.a.3* has had a checkered history of development, and has found homes in multiple areas of this classification system.

The real trouble for the 2002–2004 debates within Wassenaar, however, was a decontrol note that appeared with the Core List review, *6.A.2.a.3.'Note 2'*, "6.A.2.a.3. does not embargo silicon focal plane arrays…" (British Government, 1991*a*, p. 39).[28] One member of a delegation[29] provided me with a succinct reason for this decontrol:

> Nobody thought that you could get silicon to respond in the right wavelength. That was the original thinking. They were specifically excluded because a lot of conventional charge couple devices were made of silicon. The CCD in your camcorder is made of silicon, but it doesn't see well at night. It doesn't respond in the IR [infrared]. So in order to get the solid-state devices controlled, the [other Participating States] said, "we want to make sure we don't control the conventional CCDs." And everybody said, "sure. They're no good anyway."

To gain an understanding of why this Note provided such difficulty, it is useful to turn to a brief history of the development of focal plane arrays, and in particular uncooled focal plane arrays. The term 'focal plane array' first appeared on the 1985 CoCom lists under *IL 1548(d)*, but work on focal plane array development had already begun by the 1950s (at least in the US). This early work focused on photon detection, which requires the detector to

[28]This became *6.A.2.a.3.'Note 2'.a* by 2002.

[29]Interview with US Defense Department Official A & US Defense Department Official B, 5 February 2007.

be cryogenically cooled.[30] Over the following decades, these sensors became increasingly sensitive and are today employed for such military uses as unmanned aerial vehicle (UAV) night reconnaissance systems and targeting and acquisition systems on Apache helicopters. Unclassified resolution capabilities of cameras employing cooled focal plane arrays are such that a person could use the camera to detect the heat from a recently shot rifle from 8 miles away and 20,000 feet up.[31]

Cooled detectors have, to date, always been able to detect infrared radiation with a higher sensitivity than uncooled detectors, but the perceived downsides of cooled detectors for military use include low reliability (3,000–4,000 hours between failures for cooled detectors, compared to 40,000–60,000 hours for uncooled detectors), and that they are bigger, heavier, more expensive,[32] and require longer starting times to allow the sensor to cool down (Bogue, 2007).

Imagers based on cooled focal plane arrays, as well as all electronic sensing technology 'specially designed for military use', could be covered under *ML 11.a*, as could be all "specially designed components therefor."[33] When not designed for military use, cooled focal plane arrays are covered on the Dual-Use List by *6.A.2.a.3.a–e*, where each of the subdivisions are based on effective response in different bands of infrared radiation.

The United States provided major funding for research into uncooled focal plane arrays in the late 1980s through a classified Defense Advanced Research Projects Agency (DARPA) contract called 'high-density array development' (HIDAD). This was part of the Balanced Technology Initiative (BTI) programme managed by the US Army Night Vision and Electronic Sensors Di-

[30]Usually to 77 K (-196 C) for Mercury Cadmium Telluride (HgCdTe) detectors or 195 K (-78 C) for others such as Indium Antimonide (InSb) (Kruse, 1994).

[31]Interview with intelligence officer working with UAVs in Afghanistan.

[32]In 1993, cooled infrared imaging systems typically cost $100,000 (Wood, 1993*a*), and by 2002 they were still around $50,000 (Rogalski, 2002).

[33]*ML 11.a.'Note c'* says that *ML 11.a* includes "Electronic systems and equipment designed either for surveillance and monitoring of the electro-magnetic spectrum for military intelligence or security purposes or for counteracting such surveillance and monitoring" (Wassenaar Arrangement, 2007*b*, p. 172).

rectorate (NVESD). "DARPA was pushing this technology, because they were looking for a very low cost thermal weapons sight, and light and power and all the other good stuff[. . .] When they first developed the rudimentary [uncooled focal plane array] devices, the sensitivity was terrible. You could see a soldering iron and that was about it. A soldering iron *turned on.*"[34]

Two companies, Texas Instruments and Honeywell, received funding through this contract and each worked on developing uncooled focal plane arrays with different types of material (Buser & Tompsett, 1995). Engineers at Texas Instruments decided to make use of a physical principle called the pyroelectric effect, whereby infrared radiation hitting a ceramic—in this case, the ferroelectric ceramic barium strontium titanate (BST)—cause the ceramic to become electrically charged (Hanson et al., 1992). Engineers at Honeywell used a property of some materials—mainly different configurations of vanadium and oxygen, together called vanadium oxide (VO_x)—whereby infrared photons hitting the material cause an increase in the material's electrical resistivity (Wood, 1993*a*,*b*).

It is important to note here that NVESD had a big reputation within the night vision world, but it did not have very much money to fund projects on its own, and certainly not enough to fund the massive development needed to bring uncooled focal plane array technology to a state where it could be deployed on the battlefield. In order to get the funding, the NVESD had to, in effect, lobby DARPA through the US Congress and convince a DARPA programme manager that this research and development was worth funding.[35] Here we see an example of very non-technical reasons why some technologies are developed and others are not.

Pyroelectric focal plane arrays were first developed by Texas Instruments

[34] Interview with US Defense Department Official A & US Defense Department Official B, 5 February 2007.

[35] Interview with US Defense Department Official A & US Defense Department Official B, 5 February 2007.

in the late 1970s.[36] The basic pyroelectric phenomenon—where a change in temperature of a crystal produces a charge—was known thousands of years ago, and was described by Theophrastus in the 4th Century BC.[37] One characteristic that is commonly seen as important in these types of focal plane arrays is that they only respond to *changes* in the temperature over their area of detection (Hanson et al., 1992). If one were taking a still image or only concerned about movement in the area of detection, this characteristic would not be seen as a disadvantage. If, however, one were interested in continually viewing a scene, i.e. providing a video image rather than a still image, then this is a drawback. To get around this characteristic, pyroelectric focal plane arrays used for video purposes are fitted with a 'chopper' that effectively works like a shutter of a camera, combined with electronics to integrate the chopped still images into a video, typically at a speed of 30 frames per second (30 Hz), which is about the speed where humans can no longer disassociate individual images from one another.

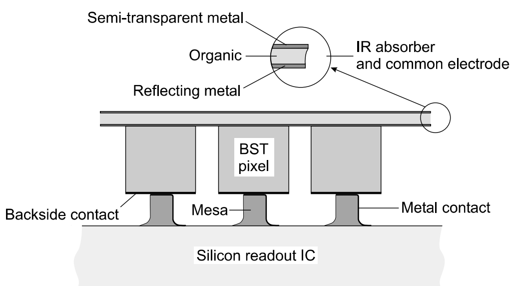

Figure 6.8: *TI BST pyroelectric focal plane array implementation (Hanson et al., 1992)*

Resistive microbolometer focal plane arrays do not need a chopper because they make use of a different physical phenomenon. A 'microbolometer' is a technology that, according to the Wassenaar Arrangement, is "a thermal imaging detector that, as a result of a temperature change in the detector caused by the absorption of infrared radiation, is used to generate any useable signal."[38] The concept of such a technology has been moving within communities of sensor experts since at least Samuel

[36] See, for instance, US Patents 4080532, 4142207, 4143269, 4162402.
[37] For a history of pryoelectricity from Theophrastus through to the 1970s, see Lang (1974).
[38] *6.A.2.a.3.f.'Technical Note'* in lists after 2003.

Pierpont Langley's first demonstration in 1879 of a bolometer for astronomical observations (Barr, 1963; Langley, 1880–1881*b*, 1881*a*). Most sources say that the microbolometers developed by Honeywell used VO_x as their detecting element (e.g. Cole et al., 1998; Kruse, 1994; Rogalski, 2003), but early publications shortly after the HIDAD programme was declassified refer only to *silicon* microbolometers (e.g. Wood, 1993*a*; Wood et al., 1992).

Indeed, both the Texas Instruments' focal plane array and Honeywell's relied on at least a silicon base for their detectors (Figures 6.8 & 6.9), *but this was not seen by the Participating States within Wassenaar as meaning that these technologies were not controlled*, even though there was a decontrol note for 'silicon photodevices'. It was not until a subset of microbolometers gained the label 'amorphous silicon' that questions of the control status for the technology came up, i.e. the technology became an *anomaly*. Unlike 'quantum cryptography', where having the word 'cryptography' in the name aided its placement on the Dual-Use List, calling this technology an 'amorphous silicon' (α-Si, pronounced 'alpha silicon') microbolometer caused tension in the classification system because parts of Participating State delegations that were expressing the competitive framing—such as various Ministries of Trade—argued that the decontrol note, which to them did not apply to the BST or VO_x focal plane arrays even though they also depended on silicon, very much applied to α-Si.

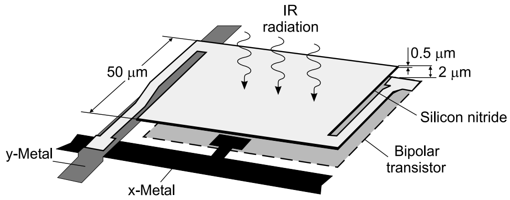

Figure 6.9: *Honeywell VO_x resistive microbolometer focal plane array implementation (Wood, 1993*a*)*

α-Si was developed in several countries, but most notably in the US, Australia, and France. In the US, Texas Instruments did initial development then handed the technology to Raytheon, which has since become L3. In Australia, the Ministry of Defence (DSTO) put in significant effort on α-Si, handing it off to the company Infrared Components Corporation (Liddiard et al., 2001). In

France, CEA/LETI (the Electronics and Information Technology Laboratory of the French Atomic Energy Commission) pushed for commercial development of α-Si focal plane arrays by setting up ULIS, a company that took the initial work on focal plane array functionality and developed packaging and industrial production processes (Tissot, 2002). Each of these countries demonstrated that it was possible to make microbolometers out of α-Si using the same fabrication techniques that build computer chips, thus lowering production costs—a key factor if one's goal is the mass deployment of these detectors. Indeed, the process is so similar that it is possible that many government officials would not classify this technology as a focal plane array at all: "you have people in different government organisations, and unless they're clued in or tuned in or sensitised to certain issues, they're not going to recognise it. To them it's just another integrated circuit."[39] In addition to the trouble in distinguishing an α-Si microbolometer from an integrated circuit, this technology also makes it much more difficult to distinguish between a focal plane array and an imaging system, as shown by the following quote:

> Interviewee: And basically, what is happening with these is[...] how do you distinguish a core from a camera? Nobody could come up with a fool-proof way of drawing a hard line between a camera and a core. Therefore, they were merged. Everybody knows what a bare FPA is, ok or just side electronics with the FPA.
>
> SE: but then you add the lenses and box-
>
> Interviewee: Well it's not only that, but it's the formatting electronics- you have to address these focal plane arrays. They're silicon chips, you have to put digital signals into them, analogue voltages to power them. But you do need some side electronics in order to get a signal out that you can use. All of that is done basically in the core. The hard part is done in the core. Slapping a lens on it, or a display, that's trivial. So that's how the difference between a camera and a camera core disappear.[40]

[39] Interview with US Defense Department Official A & US Defense Department Official B, 5 February 2007.

[40] Interview with US Defense Department Official A & US Defense Department Official B, 5 February 2007.

The production process for α-Si microbolometers generates an anomaly for the Wassenaar classification system in terms of the technical parameters. This alone, however, may not have led to a controversial debate within Wassenaar were it not for the fact that many companies, once a determination was made that this technology was not export-controlled, began finding non-military applications for the technology. Many non-military uses for VO_x and BST focal plane arrays had already been identified by the early 1990s. They included product inspection for fire detection and prevention in both aircraft (Parsons et al., 1990) and spacecraft (Harper et al., 1990), remote temperature measurement in aeromechanics (Lutovinov et al., 1990), medical diagnosis (Black et al., 1990), monitoring of burns patients (Cole et al., 1990), and automotive vision enhancement (Callahan, 1991). All of these applications, before the development of α-Si, were subject to export controls. But by employing α-Si technology, the controls were lifted and a significant export market opened up. While some actors in the Wassenaar debate—those wishing to strengthen the hierarchical framing—argued for showing how α-Si was actually like VO_x and therefore should be subject to the same controls, others—wishing to strengthen the competitive framing—used the same reasoning to argue that VO_x should also be decontrolled. We now turn to this debate to see how the anomaly was eventually resolved by removing the decontrol note, adding *6.A.2.a.3.f*, and adding more decontrol notes for specific applications. This required the hierarchical framing to employ anomaly-handling strategies both to increase the scope of control by incorporating the anomaly (monster-adjustment) and to decrease the scope of control through decontrol notes (exception-barring).

The proposal process

The first proposal to modify *6.A.2.a.3* in relation to the silicon decontrol note came in 2002. The French delegation submitted a proposal to simply eliminate the decontrol note, since the original concerns about *6.A.2.a.3* controlling technologies used for video cameras were addressed by the choice of wavelength as a technical parameter, i.e. it only controlled detectors for infrared, not visible, light. This proposal, however, was dismissed by the US delegation:

> We killed it because we didn't understand it[...] That pertains to a lot of controls- they depend on the people on the job. If they're not tuned in, if the organisation is not set up to represent the disciplines, at least at a passable level, an adequate level, you're going to miss a whole lot of stuff, and that's what happened here. The controlling organisations, or at least the people concerned with export controls, didn't recognise that what the French had proposed was fine! Problem solved, had everybody accepted that. But anyway, the Americans[...] basically scuttled it.[41]

The next year, 2003, the Swedish delegation submitted a proposal for decontrols on cameras that incorporate focal plane arrays which are used for civilian applications:

> Sweden circulated a proposal[...] related to infrared cameras and focal plane arrays- focal plane arrays were mentioned as a way of determining the sophistication of the camera. We released the proposal during the first Expert Group, saying that we would like to release some of these cameras for wider distribution without license because there was a plain commercial use for these cameras. This was launched in March because that was the date for proposals, and it wasn't so much discussed at that point in time, but many countries expressed their interest in this because they could see the big market for the automotive applications, the industrial maintenance applications, the firefighting - they all saw these areas where this technology would be very handy.[42]

Imaging cameras incorporating focal plane arrays are covered by *6.A.3.b.4*, but the parameter of control that this proposal wanted to use to define the technology was the pixel count of the focal plane array within it. This was in line with the current decontrol note, as shown in Figure 6.10.

Such a decontrol, however, was not acceptable to members of the US delegation, who argued that a camera that is exported ostensibly for e.g. fire-fighting can, with minimal modification, be employed as a rifle sight. For two years in a

[41] Interview with an anonymous US source.

[42] Interview with Swedish Former Government Official, 14 September 2006.

4. Imaging cameras incorporating "focal plane arrays" having the characteristics listed in 6.A.2.a.3.

   Note *6.A.3.b.4 does not control imaging cameras incorporating linear "focal plane arrays" with twelve elements or fewer, not employing time-delay-and-integration within the element, designed for any of the following:*
   a. Industrial or civilian intrusion alarm, traffic or industrial movement control or counting systems;
   b. Industrial equipment used for inspection or monitoring of heat flows in buildings, equipment or industrial processes;
   c. Industrial equipment used for inspection, sorting or analysis of the properties of materials;
   d. Equipment specially designed for laboratory use; or
   e. Medical equipment.

Figure 6.10: *6.A.3.b.4 Imaging cameras incorporating focal plane arrays (Wassenaar Arrangement, 2001)*

row, then, anomalies were prevented from arising around the focal plane array technology. The first time was through an apparent lack of technical knowledge of the proposed change, and the second time was a refusal to accept 'use' as a parameter of a technology, i.e. decontrol for 'civilian use'.

Sweden agreed to withdraw its proposal from the 2003 list modification process, and re-work it for 2004:

> We submitted a proposal, again taking out the focus on the focal plane array, but focused on the camera instead, on the actual end-use, on what the camera would do, to limit it to those cameras that would be used for firefighting and industrial maintenance. The debate was about how far these cameras could see, how clear the picture was, how easy it would be to open up the camera, take out the focal plane array, cluster it with other focal plane arrays and thus get a better range and focus. What the cameras can do is that you can measure the heat and you can see almost down to the facial features of the person, if it's a really good camera. So the rationale for the Swedish proposal was to take the cameras that were less sophisticated, were tamper-proof, the range, the sharpness of the image - these were the issues that we were trying to work around and get some consensus on.[43]

The US, in the meantime, developed a proposal for modifying *6.A.2.a.3* by adding a new item (*6.A.2.a.3.f*), which it also submitted in 2004. The basic premise of the proposal was to 'close the loophole' created by the silicon

[43] Interview with Swedish Former Government Official, 14 September 2006.

decontrol note.[44] This was widely seen as a desirable move, but several delegations thought that, in addition, the US was trying to expand controls on focal plane arrays in a way that would control too many civilian applications.[45] For example:

> I expect the silicon was there[...] probably because of silicon photodetectors which will work in the near-infrared. and the α-Si companies grabbed ahold of it and said, "that's there, therefore we are not covered." Which was ok when the α-Si was relatively poor performance. But as it improved it became quite significant. And the whole point of the discussion in 2004 was that we wanted to get rid of the exception for silicon because it's anomalous, because α-Si is now performing just as well as everything else. So why should it be a special case?[46]

Noticing the similarities between the Swedish and American proposals, one Participating State suggested that the proposals be dealt with simultaneously. The discussions were very intensive, with multiple meetings outside of the formal and informal Wassenaar Expert Group meetings.[47] The issue, however, quickly became polarised between those arguing for controlling based on military utility (simply saying that focal plane arrays are *relevant* to Wassenaar and therefore should be controlled) and those arguing for decontrol on account of either foreign availability or controllability. This polarisation was shown very clearly when, early on in the discussions, those arguing for control brought a very high-ranking Army officer to the Expert Group meeting to point out how critical night vision systems were to military affairs, and how military capabilities of Wassenaar Participating States would be compromised if these technologies found their way into enemy hands. The officer then quickly proceeded to ask the focal plane array Technical Working Group not to ask him

[44] Interview with US Defense Department Official A & US Defense Department Official B, 5 February 2007.

[45] I spoke with several Officials from other countries that found issue with the US proposal.

[46] Interview with British Wassenaar Industry Consultant C for thermal sensing technology, 5 June 2008.

[47] Sources noted meetings in Paris, Brussels, and Moscow.

any technical questions, as he did not have any technical knowledge in this area.[48]

Those arguing for control engaged upon an extensive campaign to raise awareness amongst the other delegations' Ministries of Defence:

> What we wanted to make sure was that the Ministries of Defence weighed in[. . .] There are usually MoD reps from about 10-12 countries that show up at Wassenaar Meetings. So that means that there are about 20 countries that don't have MoD reps, and so the defence perspective isn't represented. So we thought that we needed to meet with defence reps and tell them about this issue so that they could weigh in with their government. Otherwise it was run by the Ministry of Trade and Industry or the Ministry of Foreign Affairs, and we just wanted to make sure that- We thought that our way of thinking was in line with the way probably that most of the Ministries of Defence were thinking.[49]

This was seen by many Participating States as 'going behind the back' of their national delegation, and did much to erode the trust among States which had been developing. Maintaining the trust of actors trying to strengthen different framings of the problem of dual-use technology, as we shall see in Chapter 7, is a key part of maintaining the legitimacy of the forum where the discourse among framings occurs—in this case the Wassenaar Arrangement as a whole. Here, it is important to point out that none of the countries was arguing that α-Si microbolometer focal plane arrays should not be covered under the Dual-Use List. The anomaly, in that sense, was easily resolved. The difficulty in this case was determining what level of integration was appropriate to control. Most delegations believed that controlling at the level of the focal plane array was impractical, both because they were now mass-produced, and, more subtly, because it was difficult to disassociate the focal plane array from more integrated technologies. The production process used for α-Si focal plane

[48] This event was mentioned to me by several people in different delegations who were at the meeting.

[49] Interview with US Defense Department Official A & US Defense Department Official B, 5 February 2007.

arrays created an array that was already packaged with at least a minimal set of electronics. Was the thing produced a focal plane array, or was it something else, e.g. an 'integrated array' or a 'camera without the lens'?

There was also the difficulty of deciding the parameters for *6.A.2.a.3.f*, as noted in one of my interviews:

> Interviewee: [The Technical Working Group] was quite friendly and collaborative, until you get, for example, [State A] determining that the detectivity shouldn't be below this and [State B] determined that it shouldn't be below this and the two don't match and you reach a stalemate. And they each contact their capitals in the night and they come back in the morning and it's still a stalemate. So yes it was friendly and open and frank, but you did reach these points where you couldn't go any further and it comes to a full stop. And that's why we had to compromise on this rather than define it on performance, which is what everybody really thought was the best thing to do - to define it on performance.
>
> SE: Give me an example of defining it on performance.
>
> Interviewee: Detectivity. Number of elements. Those are the major two. The number of elements: should it be 16x16, 32x32, 100x100. We couldn't agree on where the limits should be as to what was useful or not. And detectivity even more so. Not only could you not get them to agree on what they figures should be, you couldn't get agreement on how you should measure it.[50]

From an engineering standpoint, the best definition of the performance of an imager is its non-equivalent temperature difference (NETD), but this can only be defined for an *array* when the array is fitted with a lens to make a camera (Kruse & Skatrud, 1995).

The complaint voiced most often to me about the focal plane array debate was that the polarised position of the US allowed for very little negotiation. The US was not seen to give sufficient credit to the other delegations for their acknowledgement that controls on focal plane arrays were *relevant* to the Arrangement. Similarly, the US was not seen to give sufficient weight to

[50]Interview with British Wassenaar Industry Consultant C for thermal sensing technology, 5 June 2008.

the practicalities of their proposed change, i.e. the controllability and foreign availability of focal plane arrays. Here are a few technologies that other Participating States believed would fall under control if the US proposal had been approved as it was:

The Autoliv Night Vision System developed by BMW. It has a refresh rate of 30 Hz, meaning that it can provide a video feed, and is capable of detecting objects at up to 300 m (Kallhammer, 2006).

The IRISYS IRC 1004, a people counter used to monitor traffic flow in buildings. Such technology is useful in settings like grocery stores to know how many people come into the store and therefore how many cashiers need to be ready to check them out.

Negotiations on both *6.A.2.a.3.f* and *6.A.3.b.4* continued right until the night before the Plenary session in 2004. The US was caught in the position of having taken a very firm no-negotiation stance, but at the same time it would fail completely in its task if any Participating State vetoed the list modification. Britain was willing to veto if compromises were not reached, and that helped break the deadlock in the debate, because the US had to begin to negotiate. The overall British stance in this is typical of that Participating State's attempts to balance security and economic concerns:

> The MoD was virtually 100% behind the US in wanting to control virtually every focal plane array - again based a lot on the fact of the banning of land mines, because they were developing sensors that they were going to throw out of aircraft in the thousands, with very simple focal plane arrays in them that would detect movement. So you scatter these on the battlefield and they literally just sit there and say, "hello, there's movement there." So that meant that they wanted to control very simple focal plane arrays[. . .] On the other end of the scale, I had British industry saying to me, "This is going to affect us, this is going to control garage door opening, people detectors, all sorts of very mundane items." So that was the

> real two ends of the equation[...] We certainly considered where things were going, although I made it certainly clear to them that we could not have, from an industry point of view, these types of focal plane arrays being under control. That was accepted as our bottom line for our negotiations, which as I said earlier did come down to Britain standing out against the US, of which [members of our delegation][...] convinced the foreign office that Britain was right on this occasion. And whilst there was a military use for these, they were so widely available that it was stupid to control the bottom end of the market. And it was only when the US found out for themselves that I had Foreign Office permission, that they came to me.[51]

Note 1 *'Imaging cameras' described in 6.A.3.b.4 include "focal plane arrays" combined with sufficient signal processing electronics, beyond the read out integrated circuit, to enable as a minimum the output of an analogue or digital signal once power is supplied.*

Figure 6.11: *6.A.3.b.4.'Note 1' The definition of an 'imaging camera' (Wassenaar Arrangement, 2004c)*

A significant amount of this discussion was spent on the *Notes* for *6.A.3.b.4*, which mushroomed from the 12 lines they constituted in 2003 to 63 lines. *'Note 1'* (shown in Figure 6.11) provides us with insight into the difficulty of resolving this anomaly. The final definition of an 'imaging camera' indirectly defines the bound of what is a 'focal plane array'. As we can see, a focal plane array may include a readout circuit, but cannot on its own produce either an analogue or digital signal if it gets power. This is still in line with the general definition of a focal plane array (Figure 6.5), but this *Note* provides evidence that the line between a focal plane array and an imaging camera was in need of clarification, i.e. monster-adjustment.

More telling of the eventual concessions that were made in the days before the 2004 Plenary is *Note 3* (Figures 6.12 & 6.13). Part *(a)* of *Note 3* defines the maximum frame rate that a decontrolled camera may have, but the scientific basis for this number is tenuous:

[51] Interview with British Former Government Official, 8 March 2007.

<u>Note 3</u> *6.A.3.b.4.b. does not control imaging cameras having any of the following characteristics:*

a. *A maximum frame rate equal to or less than 9 Hz ;*

b. Having all of the following:

1. Having a minimum horizontal or vertical Instantaneous-Field-of-View (IFOV) of at least 10 mrad/pixel (milliradians/pixel);

2. Incorporating a fixed focal-length lens that is not designed to be removed;

3. Not incorporating a direct view display; <u>and</u>

<u>Technical Note</u>:

'Direct view' refers to an imaging camera operating in the infrared spectrum that presents a visual image to a human observer using a near-to-eye micro display incorporating any light-security mechanism.

4. Having any of the following:

a. No facility to obtain a viewable image of the detected field-of-view; <u>or</u>

b. The camera is designed for a single kind of application and designed not to be user modified; <u>or</u>

<u>Technical Note</u>

Instantaneous Field of View (IFOV) specified in Note 3.b. is the lesser figure of the Horizontal FOV or the Vertical FOV.

Horizontal IFOV = horizontal Field of View (FOV)/number of horizontal detector elements

Vertical IFOV= vertical Field of View (FOV)/number of vertical detector elements.

Figure 6.12: *6.A.3.b.4.'Note 3': Decontrols for cameras incorporating microbolometer focal plane arrays (part 1). (Wassenaar Arrangement, 2004c)*

The US position was 5 Hz and other people wanted 30 Hz or whatever. It turns out that normal video rate is 30 Hz. At about 15–17 Hz you get a very jumpy picture that looks like a movie from the 1920s. Our Defense Department does not want people to produce a video camera - they want a still camera. So 5 Hz is definitely still. 15 is a jumpy moving thing. So it was then 10 and 5, and then the US went to 8 and someone held out and wouldn't compromise so we went to 9 because the difference between 8 and 9 [laugh] it's not quite still but it's still enough that you can't see motion very- and what [the Department of] Defense doesn't want is for someone to be able to use a camera like this and see someone throwing a

c. *Where the camera is specially designed for installation into a civilian passenger land vehicle of less than three tonnes (gross vehicle weight) and having all of the following:*
   1. *Is only operable when installed in any of the following:*
      a. *The civilian passenger land vehicle for which it was intended; or*
      b. *A specially designed, authorized maintenance test facility; and*
   2. *Incorporates an active mechanism that forces the camera not to function when it is removed from the vehicle for which it was intended.*

   Note: When necessary, details of the item will be provided, upon request, to the appropriate authority in the exporter's country in order to ascertain compliance with the conditions described in Note 3.b.4. and Note 3.c. above.

Figure 6.13: *6.A.3.b.4.'Note 3': Decontrols for cameras incorporating microbolometer focal plane arrays (part 2). (Wassenaar Arrangement, 2004c)*

grenade.[52]

One reason that the control text needed to be at least 9 Hz was that it allowed for the decontrol of some thermal imagers, a point in favour of actors taking a competitive framing of the problem of dual-use technology:

> If it's chopped at less than 9 Hz or if its update rate is less than 9 Hz then it's not controlled. So that covers our imagers. Because they at the time updated at 8Hz. And that's where the 9 Hz came from. We tried for 30 Hz, and I've got an email here that I sent to [a member of the delegation] which says, 'these are the limits which we'd like to see. 30Hz is what we desire, but 8Hz is our limit. We've got to have 8 Hz.' And so it was 9 Hz that was put in.[53]

People counters, mentioned above, are decontrolled by *Note 3.b*:

> But the other thing that we put in was basically to cover our counters when you don't have a chopper. And that was defined in terms

[52] Interview with US State Department Official B, 19 January 2007.

[53] Interview with British Wassenaar Industry Consultant C for thermal sensing technology, 5 June 2008.

> of (a) that there was no image displayed on it, and (b) the field of view is defined in terms of 'instantaneous field of view (IFOV)', so it's fairly useless for any military application. So the two bits of that - the 9Hz chopping and the IFOV and no display - were written effectively around our imager and counter.[54]

We can see the bounds of the definition of a camera, as well as a focal plane array, being stretched here. *6.A.3.b.4.'Note 3'.b.4.a*, for instance, decontrols imaging cameras that have "no facility to obtain a viewable image of the detected field-of-view."

The civilian passenger vehicle note (*'Note 3'.c*) was not seen as immediately obvious to some delegations:

> If you were a car manufacturer, then you are shipping 10,000 of the sensors twice a year to your main manufacturing places. That's not a licensing burden, because it's a bulk license. You don't send out two or three, you send out a thousand twice a year. The problem arises in the repair situation. That's where the licensing burden, in theory, kicks in. And that's why you have this weasely wording that's trying to get around that problem. That only came out as part of the discussions. It wasn't immediately obvious to us that that was the main problem. We were thinking, "Well this is not a licensing burden." Whereas for us, it was a licensing burden potentially, and a huge headache, because the people counters and the door-opening devices were sold in hardware shops. And how do you expect the general public to know if they've bought something that's going to require an export license.[55]

At the end of the 2004 negotiations, each of the delegations was able to return to their capitals saying that they had achieved their goals in relation to focal plane arrays. The anomaly—uncontrolled amorphous silicon microbolometer focal plane arrays—had been resolved by removing *6.A.2.a.3.'Note 2'.a*, through a process of monster-adjustment. In the process, however, significant concessions were made on other parts of the list, most notably the decontrol

[54] Interview with British Wassenaar Industry Consultant C for thermal sensing technology, 5 June 2008.

[55] Interview with British Former Government Official, 8 March 2007.

notes for *6.A.3.b.4*, which were examples of actors within the hierarchical framing employing the exception-barring strategy to define more narrowly the scope of controls. The definition of a focal plane array and an imaging camera was shifted. The Dual-Use List as a construct—an ordered classification system—was severely tested. One delegation spent its time in the EG largely making sure that the logic of the control text was maintained.[56] Perhaps the most significant outcome from this process was the breakdown of trust among Participating States that had been slowly developing, which I will address in the next chapter. "That's right. Politics came into the Expert Group. It shouldn't happen but it does on occasion, and this was one of those occasions."[57]

Was this contention necessary? Many states think that it was not. Even a member of the US delegation said, "In the intervening two years [between the French and US proposals], the right advice wasn't sought, and/or it wasn't followed. So it was really a mishmash, and unnecessary battles were picked. Unnecessary battles were fought [laugh], and the US was really chasing its tail in a circle."[58] However, this case is an extreme example of the types of events that continually occur within the Wassenaar Expert Group in defining what is a dual-use technology.[59] Many of the list modifications require discussions on

[56] Interview with German Government Official, 28 March 2007.

[57] Interview with British Former Government Official, 8 March 2007.

[58] Interview with US Defense Department Official A & US Defense Department Official B, 5 February 2007.

[59] There is another case, discussed at length in Mastanduno (1992), of the US Department of Defense trying to establish an ultimatum which other delegations—and indeed the rest of the US delegation—must accept. It is worth quoting at length here, as the resemblance to the focal plane array debate is striking:

> US officials, primarily those in the DoD, were perceived by their CoCom counterparts as arrogant, condescending, and unwilling to listen to or accommodate the views of others. Attempts by defense officials to dictate policy in a context in which compromise and consensus building had been the historical norm led to incoherence in US negotiating strategy as well as conflict in CoCom.
>
> The most well known incident involved negotiations in the critical area of computer controls. The inability to resolve intra-alliance disputes had plagued CoCom since 1979, but negotiations in 1982 and 1983 eventually narrowed the gap between the more restrictive stance of the United States and the more liberal one of other members. A final compromise was planned for October 1983. On the eve of the meeting, however, Defense officials informed their State Department counterparts that no compromise was acceptable and that the United

parameter choice and the value of that parameter. Negotiating the choice and value of parameters, as we have seen, is done through an inseparable mix of politics, interpersonal relations, and concerns for national economies as well as the more obvious security concerns and engineering choices.

Both the quantum cryptography and the focal plane array cases resulted in an anomaly being resolved, though with differing amounts of uncomfortable knowledge. The next case analyses a list modification where the hierarchical framing tried to find a controllable parameter for computers and failed on successive occasions. Each time, a redefinition of the technology occurred through a process of exception-barring, but in employing this strategy, actors within the hierarchical framing acknowledged that technologies which should be controlled were not, thus creating uncomfortable knowledge.

6.3 Computers

In 2005, the Wassenaar Arrangement modified the definition of dual-use high-performance computers by shifting the emphasis for control from processing speed to the software needed to run them. In this section, I analyse the debate that occurred within and around the Arrangement about whether processing speed is a useful metric in defining computers subject to export controls. The 2005 modification, I argue, represented an exception-barring strategy that resulted in uncomfortable knowledge for actors trying to strengthen the hierarchical framing. Processing speed, while an important factor in a computer's military relevance, was no longer seen as an adequate parameter for preventing an end-user acquiring high-performance computing capabilities. I begin the section with a description of the development of high-performance computers,

States would not deviate from its initial 1982 position. Defense added that in any event, CoCom was not an appropriate forum in which to negotiate computer control and that the negotiations should take place in an unspecified forum with a senior defense official representing the United States[...] The computer stalemate was resolved only in the summer of 1984, when DoD relented and compromised.

from the early days in the 1960s through the development of cluster computing. I then turn to the development and use of MTOPS as a metric of computer performance, followed by a discussion of the debate within Wassenaar to do away with MTOPS in 1999–2005.

The development of high-performance computers

Early physical forms of modern digital computers took shape before and during World War II (Hennessy & Patterson, 1998).[60] These included the Colossus, developed by the British and used at Bletchley Park during the War to crack the German Enigma code (Copeland, 2006); the Z-series calculators, developed by Konrad Zuse in Germany (Zuse, 1993); and the ENIAC, designed and built in the US to compute ballistic missile trajectories (Randell, 1973).

Ever since that time, computing power has been continuously pushed forward through developments in architecture, processor, memory, and software design. One of the significant characteristics of digital computers in relation to export controls is that they closely resemble a 'universal Turing machine', which means that, given enough time and storage, and the proper programming, any one of them can solve the same computational problem that any other of them can solve.[61] By increasing the processing power and memory capacity, reducing the energy and time used to move data from the processor and memory, and optimising the software employed, engineers and programmers have been able to reduce the overall time that calculations require. This reduction in time, usually stated as an 'increase in performance', has followed an exponential curve since the 1950s, as shown in Figure 6.14.[62] This curve is often related to 'Moore's Law', an observation that the number of transistors that can be placed on an integrated circuit has doubled roughly every two years since the integrated circuit was first invented in 1958 (Moore, 1965).

[60]There were earlier attempts at digital computers, most notably the work of Charles Babbage (Babbage, 1889), but these are largely disassociated from modern developments.

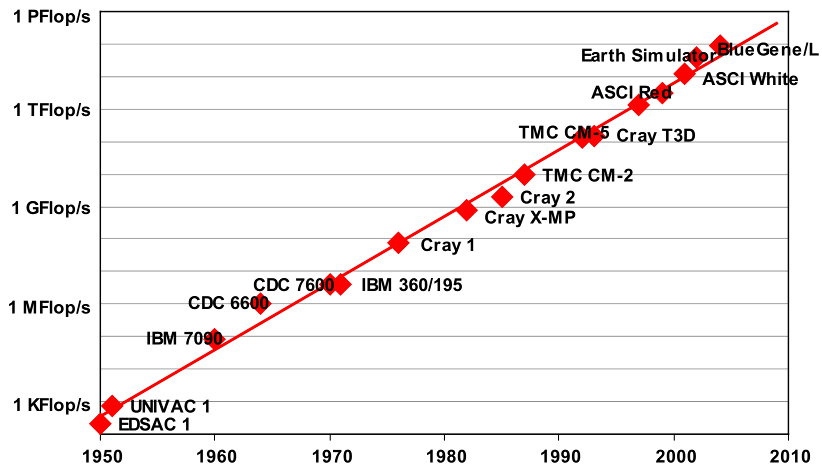

Figure 6.14: *Development of high-performance computational power, 1950-2005 (Strohmaier et al., 2005)*

Many different architectures have been used in maintaining this growth rate over five decades.[63] I should note, however, that defining what counts as a particular architecture is ambiguous within the community of computer engineers. The terms I use here—and the way in which I use them—are largely based on the work of Dongarra, Sterling, Simon & Strohmaier (2005), particularly because of their reflexive take on terminology:

> Terminology and taxonomies are subjective. No absolute truths exist (except that no absolute truths exist), and common usage dictates practical utility, even when self-contradictory or incomplete in meaning. Yet, in spite of its imperfections, technical nomenclature can be a powerful tool for describing, distinguishing, and delineating among related concepts, entities, and processes (Dongarra et al., 2005, p. 51).

To understand how the definition of a 'high-performance computer' has become blurred over time, we can begin by thinking of a 'computer' as a processor, connected to a memory, which interacts with data in the memory through a

See Randell (1973).

[61] This is the Church-Turing thesis (Kleene, 1952).

[62] Exponential curves are shown as straight lines when graphed on a logarithmic scale.

[63] For this history of high-performance computing, I have drawn from Bell & Gray (2002); Dongarra et al. (2005); Kuzmin (2003); Strohmaier et al. (2005); Woodward (1996).

set of algorithms (the 'software'). A 'high-performance' computer is one that is considered (for our purposes, by the export control community) to be in the top range of currently available computers. The first high-performance computers employed single scalar processors, which could only perform one operation on a single piece of data at a time. The Control Data Corporation's (CDC) Star high-performance computer in 1974 introduced the vector processor design, which performed an operation on an array of data in a single cycle. This design is also referred to as 'single instruction, multiple data' (SIMD) processing. SIMD processing allowed the computer to process rapidly batches of data, but only if the exact same operation needed to be done on each piece of data. There was therefore much work that programmers needed to do to organise the data to take advantage of the vector processor's capabilities, and it is important to note that not all computational problems can be solved more quickly with a vector processor, but that they are particularly well-suited for computing two- and three-dimensional graphics. Vector processors formed the bulk of supercomputer designs for much of the 1970s and 1980s, led by companies such as Cray Research.

Computer performance continued to increase through more processors being placed in a single computer, all of which used a common memory. This is called symmetric multiprocessing (SMP) and has the advantage of allowing any processor to work on any piece of data in the memory. SMP is a form of parallel processing, where multiple operations are carried out simultaneously on multiple pieces of data.[64] These operations can be carried out on a set of either vector or scalar processors, or a combination of the two. Many computers today, from consumer models to the highest end computers, employ some form of SMP.

With a computer based on SMP, we can begin to see a blurring of the definition of a 'computer' that I set out above. There are multiple processors, and each processor can run its own software. We might hesitate to call it

[64]This is also called 'multiple instruction, multiple data' (MIMD) processing.

'multiple computers', because all of the processors are connected to a single memory. But systems with multiple memories began to be developed in the 1980s. Called 'massively parallel processing' (MPP) computers, they further blurred the line between what is and is not a 'computer'. An MPP computer is a set of processors, each with its own memory and stored software, connected together by a 'interconnect'. We can think of an MPP computer as a series of parts which are *specially designed* to work together. As such, members of the export control community could still classify it as a single computer, even though it does not have a single processor, a single memory, or a single set of software.

But what if all of the parts were not specially designed to work together? This is the problem that was raised within the Wassenaar Arrangement in the late 1990s. At that time, many of the world's fastest 'computers' were actually groups of commercially available desktop computers (which could be bought by individual families and persons), connected together with standardised network connections. This shift in high-performance computer design was aided in 1994 by a NASA call to produce a computer capable of 1 billion floating point operations per second (1 gigaFLOPS) for under $50,000. Donald Becker and Thomas Sterling responded to the call and produced the 'Beowulf cluster', which combined 16 commercially available DX4 computers with a 10Mb/s ethernet, also commercially available.[65] Beowulf clusters quickly became popular with communities who wanted high-performance computing at a third or a tenth of the price. These clusters are capable of solving very complex problems in much less time than the vector computers or MPP computers that came before. Also, they are extremely scalable; adding a few hundred or thousand more desktop computers can be as simple as just plugging in network cables and turning them on. The high-performance computer engineering community recognised that the concept of 'a computer' was no longer useful in discussing

[65] The idea of clustering many microprocessor computers together was discussed in the high-perfomance community from at least the early 1980s (see Bell & Gray, 2002).

'high-performance *computing*', and therefore referred to these groups as 'distributed computing systems'. What defines these systems is not that they can be considered as a 'single computer' but rather that they are working together to produce a single output. The rise of the prominence of cluster computing is clearly shown if we graph (Figure 6.15) the rankings of different types of high-performance computers on the Top500.org website, which uses the widely accepted (within industry) Linpack benchmark to determine the amount of floating point operations per second (FLOPS) that each system can sustain.

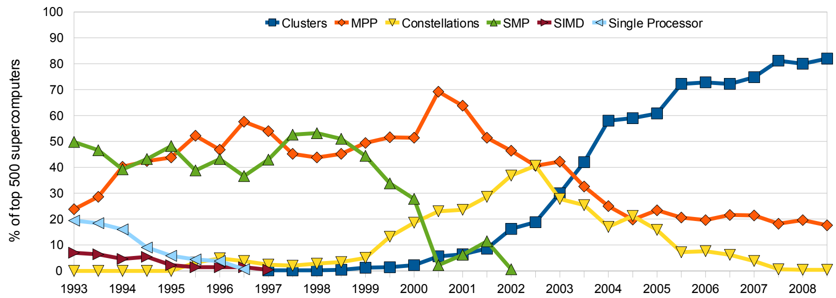

Figure 6.15: *Percentage of top500 spots occupied by various computer architectures from 1993–2008 (data source: http://top500.org)*

The reason this final shift caused significant tension within the Wassenaar Arrangement is that the classification system in use depended on defining the performance of a *single computer*, or failing that, defining the performance of a single group of computers. *It assumed that computer performance was a controllable parameter.* But when it becomes relatively easy to increase performance by buying a commercially available computer and adding it to the system, such a metric loses most of its use in controlling who has access to this technology. It is important to note, however, that the control still does serve a use; it still makes it more difficult for a person or group to acquire a computer over a certain performance because they cannot, for instance, ask for it in a single order.

We turn now to how the performance parameter changed over the course of CoCom and Wassenaar to see how its adequacy was undermined by a mix of opposing arguments and technological development.

From megabits per second to MTOPS

Until the 1969 CoCom lists, all 'digital computers' were controlled. In one of the more interesting classification schemes used in these lists, item *1565* "Electronic computers and related equipment, not elsewhere specified, as follows" specified parameters for controlling digital computers based on memory (sub-item *(d)*) and operation temperature *(e)*. But then it also controlled "(g) digital computers and digital differential analyzers (incremental computers) other than those in (d), (e), and (f) above" (British Government, 1966, p. xi). This is effectively a catch-all clause, and meant that any computer being exported needed a license. This way of generating the list was most likely in place to differentiate controls on embargoed items versus items which would likely get a license, as shown in *'Note 1'* of the 1966 version of item *1565*:

> The [British] Export Licensing Branch will consider applications for licenses for the export to the Sino-Soviet Bloc of (i) computers covered by sub-items (c) and (g); and (ii) specialized parts, components, sub-assemblies and accessories therefor, not elsewhere specified, covered by sub-item (h), subject to certain conditions. The principle conditions are[...]"

In 1969, the catch-all phrase that was *1569(g)* was removed and several more parameters for control were put in, including: whether the computer could perform 'floating point operations' *(d)(1)*; its 'total effective bit transfer rate' *(d)(2)*; the type of display it used *(d)(5)*; and whether it could accept, process, store, and output data using a stored sequence of operations that were 'modifiable by means other than a physical change in memory' *(f)(1)–(4)*. In addition to this change, the note at the end of *1565*—which outlined parameters which, if the technology met them, might result in a successful license application—was the first instance of the performance parameter for computers, as shown in Figure 6.16.

Analogue computers covered by sub-items (a) (1) (i) (a), (a) (i) (ii) (a), (a) (2) and (c), digital computers covered by sub-items (d) (1)-(4) and (f) and equipment for such computers covered by sub-item (h), subject to certain conditions, including:

(a) that the equipment is primarily used in non-strategic applications;

(b) that the equipment will be used primarily for the specific non-strategic applications for which the export would be approved and that the number, type and characteristics of such equipment are normal for the approved use;

(c) that if they are analogue computers covered by sub-items (a) (1) (i) (a), (a) (1) (ii) (a) or (a) (2), the static rated error for summers, inverters and integrators are not less than 0.01 per cent and for multipliers are not less than 0.025 per cent and there are not more than 350 operational amplifiers;

(d) that if they are digital computers covered by sub-item (d) (1)-(4), all of the following additional conditions are met:

(1) The sum of either the 'I/O bus rate' or the 'total effective bit transfer rate', whichever is less, and the 'CPU bus rate' does not exceed 40 million bits per second;

(2) The 'processing data rate' for CPUs which implement floating point operations by hardware does not exceed 8 million bits per second;

(3) The internal memory total connected capacity (excluding parity, word marker and flag bits) does not exceed 2.36 million bits;

(4) For peripheral memory devices with which the computer is equipped:

(i) No more than 12 magnetic tape transports;

(ii) The 'total effective bit transfer rate' excluding data channels not equipped with peripheral memory units does not exceed 8 million bits per second;

(iii) The 'effective bit transfer rate' of any peripheral memory or data channel does not exceed 1.5 million bits per second;

(iv) For peripheral memory devices other than magnetic tape transports;

(a) Total connected 'net capacity' does not exceed 305 million bits;

(b) For each independent device, 'net capacity' (in millions of bits) does not exceed 'average access time (in seconds) raised to the 3/2 power and then mutiplied by 8,000; and

(c) 'Total number of accesses' does not exceed 150 per second.

Figure 6.16: *Decontrol note for Item 1565 from 1969 CoCom List. (British Government, 1969, p. xii)*

The performance parameter can be seen in *(d)(2)*, which defines the parameter as "processing data rate". While "processing data rate" is in quotes, it is not actually defined in the 1969 list, nor in any of the lists until 1985, when it was relabelled "total processing data rate". Instead, there is a note at the end of the text for *1565* that says "Interpretive definitions of the terminology used such as 'CPU bus rate', 'average seek time', etc. will be provided, if required, on application to the Export Licensing Branch." This is most likely because the processing data rate is a complex parameter to calculate, as shown when its definition was finally included in the list in 1985 and totalled 9 pages.

Initially, processing data rates of less than 8 million bits per second (Mbps) were likely to receive favourable review. This parameter stayed constant until 1985, when it was relaxed to 28 Mbps for "any one 'embedded'" digital computer and "the sum of the 'total data processing rate' of each 'embedded' 'digital computer' does not exceed 50 million bits per second", but was tightened to 5 Mbps for "incorporated" digital computers and 2 Mbps for digital computers "shipped as complete systems" (British Government, 1985, p. 37). According to The Wall Street Journal (1984), this translated into allowing the export of most microprocessor computers that were marketed at individuals and families, such as the Apple II and Hewlett-Packard's HP 140. Companies selling some more powerful mainframe computers, like IBM's VAX 11/782, were allowed at least to apply for licenses. But it is very important to note here that none of these computers was named in the CoCom lists. Nor was 'processing data rate' a standard measurement often used in industry. Officials from the US Commerce Department went on record shortly after the list modification was announced, complaining of the monumental complexity of the changes and predicting that it would "probably take us years to figure out what they say. I mean that" (Mann, 1984).[66]

According to Mastanduno (1992, p. 181), the fact that the controls did not change for sixteen years did not mean that there was no earlier push for a change. Even by 1978, "other CoCom members pressed for relaxation of control parameters on computers, while the United States proposed even higher levels of restriction. The need for liberalization was suggested by the fact that the majority of CoCom exception requests involved computers."[67] The US push for more restriction, however, was paradoxically combined with the highest number of license requests. The debate in the 1982–1984 list review process is also well described by Mastanduno (1992, p. 269):

> The U.S. Defense Department urged comprehensive controls, even on personal computers, which Assistant Secretary of Defense Richard Perle claimed were used by the United States—and could be used by

[66] This article in Aviation Week & Space Technology provides a rare look at—albeit only one government's view of—the internal debates that occurred within CoCom. I quote it here at length to show the complexity of translating the parameters of control into measures that industry can understand:

> Another Commerce Department official warned that a great deal of analysis of the agreement would be necessary and that "anybody who says that they can articulate what the hell we agreed to without really thinking it through is crazy."
>
> But he said mainframe manufacturers "clearly are going to be better off" and "small personal computer manufacturers are going to be much better off. For smaller stuff there's no CoCom review, it's national discretion."
>
> [Chairman of the Department of Commerce's Computer Systems Technical Advisory Committee Donavan W.] Pederson said, after being briefed by the Defense Department officials, that it was his understanding that all eight-bit systems, except those that can be networked, and 16-bit machines, except high-speed ones, would be decontrolled.
>
> Both Defense and Commerce officials described the agreement as a series of compromises containing "something for everybody." The two departments had fought at length over how restrictive the new CoCom guidelines should be.
>
> "We tried to get at the things that can potentially do the most harm to us and really insist on controls there," [deputy assistant secretary of Defense and architect and negotiator of the modifications Stephen D.] Bryen said, "and to mix it up where we thought we could make compromises that would accomplish major objectives. In the small computers we have a big compromise on the whole, because it's practical, it has a chance to be enforced, and that's key to us. We bled over a few of those, for sure."

[67] See also US Office of Technology Assessment (1979, p. 158–159).

> the Soviets—to target nuclear weapons in the European theater.[68] Western Europe and Japan resisted, pointing to widespread foreign availability.

The feud between US and European counterparts over whether a tightening or relaxation of controls was needed, as we can see, was alive and well in the 1980s just as it was in the focal plane array debate in the last section. The *Wall Street Journal* referred to it thus:

> The Europeans want a broad economic relationship with the Soviet bloc; they think the link adds to European security. The Pentagon brands that attitude as naive. "The fundamental problem is that the American concept of security is overwhelmingly military in nature," says Karl Kaiser, director of Bonn's Foreign Policy Institute. "That espoused by Europeans is equally economic." Those philosophical and economic differences give rise to trench warfare in negotiating sessions. Paul Freedenberg, a U.S. Senate aide who recently visited Cocom, complains about "the device of prolonged debate or endless haggling about the meaning of words to stretch discussions into years of debate" (Kempe & Lachia, 1984).

This 'meaning of words' debate (also referred to in the press as 'horse-trading' (Buchan, 1984)) resulted in the increase of the processing data rate parameter on the list (meaning the controls were relaxed) but at the same time implemented controls on the export of *knowledge of how to make computers*. This was shown by the new section *1565(j)*, shown in Figure 6.17. This was one of the first implementations of controls on 'intangible technology', which we will cover in detail in the next chapter.

In 1987, the "embedded" digital computer performance parameter was relaxed again to 43 Mbps for any one computer, and a sum less than 100 Mbps, 15 Mbps for "incorporated" digital computers, and 6.5 Mbps for complete systems. There were also complicated decontrol parameters specifically for China beginning in the 1987 lists.

[68] Mastanduno cites Perle's statement as coming from "U.S. Congress, Senate, Committee on Governmental Affairs, Permanent Subcommittee on Investigations, *Transfers of Technology*, hearings, 98th Cong., 2d sess., April 2, 3, 11–12, 1984, p. 158–64". See also Marsh & Buchan (1984).

INDUSTRIAL LIST

equal to ± 0.004 per cent; *and*
- **2** An active digitizing area less than or equal to 1,700 mm (66.9 inch) by 1,300 mm (51.2 inch);

i Not used;

j Optical mark recognition (OMR) equipment;

k Optical character recognition (OCR) equipment which:
- **1** Does not contain "signal processing" or "image enhancement" equipment; *and*
- **2** Is only for:
  - **i** Stylized OCR characters;
  - **ii** Other internationally standardized stylized character fonts; *or*
  - **iii** Other characters limited to non-stylized or hand printed numerics and up to 10 hand printed alphabetic or other characters;

l Cathode-ray tube displays for which circuitry and character-generation devices, external to the tube, limit the capabilities to:
- **1** Alpha-numeric characters in fixed formats;
- **2** Graphs composed only of the same basic elements as used for alpha-numeric character composition; *or*
- **3** Graphic displays for which the sequence of symbols and basic elements of symbols are fixed;

m Cathode-ray tube graphic displays, not containing cathode-ray tubes embargoed by Item **IL 1541**, which are limited as follows:
- **1** The "maximum bit transfer rate" from the electronic computer to the display does not exceed 9,600 bit per second;
  Note: Direct driven video monitors are excluded from this limitation.
- **2** Not more than 1,024 resolvable elements along any axis; *and*
- **3** Not more than 16 shades of grey or colour;

n Cathode-ray tube graphic displays, not containing cathode-ray tubes embargoed by Item **IL 1541**, provided that they are:
- **1** Part of industrial or medical equipment; *and*
- **2** Not specially designed for use with electronic computers;

o Graphic dsiplays specially designed for signature or security checking having an active display area not exceeding 150 sq cm (23.25 sq inch);

p Other displays, provided that:
- **1** Circuitry and character-generation devices external to the display device (eg panel, tube) and the construction of the display device limit the capabilities to:
  - **i** Alpha-numeric characters in fixed formats;
  - **ii** Graphs composed only of the same basic elements as used for alpha-numeric character composition;
  - **iii** Graphic displays for which the sequence of symbols and basic elements of symbols are fixed; *and*
- **2** They are limited to:
  - **i** A capability for displaying no more than 3 levels (off, intermediate and full on); *and*
  - **ii** A minimum character height of not less than:
    - **a** 5.5 mm (0.22 inch) if the area is 1,200 sq cm (186 sq inch) or less; *or*
    - **b** 20 mm (0.79 inch) if the area is more than 1,200 sq cm (186 sq inch); *and*
- **3** They do not have as an integral part of the display device:
  - **i** Circuitry; *or*
  - **ii** Non-mechanical character-generation devices;

q Light gun devices or other manual graphic input devices which are:
- **1** Part of unembargoed displays; *and*
- **2** Limited to 1,024 resolvable elements along any axis;

r Disk drives for non-rigid magnetic media (floppy disks) which do not exceed:
- **1** A "gross capacity" of 17 million bit;
- **2** A "maximum bit transfer rate" of 0.52 million bit per second; *or*
- **3** An "access rate" of 6 accesses per second;

s Cassette/cartidge tape drives or magnetic tape drives which do not exceed:
- **1** A "maximum bit packing density" of 63 bit per mm (1,600 bit per inch) per track;
- **2** A "maximum bit transfer rate" of 1.28 million bit per second; *or*
- **3** A maximum tape read/write speed of 254 cm (100 inch) per second; *or*

t Cassette/cartridge tape drives which do not exceed:
- **1** A "maximum bit packing density" of 107 bit per mm (2,700 bit per inch) per track; *or*
- **2** A "maximum bit transfer rate" of 0.128 million bit per second;

v Input/output interface or control units, as follows, which may contain "embedded" microprocessor microcircuits but which lack "user-accessible programmability":
- **a** Designed for use with peripheral equipment free from embargo under sub-item **h 2 iv** above; *or*
- **b** Designed for use with digital recording or reproducing equipment specially designed to use magnetic card, tag, label or bank cheque recording media, free from embargo according to Item **IL 1572 a ii;**

i Not used;

j Technology, as follows:
- **1** Technology applicable to the:
  - **i** Development, production or use (ie installation, operation and maintenance) of electronic computers or "related equipment", even if these electronic computers or "related equipment" are not embargoed by this Item; *except*
    - **a** Technology which is unique to "related equipment" free from embargo under sub-item **h 2 iv a** to **c, e, f, l, n, p** or **q** and which is not otherwise embargoed by any other Item in these Lists;
    - **b** The minimum technical information necessary for the use of electronic computers or "related equipment" free from embargo; *or*
  - **ii** Development, production or use of equipment or systems embargoed by sub-item **b** or **g;** *or*
- **2** Technology for the integration of:
  - **i** Embargoed electronic computers or embargoed "related equipment" into other equipment or systems whether or not the other equipment or systems are embargoed; *or*
    Note: Nothing in the above should be construed to embargo technology for the integration which is unique to the other equipment or systems if they are free from embargo.
  - **ii** Unembargoed electronic computers or unembargoed "related equipment" into embargoed equipment or systems.
    Note: This does not, however, release from embargo the technology for the integration of electronic computers or "related equipment" which are freed from embargo only by sub-item **h 2 i** or only by sub-item **h 2 ii.**

Notes:

1 *"Digital computers" and "related equipment" therefor embargoed by sub-item* **h** *when contained in other equipment or systems covered by another Item in these Lists, may be exported subject to the provisions of that Item, provided that:*
- **a** *They are "incorporated" in other equipment or systems;*
- **b** *They are not the "principal element" of the equipment or systems in which they are "incorporated";*
- **c** *The other equipment or/ systems are embargoed by other Items in these Lists and they are permitted for export according to the provisions of the appropriate Item;*
- **d** *The "total processing data rate" of any "incorporated" "digital computer" does not exceed 15 million bit per second;*
- **e** *All other parameters do not exceed the relevant limits of* **Note 9 b 1 ii to iv** *and* **b 2 to 9** *to this Item; and*
- **f** *The "incorporated" "digital computers" or "related equipment" therefor do not include:*
  - **1** *Equipment embargoed by Item* **IL 1519 c** *or by Item* **IL 1567;**
  - **2** *Equipment described in sub-item* **h 1 ii;** *or*
  - **3** *Equipment described in sub-item* **h 1 i a to m,** *other than for:*
    - **i** *"Signal processing" or "image enhancement" when lacking "user-accessible programmability" and being "embedded" in medical imaging equipment; or*
    - **ii** *"Local area networks" implemented by using integral interfaces designed to meet ANSI/IEEE Std 488-1978 or IEC Publication 625-1.*
      NB: *"Digital computers" or "related equipment" "incorporated" in equipment exportable under the provisions of Items* **IL 1501, 1502, 1510 or 1518,** *which are for internal functions which incidentally might be considered to be described by sub-item* **h 1 i**

38 Security export control 14 June 1985

Figure 6.17: *1565(j), which shows the new controls on intangible technology for computers (British Government, 1985)*

In the 1989 list entry for *1565*, “total data processing rate” appeared in seventeen places, and had ten different values, from 6.5 Mbps for complete systems to 285 Mbps for “the sum of the ‘total data processing rate’ of all embargoed ‘digital computers’ directly connected to a ‘local area network’” (*1565.Note.9(b)(7)(vi)*). At the low end, this decontrolled computers such as the IBM PC-Junior, but it also decontrolled the fast-growing markets of the IBM-AT 80286. The complexity of the computer controls at this period of time shows the extent to which the balance of economic and security interests was becoming more and more difficult. There was much internal debate within the US during this time, primarily between the Departments of Defense and Commerce, about liberalising the computer controls, but spurred on by a Presidential Directive NSD-39, the US did agree to further relaxation of the controls. In the March 1991 lists, *1565* only had five references to “total data processing rate”, ranging from 275 Mbps for complete systems to 1,000 Mbps for “central processing unit - ‘main storage’ combinations.” According to later testimony of Paul Freedenberg, former Under-Secretary of Commerce, this came “as such a surprise to the business community. Overnight, the decontrol level for computers jumped to a PDR of 275 Mbps, which encompassed all of the 80386 microprocessor-driven microcomputers, many of the minicomputers of the Digital Equipment Company’s VAX line, and a number of the slower mainframes of IBM, Unisys, and Control Data as well” (Freedenberg, 1995).

We can see here a relaxing of controls, but also a shift in what the controls were there to do. Since the Soviet Union had crumbled, there was no need for the value of the performance parameter to be based on what the Soviets could develop themselves. Instead, as global trade routes opened up, the value of the parameter became based on which computers were considered ‘commodity level’, or ‘commercially available’, i.e. those that could be bought in stores for households or businesses.

This important shift in the political and economic environment had a direct impact on the definition of a dual-use high-performance computer. We can see this shift by looking at the Core List review process of 1991, which I discussed in the previous chapter. 'Total data processing rate' was replaced in the September 1991 lists with 'composite theoretical performance', which was measured in millions of theoretical operations per second (MTOPS). The shift from the 'processing data rate' (PDR) metric to 'composite theoretical performance' (CTP) was seen by members of CoCom as needed because PDR was not applicable to certain computer architectures such as vector processors, massively parallel processors, and array processors. CTP, on the other hand, was able to account for both floating and non-floating point operations, as well as variations in word length, number of processors, and whether the computer used shared or distributed memory (Goodman et al., 1998). The need to incorporate more factors into determining what constituted a dual-use computer makes sense if the goal of CoCom was to balance military security with economic competitiveness, i.e. the hierarchical framing with the competitive framing of the problem of dual-use technology. This shift, however, was unwelcome for many in industry, as a prominent member of that community noted:

> What the [US Department of Commerce's Bureau of Export Administration] is worried about is getting a new, single-value metric to measure supercomputer performance. The current metric, processor data rate (PDR), is actually OK, if one is fixed on getting just one number that signifies the ability to do 64-bit arithmetic computation. A footnote is needed, however, that says that a machine actually has to be capable of delivering the PDR on a test program that the formula gives. On the other hand, the proposed new metric, composite theoretical performance (CTP), is a bureaucrat's delight and was probably cooked up by a former high-level Internal Revenue Service form and instruction designer who wanted to harass the computer industry[...] CTP bears no relationship to a computer or its performance on any program or work load (Bell, 1991).

We now turn to an analysis of the use of CTP as a parameter to define a dual-use computer. Just as the move from PDR to CTP happened concomitantly with a shift in the political, economic, and technological environments, so shall we see that the abandoning of the CTP metric was also a result of a mix of political, economic, and technological shifts.

From MTOPS to software

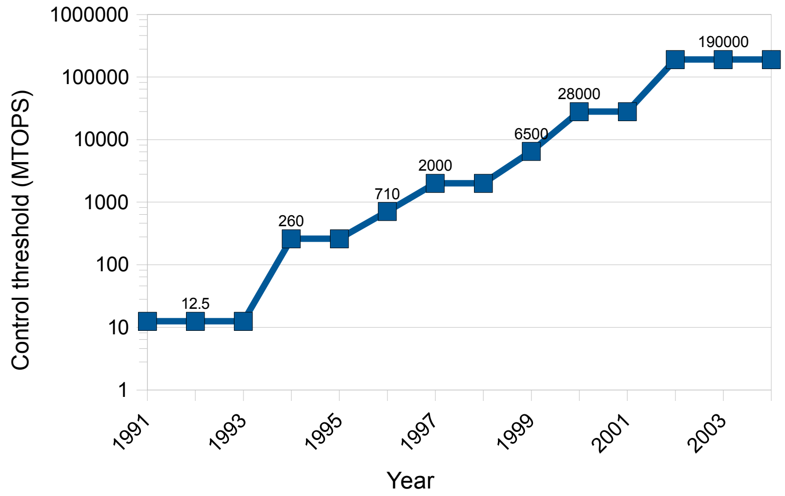

Figure 6.18: *The value of the CTP control parameter, 1991–2004*

In 1991, the control threshold for the composite theoretical performance of computers was set at 12.5 MTOPS (British Government, 1991*a*, Item 4.A.3.c.). Said another way, a dual-use computer was defined as a computer which was able to perform at or above 12.5 MTOPS. Over the course of its thirteen year existence, the CTP parameter increased exponentially almost every year, as shown in Figure 6.18. Constantly changing the value of the parameter was not in itself a problem for the Arrangement,[69] but recognising that modifications to the lists can take two years or more from the time they are proposed, and taking into account that computing power was doubling every 18–24 months, it became a bit of a game with many of the delegations to guess how high the parameter would go.[70]

[69]Interview with German Government Official, 28 March 2007.

[70]Interview with British Former Government Official, 8 November 2007. Most of the

There were technological reasons why the composite theoretical performance became problematic; it was argued that the hardware needed to develop a high-performance computer became *uncontrollable*. John Gage, then Director of the Science Office at Sun Microsystems Laboratories, explained to the US House of Representatives Foreign Affairs Committee that, in 1993 when the CTP was set at 12.5 MTOPS, one could easily get around the controls by buying an uncontrolled computer and replacing the parts in it with more sophisticated parts from foreign suppliers to achieve a computer that could perform well above 12.5 MTOPS (US Congress, 1993). In his closing remarks at the same hearing, Tim Dwyer, vice president and general manager of Intercontinental Operations at Sun Microsystems Inc., plainly gave his views of export controls on computers. "Ultimately, the workstation and PC industry is going to multiprocessor systems. Frankly, they are reproducing like rabbits and trying to control the export of such prolific commercial technology just forces manufacturing and jobs overseas. It is just simply absurd." Here we see how closely tied are the technological and economic arguments for changing the definition—or in this case actually abolishing the definition—of dual-use computers.

The development of clustering computers also caused problems for maintaining the CTP parameter. For many years, one of the primary difficulties in taking advantage of clusters of commodity-level computers was not that such clusters were difficult to build; several books had been published about how to construct a cluster out of non-export-controlled technology (e.g. Ford, 2002; Sterling, 2002). It was that special software was needed to take advantage of the cluster's combined resources (Kuzmin, 2003, p. 11). This software needed to be specially written using code that is unfamiliar to those outside of the high-performance computing community.[71] However, since at least the early 2000s,

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debates over the value of the parameter were between the US and Japan, as they had the most advanced technology in this area.

[71]Though it is freely available. See, for instance, the webpage on the US Department of Energy's website: http://www-unix.mcs.anl.gov/mpi/

software such as OpenMosix[72] and OpenSSI[73] has allowed more mainstream programmes to benefit from the resources of clustered computers. It has also meant that these systems could reach MTOPS levels well above the threshold simply by adding more computers to the cluster. Since high-performance computers became so nebulous in their configuration, with parts from one supplier coupled with parts from another, and all of the parts available in stores to be bought by anyone, it became much more difficult for Wassenaar Participating States to argue that the items were *controllable*, one of the key criteria for defining technology as 'dual-use'.

The economic arguments were significant as well. In the 1990s, manufacturing technology for computers was being developed in non-Participating States which could produce systems of comparable speed and price to those in the US or Japan. They became much cheaper, however, when one added on the cost of complying with export control regulations. Examples of regulations imposed by the US included having guards continuously monitor exported technology, and placing it in secure facilities. There were also significant amounts of paperwork that had to be completed, and often delays of three months to years to process the applications. These extra costs in time and money meant that customers were less likely in general to buy from CoCom suppliers if they could get comparable goods from non-CoCom countries (see remarks by Hughes and Manzullo in US Congress, 1993, p. 29).

In one case, the delay in sending a Cray computer from the US to India resulted in India developing their own version of the system themselves (Wolcott et al., 1998). This example highlights the economic loss from a failed sale, the further loss from a new competitor who does not have to comply with CoCom restrictions, and the security concern of having a foreign source of controlled technology. It is a classic example of the difficulty of controlling

[72] http://openmosix.sourceforge.net/
[73] http://openssi.org

the international distribution of computer technology, and it highlights the *foreign availability* of the technology, which is another criterion used to define the technology as 'dual-use'.

There were also political concerns. The US had a tendency to argue for a very low level of MTOPS within Wassenaar, but then grant general open licenses up to a much higher MTOPS level. This greatly angered European Participating States, because their licensing procedures were governed by European regulations, which were directly adopted from the Wassenaar lists. This in effect meant that the US had a comparative advantage—inadvertently or not—over other Wassenaar Participating States in selling computer technology on the open market. As one member of a national delegation put it in one of my interviews[74], the definitions of technology on the Dual-Use List "can be used as a trade measure within the regime! I wouldn't argue that the US was so well versed in European Union politics at that point in time that they realised what they were doing. But it had this consequence, which I think, when they did it for the third time, they were starting to clue in."

This action on the part of the US highlighted one of the problems that critics have often levelled at the Arrangement's structure. They argue that one Participating State can use the Dual-Use List to gain a comparative advantage in trade over other Participating States, in this case by providing a loophole in one state's national legislation that other states were unable to match. This problem, critics argue, will constantly recur unless there is an agreement between States not to engage in such practice. Such an agreement does exist, however.[75] It is one of the few Non-Disclosed Statements of Understanding, which are not made publicly available, and it states that no Participating State should unilaterally raise controls based on the way they make their licensing procedures. It was likely not made public because it could at the time be seen

[74] This quote is provided on condition of anonymity.

[75] This information comes from two members of different Participating State delegations to Wassenaar.

as being directed solely at the US.

Given the political, economic, and technological difficulties of using the CTP parameter, it is not surprising that there was a great deal of discussion around changing not only the value of the MTOPS controlled, but also the parameter itself. Composite theoretical performance was no longer seen as a useful parameter to describe dual-use computers by many of the members of national delegations to Wassenaar. There was discussion early on to maintain a Cold War style control threshold, because even basic computing power allows for many military applications: the US, for instance, developed the first atomic bomb without a computer at all, and went to the moon using a computer less powerful than today's calculators or mobile phones.

In a US Government Accounting Office (GAO, 2000) report to the US Senate, ten alternatives to using CTP to define a dual-use computer were collected from various US departments as well as experts in industry and academia.[76] They included: counting processors instead of using MTOPS; measuring power dissipation; indexing control thresholds to a common benchmark; tagging and remote monitoring of exported technology; assessing end-user attainable performance; raising export control thresholds to the level obtained by clustering; controlling software applications; controlling technology used for interconnection; controlling computer systems based on bandwidth; and implementing countermeasures to military advantages gained by countries of concern from more advanced computer exports. The GAO noted, however, that "these ideas have not been assessed for their feasibility to replace the current export control mechanism; moreover, most of them do not address the challenge created by advances in clustering technology" (p. 28).

Two US Department of Defense officials, commenting on the uselessness of controlling computers based on their performance, clearly state that "the original intent of the MTOPS-based policy was to restrict exports of high-performance computers, otherwise known as supercomputers" (Etter et al.,

[76] See also McLoughlin & Fergusson (2005).

2001, p. 25). Such controls, they argue, are "no longer feasible" and they suggest that, instead, the government should focus on "protecting our software used specifically for national security applications." A report by James Lewis (2001) at the Center for Strategic and International Studies also proposed abolishing all controls on computer hardware and focusing on software instead.

In 2002, The Arrangement agreed to add more text to the 'Software' and 'Technology' subcategories of Category 4, specifically sub-items *4.D.1.b* and *4.E.1.b*, shown in Figure 6.19.[77] In 2002, the CTP (*4.A.3.b*) was raised to 190,000 MTOPS, but software and 'technology' (i.e. knowledge) to develop, produce, or aggregate computers was controlled if it was specially designed for computers above 28,000 MTOPS (which was the old level of *4.A.3.b*). In 2004, the CTP threshold in *4.D.1.b* and *4.E.1.b* was raised to 75,000 MTOPS.

This emphasis on controlling the software and 'technology' necessary to develop, produce, and aggregate computers was a preamble to the 2005 list review process, where it was eventually decided to drop the composite theoretical parameter. In its place they substituted 'adjusted peak performance' (APP), measured in trillions of floating point operations per second (teraFLOPS), but the APP parameter serves a very different purpose than the CTP does. The Participating States of the Wassenaar Arrangement tried to make CTP be a single metric to cover all possible computers that might be militarily significant. APP, on the other hand, is only meant to prevent the most blatant attempts of non-Participating States to acquire high-performance computing systems. There was recognition within Wassenaar that the hardware needed to cluster computers together to achieve a system with an APP above the control threshold (0.75 teraFLOPS) was widely available from non-Participating States, and there was little that Wassenaar could do to prevent an individual or group from acquiring all of the parts individually. All that was left was to

[77] This text is actually from the 2003 list, as the 2002 list was unavailable. There was no change in this section of text between these two years.

4. D. 1. a. "Software" specially designed or modified for the "development", "production" or "use" of equipment or "software" controlled by 4.A. or 4.D.

b. "Software", other than that controlled by 4.D.1.a., specially designed or modified for the "development" or "production" of:
1. "Digital computers" having a "composite theoretical performance" ("CTP") exceeding 28,000 Mtops; or
2. "Electronic assemblies" specially designed or modified for enhancing performance by aggregation of "computing elements" ("CEs") so that the "CTP" of the aggregation exceeds the limit in 4.D.1.b.1.

2. "Software" specially designed or modified to support "technology" controlled by 4.E.

3. Specific "software", as follows:
a. Operating system "software", "software" development tools and compilers specially designed for "multi-data-stream processing" equipment, in "source code";
b. Deleted
c. "Software" having characteristics or performing functions exceeding the limits in Category 5, Part 2 ("Information Security");
Note *4.D.3.c. does not control "software" when accompanying its user for the user's personal use.*

d. Deleted

4. E. TECHNOLOGY

4. E. 1. a. "Technology" according to the General Technology Note, for the "development", "production" or "use" of equipment or "software" controlled by 4.A. or 4.D.

b. "Technology", other than that controlled by 4.E.1.a., specially designed or modified for the "development" or "production" of:
1. "Digital computers" having a "composite theoretical performance" ("CTP") exceeding 28,000 Mtops; or
2. "Electronic assemblies" specially designed or modified for enhancing performance by aggregation of "computing elements" ("CEs") so that the "CTP" of the aggregation exceeds the limit in 4.E.1.b.1.

Figure 6.19: *4.D. 'Software' and 4.E 'Technology' sections of Category 4 - Computers (Wassenaar Arrangement, 2003)*

(a) control what still could be controlled, i.e. custom-built systems over the control threshold, and (b) control the software and 'technology'.

It was very hard to let go of the CTP parameter and accept the uncontrollability of computers, as elaborated in one of my interviews:

> Interviewee: Once it becomes a mass market good, once everyone's got one in their pocket, once- I mean we saw that with computers.
>
> SE: Yeah, like the playstation
>
> Interviewee: exactly. It met the definition of the supercomputer in 1996.
>
> SE: Well certainly when the Apple came out with their new G4

Interviewee: Yeah, that's right. As soon as everybody's got one, or as soon as they're cheap, it's very hard to control. And that's why stuff has to come off the lists and stuff has to go on the lists. And I think that probably when you put everything together and you want to come up with why does stuff come off the lists, it's going to be because it gets cheap. That's not with everything, because there are some real cheap components that remain on the lists, but you don't see them- because everybody doesn't have one in their pocket. Uh, analogue digital converters. Pretty cheap, but you're not going to go to the supplier and say, I want a thousand of those, put them in your pocket, and go someplace, because they do nothing for you. And once they're attached to a board, they are no longer a component.

SE: Yeah, but again, in determining-

Interviewee: That's not a control criteria, I'm just saying that when you do your research and you find out why the stuff falls off the list, it's going to be in relation to price.

SE: But, is that a consideration that might be taken into account in determining things? For instance, you're saying, "I have a feeling that this technology may not be really effective to be controlled, maybe we shouldn't control it anymore. How do we figure that out? Well, let's do a thumbnail sketch, a back of the envelope sketch. Let's go and see how cheap one of these things is, and how expensive it is, and then-"

Interviewee: Comes up all the time.

SE: I guess what I'm interested in is saying- if I could see what people do on their back of the envelope sketch, and say, "What are the factors that you see as important in making that back of the envelop calculation." Because with that I can then say, "Well, ok, it seems here that the important aspects of the technology that you are focusing on are ones of economy or ones of interpretability or ones of- or what are the factors that you see-"

Interviewee: They're all there. And the price curve follows- the price and costs curves are identical, almost. And that's also the maturity curve for the technology. As it becomes more mature it becomes cheaper to make. They don't have to do a lot of brainwork anymore, they just turn on a machine and it punches them out. So that's an indicator. So if you were to look at- most of the end items that are controlled are more expensive than the ones that aren't. Most. And there are exceptions to everything, but I'm saying that's one of the things that you're going to come up with in your research, if you look at technologies. And you'll find that

> they tend to become decontrolled as soon as they begin to cross a threshold of concern, and that just make sense.[78]

The decontrol of computer hardware represents a case of exception-barring, but one where the exceptions do more to undermine controls than strengthen them. There are clear military uses for the technology, and yet technological, political, and economic arguments were made that controlling the technology did more harm than good. Even though computers are something that actors trying to strengthen the hierarchical framing would very much like to control, they are unable to do so while still remaining a legitimate member of the overall debate. If actors expressing the hierarchical framing had continued to flaunt the competitive framing for much longer and insisted that they had their way, the ramifications to the institutional structure of the Wassenaar Arrangement would have likely been much greater than they were for the focal plane array case. Computer exports, in contrast to thermal imaging exports, make up a significant portion of several Participating States' overall exports per year. If controls were seen as too stringent, actors employing the competitive framing would feel that their concerns were not adequately addressed, and having exhausted the 'voice' option of Hirschman's (1970) framework, they would be less inclined to maintain their loyalty and would have more incentive to exit from the institution altogether and not be bothered with export controls at all. Judging the alternative to be too costly a gamble, actors favouring the hierarchical framing decided that they were not going to win this battle to institutionalise further their form of organisation. That is the essence of an an exception-barring generating uncomfortable knowledge. This case created uncomfortable knowledge for the hierarchical framing because the recognition that there is something which should be controlled but cannot be controlled undermines the assumption that control is possible.

While there was exception-barring in one area (computer hardware), there was also a seeming monster-adjustment of the anomaly into the software and

[78] Interview with US Defense Department Official A, 8 August 2006.

'technology' sections of Category 4. But is it really possible to control intangible technology, such as software and knowledge? The Participating States of the Wassenaar Arrangement believe that it is possible, but as we have already seen above, the programming code needed to aggregate computers into large clusters is already in the open-source community, publicly available to anyone in the world via the internet. Whether or not the Arrangement is capable of controlling intangible technology given its current institutional form, is the topic of the next chapter.

6.4 The Wassenaar Arrangement as an incompletely theorised agreement

"Of course a completely theorized agreement would have many virtues if it is correct. But at any particular moment in time, this is an unlikely prospect for human beings"
— Cass Sunstein (1996)

There is much evidence in the cases analysed above to suggest that the Wassenaar Arrangement is an 'incompletely theorised agreement'. Recall from Chapter 3 that Sunstein (1996) describes three forms of incompletely theorised agreements. The first form of is agreement *on a general principle*, where "people who accept the principle need not agree on what it entails in particular cases" (p. 35). Thus, people may agree on principles such as 'murder is wrong', 'racial equality', or in our case, 'dual-use technology should be controlled', without agreeing on what that means in particular cases. The second form is where agreement is reached on a mid-level principle, but disagreements remain on both general theory and particular cases. The third form is an agreement on particular outcomes and the low-level principles that accompany them, with disagreements remaining about higher-level principles. There does not have to be agreement on all three levels in order for a social system to function. Agreements are reached where and when it is possible. Sometimes this involves consciously avoiding topics that are contentious, sometimes it involves transforming the topic into one that is more likely to reach agreement.

In this chapter, we have looked at three agreements on particular outcomes, by which I mean the modification of the lists. Each of the cases showed agreement on modifying the text of the lists, even though there were often different interpretations of what that text meant. For some, it satisfied the need to be seen to be controlling the technology. Such was the case for the US Defense Department in the focal plane array case, or the maintenance of controls on computers after 2005. For others, it carved out an exception for the transfer of their particular technology. The decontrols for night vision cameras in automobiles and car ferries are a good example of this, as is the mass market cryptography decontrol note. For still others, the agreement avoided having to undergo discussions on a more politically sensitive topic. A prime example of this is the discussion on quantum cryptography, where too detailed a discussion about the technology may have resulted in other governments within the Arrangement acquiring the ability to produce it, which was not likely the desire of the countries who already knew how to do so.

While striving for complete theorisation in agreements may "reveal bias, confusion, or inconsistency," (p. 38) and therefore serve a useful purpose in developing institutions, Sunstein discusses several advantages incurred from allowing agreements to remain incompletely theorised. One is the constructive use of silence that they allow. "Silence—on something that may prove false, obtuse, or excessively contentious—can help minimize conflict, allow the present to learn from the future, and save a great deal of time and expense" (p. 39). We can see an obvious use of silence in the achieving of consensus within the Wassenaar Arrangement. As one national delegation member noted:

> I have chaired multilateral meetings where someone made an 'I just think this is a bad idea' statement, and my sense was that he was making a statement for the record and was not trying to break consensus. So we get to the point where we have to decide and I say, "Here's what I think we've agreed to do, do we have agreement?" and I look at this guy, and he's just looking at me stone-faced. His

> answer is yes but he won't nod. If he disagreed he would turn up his flag.[79]

Another advantage of an incompletely theorised agreement is that it allows the parties to the agreement to show one another "a high degree of mutual respect" (Sunstein, 1996, p. 40). If two Participating States disagree strongly on an issue, for instance capital punishment, they may agree not to discuss that issue at the Wassenaar table, "as a way of deferring to each other's strong convictions and showing a measure of reciprocity and respect (even if they do not at all respect the particular conviction that is at stake)" (p. 40). Such a discussion, some might say, is outside the bounds of the Wassenaar Arrangement, but that is exactly my point. Whether to control the technologies to perform lethal injection, electrocution, or other methods of enforcing capital punishment is a topic of debate within Wassenaar, but the Arrangement has been designed such that there is a minimum amount of necessary contention between opposing views.

Incompletely theorised agreements are continually re-agreed, thereby "reducing the political costs of enduring disagreements" (p. 41). An example of this occurring is the validity note placed on the focal plane array list modification, where the changes could be revisited after two years. If Participating States disagree on more abstract theories—such as the appropriate balance between security and economy—particular decisions about list modifications do not directly undermine those abstract theories. If a decision were taken to decontrol one item, there would likely be other decisions to strengthen controls in another area. Seeing the text of the Arrangement as a continual *process* rather than, say, a treaty that is signed and put away, allows the States to continue to negotiate, winning some debates and losing others, but always keeping their voice in play.

Incompletely theorised agreements are pragmatic, and "may be the best approach that is available for people of limited time and capacities" (p. 42).

[79]Interview with US State Department Official A, 28 September 2006.

By seeing the Wassenaar Arrangement as a series of small agreements rather than a take-it-or-leave-it single agreement, Participating States can focus on a restricted area of the lists or a particular agreement within the General Working Group without having continually to ask themselves whether such an agreement makes the Arrangement as a whole more coherent—a question that would take far more time than most States have to devote to the affairs of Wassenaar.

There are other points about incompletely theorised agreements raised by Sunstein which I will address in the next chapter. My final point about these agreements here is that Sunstein bases his exposition of incompletely theorised agreements on the assumption that "human morality recognizes irreducibly diverse goods, which cannot be subsumed under a single 'master' value" (p. 43). This commitment to pluralism leads him to argue for the applicability of an incompletely theorised agreement for obtaining "a consensus on concrete outcomes among people who do not want to decide questions of political philosophy" (p. 47), which is mostly the type of people who make up the national delegations to the Wassenaar Arrangement.

By viewing the Wassenaar Arrangement as an incompletely theorised agreement, we can see the benefits of this approach to addressing the wicked problem of dual-use technology. However, the idea of incompletely theorised agreements has little to say about *how* agreement, particularly around contentious issues, is reached. The way that most agreements are reached with an incompletely theorised agreement seems to be through what Steven Ney calls *strategic deliberation*, "where policy actors interact in order to more effectively pursue their divergent policy goals," and in so doing do not bring into play their fundamental principles (Ney, 2006, p. 323). But when fundamental principles do come into play, Ney suggests that in order for the deliberation to be successful it must become more reflexive. In a reflexive deliberation, policy actors critically reflect on both what they are trying to achieve (the general principle, or the form of social organisation) and how they are going to achieve it (the particular outcomes).

We saw a conflict between both general principles and specific outcomes of two difference framings in the computer debate. The imperatives of the market and the need for decontrol were raised by the competitive framing, while the imperatives of security and the need for control were taken up by the hierarchical framing. The quality of the deliberation between the two could not remain strategic because the outcomes each wanted were diametrically opposed and neither was willing to compromise on their general principle. Thus, the debate became more reflexive, and the switch to focusing on software controls was created as an acceptable outcome for both framings.

In the case of the controls of intangible transfers of technology that we look at in the next chapter, however, there is a third framing with which the other two must contend. That framing, employed largely by the academic community, argues for a more egalitarian form of social organisation.

6.5 Conclusion

In this Chapter, I have gone into significant depth about three areas of the Wassenaar Arrangement Dual-Use List in order to show the anomaly-handling strategies employed by actors expressing the hierarchical framing. Each of the cases we examined produced increasing amounts of uncomfortable knowledge for the hierarchical framing.

Where contention was least—in the quantum cryptography case—the anomaly was quickly resolved by an expansion of the list, a monster-adjustment strategy. Cryptography is seen as a key part of national security as it helps secure critical information, but that also makes it key for commercial, and especially banking, transactions. This is doubly true with the rise of the internet. Quantum cryptography tries to get around one of the most difficult questions in cryptography, key distribution, by employing the theory of quantum mechanics to ensure that any interception of the key in transit can be detected. If there has been no interception, the key is secure and uncrackable—that is, at least in theory. The proposal process began with a discussion on what the technology was and whether it was anomalous. In the case of quantum cryptography, the relevant (i.e. controllable) characteristic of the cryptographic system for the hierarchical framing was the key generation rather than the encryption/decryption algorithm (the one-time pad), as the algorithm is simple and widely known, and therefore not controllable. In inscribing the technology on the Dual-Use List, the Participating States made decisions about how specified, and how ambiguous, the technology should be.

This was a case of monster-adjustment. The technology was seen as relevant and controllable, and not under control. Control was possible by expanding the classification system already in place. The text added, however, needed to be ambiguous enough not to provide knowledge on how to make the technology, while being specific enough so that licensing and enforcement officers could identify it in actual export control cases. The text, then, was purposefully designed to include some communities of practice (licensing and enforcement officers, Participating States), and exclude others (companies/governments trying to invent the technology).

The case of focal plane arrays was very different than quantum cryptography, though both ended with the resolution of the anomaly. Focal plane arrays provide a detectable change in electric properties due to absorbed thermal radiation, and are a key element in many thermal imaging systems. Night vision technology has always been very important for the hierarchical framing and has also been difficult to classify. It is important because it provides a key military advantage over those who do not have it. It has been difficult to classify because different technologies have provided this ability over the history of export controls. One source of contention in the list modification process within Wassenaar was that commercial applications of focal plane arrays were developed and a market was generated before controls were changed to include them. A source of ambiguity on the classification of focal plane arrays, particularly α-Si microbolometers, was that the technology needed to produce them was the same as that needed to produce integrated circuits used in computer processors, and was therefore widely available around the world. Another source of ambiguity was that it became difficult to distinguish between a sensor and a camera, two separate areas of the Dual-Use List.

The focal plane array case required actors upholding the hierarchical framing to employ both monster-adjustment and exception-barring anomaly-handling strategies. One of the most detrimental parts of the focal plane array debate was the unwillingness of the US delegation—which was employing a polarised hierarchical framing—to accommodate or even acknowledge alternative framings of the technology. Monster-adjustment occurred by removing the decontrol note for silicon and adding *6.A.2.a.3.f* to cover α-Si microbolometers. Exception-barring occurred through the extensive concessions made in decontrols for cameras with particular uses, such as people counters and night-vision systems in passenger vehicles. This case was an extreme example of the types of events that continually occur within the Wassenaar Arrangement Expert Group debates.

In the third case, we saw a similar straining of tensions between the hierarchical and competitive framings, but this time actors expressing the hierarchical framing found that actors expressing the competitive framing were in a stronger position, and therefore the hierarchical framing was forced to make exceptions to the controls even though the decontrolled technology was still considered relevant. High-performance computers have gone through a series of developments that have made them increasingly difficult to control. Much of this is a result of the ambiguity of what constitutes a single computer, i.e. the defining characteristic that is both essential and controllable. This resulted in the almost complete barring of the controls on computer performance. Initial controls covered all digital computers, but gradually parameters were added which defined performance parameters, specifically total processing data rate. This was a parameter that was invented by CoCom in order to have a definable and controllable parameter. This parameter was continually increased (meaning that lower-performance computers were not controlled) until the rate of increase exceeded the time taken to amend the definitions on the list. It was then barred as a useful parameter, and replaced by the 'composite theoretical performance' (CTP), another CoCom-created parameter.

The impact that the political and economic environment had on the definition of a dual-use computer was clearly shown in the modifications made to the definition after the collapse of the Soviet Union, when the definition's focus shifted from controlling what the Soviets needed, to *not* controlling commodity-level computers. This was a shift in the balance between the hierarchical and competitive framings of the technology, with the competitive framing gaining strength by institutionalising its rhetoric in the relaxed controls. Actors expressing the competitive framing pointed out that the CTP parameter was not an adequate control parameter because it could easily be circumvented. In making this argument, however, these actors were not suggesting that the parameter be replaced by something else, but rather that controls be abolished altogether. This was therefore an example of the actors wishing to strengthen the competitive framing using rhetoric stolen from the hierarchical framing in order to undermine the hierarchical framing's preferred form of organisation. As actors trying to support the hierarchical framing came to accept that CTP was not a useful parameter of control, they found themselves in a situation of increasing amounts of uncomfortable knowledge.

The development of cluster computing produced further difficulties for the CTP parameter because what made these computers work as a high performance computer was not a specially designed component, but the software to interconnect multiple computers to aggregate performance. Control was shifted once more, but this time to an industry standard parameter, 'adjusted peak performance' (APP). This shift was another shift in the purpose of the controls. CTP meant to cover all possible computers of military significance, whereas APP only meant to prevent the most blatant acquisition attempts by non-Participating States. This shift was complemented by a new control on the software needed for a functioning high-performance computer, even though such software was made publicly available shortly afterwards. The exception-barring strategy employed by actors trying to strengthen the hierarchical framing in the computer case therefore did more to undermine than to strengthen controls.

In each of these cases, we can see evidence for the maintenance of CoCom and Wassenaar as incompletely theorised agreements. Each of these cases represents an agreement on a particular outcome, where different actors were usually able to maintain their own views on the more general principles that would lead them to agree to that outcome. These agreements are seen more as milestones than ultimatums, and can be re-negotiated when they are no longer useful. This allows each of the framings of the problem of dual-use technology to know that if they lose one battle, they are still able to come back to it at some point in the future.

We now turn to look at controls on intangible technology to see how adequate the Arrangement's current institutional form is for addressing the likely future types of debates that will arise, and the difference between debates on tangible vs intangible technology.

You can release the equipment, but if you release the technology, then there's really no need to control anything anymore, because it's gone. It's gone forever.

—Interview with Former British Government Official, 8 November 2007

7

Intangible technology transfers & the shift to a complex wicked problem

Contents

So far in this thesis, I have shown how the problem of dual-use technology addressed by the Wassenaar Arrangement is intractable, insoluble, persistent, multiply defined, and characterised by 'contradictory certitudes', i.e. it is 'wicked'. Using a set of case studies from recent Wassenaar negotiations, I then showed how Participating States go about trying to address this problem through their efforts to maintain the List of Dual-Use Goods and Technologies. We saw how some members of national delegations preferred to hierarchically frame the problem as one of control, while others preferred a competitive framing. Since the hierarchical framing has been hegemonic within the Wassenaar Arrangement, we focused on how those seeking to strengthen this framing respond to anomalous technologies. We saw that some anomalies were easily resolved, while others have generated significant amounts of uncomfortable knowledge for this framing.

In this chapter, we explore whether or not the problem of dual-use technology shows signs of shifting from being a simple wicked problem, where debate is between two framings, to being a complex wicked problem, where at least three framings are involved. As an example case, we will use the development of controls on intangible aspects of technology and controls on the intangible transfer of dual-use technology. While the lists started off only controlling the transfer of the tangible aspects of technology, they have since the 1980s also controlled intangible aspects, and since the early 2000s have also controlled the intangible transfer of technologies. Has this shift in the controls also seen a shift in the relative strength of framings on the problem of dual-use technology?

The first section provides an overview of the difference between tangible and intangible aspects of technology, as well as tangible and intangible transfers of technology. I outline the development of controls on the intangible aspects of technology in the 1980s and their current status on the Wassenaar lists. I also outline the development process for the Best Practices document on intangible transfers of technology, and the trouble that one country—the United States—has had in trying to implement controls on intangible transfers. The second section provides an analysis of why the controls were sought and some possible implications for the future of the export control system.

7.1 Intangible aspects of technology & intangible transfers

For the purposes of this thesis, I provided a working definition of 'technology' in Section 2.1 as a human construction coupled with the practices and knowledge of how to engage that construction toward a particular end. This definition does not define whether the technology has a material component, i.e whether or not it is *tangible.* A technology, according to this usage, could as easily be a computer as it could be a language, a mathematical equation, or a particular skill. The Wassenaar Arrangement, and most other bodies in the history of export controls, have been concerned only with the tangible subset of technology.[1] All tangible technology, however, includes intangible aspects as well. A watch, for instance, may seem like a wholly tangible technology, but if someone does not know how to read time, it is of little use to that person *as a watch*, if we define 'watch' as something which tells time. The Wassenaar Arrangement has always been concerned only about technology with tangible aspects, but as we will see below, it has been concerned about both the tangible and intangible aspects of that technology.

The Wassenaar Arrangement distinguishes between tangible and intangible transfers of technology, although the distinction between these types of transfers is not clear from the documents the Arrangement has produced. In the

[1] There are several possible reasons for this, which are beyond the scope of this thesis to address. Likely reasons include: that they only controlled what it was possible to control, and knowledge was too ephemeral; that knowledge of how to produce weapons was widely spread, and there was little difference in the manufacturing techniques of enemies; and/or that transnational flows of knowledge about how to develop, produce, and use controlled technology were rare because the people who held the knowledge were unlikely to travel or communicate with foreign nationals.

Best Practices document analysed below, examples given of intangible transfers include phone, fax, and electronic transfers. Broadly speaking, tangible aspects of a technology can only be transferred by tangible means, while intangible aspects of a technology may be transferred by either tangible or intangible means. I will occasionally speak of 'intangible technology transfers', which is a shorthand to cover both the tangible and intangible transfers of intangible aspects of technology. We begin this section with a history of the distinction between tangible and intangible aspects of technology, followed by a history of the development of controls on the intangible transfer of dual-use technology.

Within this history, we are looking for clues as to whether a new framing of the problem of dual-use technology is developing. The theory of sociocultural viability suggests that there is a likely third framing, based on an egalitarian solidarity, that favours tightly bound groups with minimal structure. Actors expressing this framing would prefer the distribution of knowledge to be based on the principle of parity, where all have access to it. They are likely to have a long-term perspective on the problem of dual-use technology, which they frame as a problem of equality. Has the discourse on dual-use technology, while addressing the issue of intangible technology transfers, encountered this third framing? If so, has it been incorporated into the discourse?

Development of controls on intangible aspects of tangible technology

Over the course of the history of export controls, there have been two significant shifts in the types of things that were put onto the control lists. The first was the elimination of 'unmanufactured' items from control, and the second was the addition of controls on intangible aspects of technology. In this subsection I show this shift, in order to place in context the reason why it seemed logical at the time.

We begin with the early lists of controlled items, when export controls were generally seen as a tool to ensure domestic supply of war materials for a nation's military. This was a common view of export controls from at least the 17th Century through to the development of CoCom. Looking back at the list of 'conditional contraband' in the *1909 Declaration concerning the Laws of Naval War* (Table 5.1, page 166), we can clearly see the equal weight given to items that we would generally not consider to be technology (in the sense that they involve human construction) as to items we would think of as technology. The list had food, grain, and gold sitting alongside vehicles, explosives, and horseshoes. Similarly, during World War II, Britain maintained a document called the *Control of Export: list of goods prohibited to be exported from the United Kingdom.* The first of these lists, published on 25 September 1939, was divided into three sections that clearly show control of both technology and other things:

I – Food, Drink and Tobacco

II – Raw materials and articles mainly unmanufactured

III – Articles wholly or mainly manufactured

With the use of the word 'mainly', however, we can see that the line between 'unmanufactured', and 'manufactured' was blurred. Put in the terms I used to define technology, there was a recognised ambiguity between things that do not involve human construction and things that do. The definitions of what was raw and manufactured, though, were still very much human constructions.

This British classification system, however, only lasted a few months, after which items were separated into thirteen unnamed groups, which were not wholly dissimilar to the Groups found in the first published CoCom lists.[2] Within the CoCom lists, most non-technology items have been collected within

[2] See the 15 January 1940 *Control of Export* document for the first occurrence of the new classification. Other versions published throughout the War were: 15 April 1940; 15 November 1940; 15 May 1941; 1 December 1941; 15 July 1942; 15 January 1943; 15 January 1944; 15 January 1945.

the group labelled 'Metals, Minerals, and their Manufactures'.[3] That this group covered non-technology items is made clear by a note at the beginning:

> **(1) RAW MATERIALS** Where raw materials are covered by a definition the intent is to cover all materials from which can be usefully extracted, i.e. ores, concentrates, matte, regulus, residues, and dross (ashes).

This group remained until the 1991 Core List review, when it was scrapped. From 1991 on, 'materials' were still covered in Section C of each Category, but none of them refer to materials in their naturally occurring (i.e. non-human constructed) form. This shift away from controlling non-technology items did not mean that such items were no longer controlled at all in international trade. There were, and are, myriad forms of control for the shipment of food, animals, and other non-technology items (e.g. quarantine laws and regulations on health and safety of food). By removing these items from the CoCom lists, however, CoCom members were saying that such items no longer need to be controlled *for their military significance.*

This gradual shift away from controlling non-technology items was matched by a corresponding shift in establishing controls on the intangible as well as tangible aspects of technology. Recognition of the importance of the intangible aspects of technology were first noted, at least in Britain, in the preamble to the 1966 lists:

> Manufacturers are reminded that the purpose of these strategic controls will be defeated if technical information or technical know-how concerning embargoed equipment is revealed to the above countries.

This preamble remained on the lists until the Core List Review. The first actual text controlling intangible technology appeared in the 1985 CoCom list in the controls on computers (*1565*) and software (*1566*) (British Government, 1985), as shown above in Figure 6.17.

[3] This was Groups H in the 1958 list, J in the 1960 list, and H again from 1966 until 1991.

With the Core List Review, we saw the first introduction of an entire section of each category devoted to 'technology', here meaning intangible aspects of technology. Also with this newly formatted list, we find the first definition of the intangible aspects of technology (Figures 5.6, page 189) which consisted of "specific information necessary for the 'development', 'production' or 'use' of a product."

GENERAL TECHNOLOGY NOTE

The export of "technology" which is "required" for the "development", "production" or "use" of items controlled in the Dual-Use List is controlled according to the provisions in each Category. This "technology" remains under control even when applicable to any uncontrolled item.

Controls do not apply to that "technology" which is the minimum necessary for the installation, operation, maintenance (checking) and repair of those items which are not controlled or whose export has been authorised.

Note *This does not release such "technology" controlled in entries 1.E.2.e. & 1.E.2.f. and 8.E.2.a. & 8.E.2.b.*

Controls do not apply to "technology" "in the public domain", to "basic scientific research" or to the minimum necessary information for patent applications.

Figure 7.1: *Definition of the intangible aspects of dual-use technology (Wassenaar Arrangement, 2007b)*

The intangible aspects of controlled technology are defined by the General Technology Note, shown in Figure 7.1, which deserves closer inspection here. An intangible aspect of a controlled technology is controlled if it is "'required' for the 'development', 'production' or 'use' of items controlled in the Dual-Use List according to the provisions in each Category. This 'technology' remains under control even when applicable to any uncontrolled item." 'Required' technology is defined in the Definitions section of the Dual-Use List, and shown in Figure 7.2. Note that 'required' 'technology' may be "shared by different products," and that those products may be uncontrolled items, but the 'technology' will still be controlled. This provides the broad scope of the intangible aspects of technology that Wassenaar controls.

Cat 5	"Required"
Cat 6, 9	As applied to "technology", refers to only that portion of "technology"
GTN	which is peculiarly responsible for achieving or exceeding the controlled
ML 22	performance levels, characteristics or functions. Such "required"
	"technology" may be shared by different products.

Figure 7.2: *Definition of 'required' (Wassenaar Arrangement, 2007*b*)*

There are two caveats on the controls, however. The first is that the Dual-Use List does not control an intangible aspect of a technology "which is the minimum necessary for the installation, operation, maintenance (checking) and repair of those items which are not controlled or whose export has been approved." Also, the final paragraph of the General Technology Note states that the list does not control intangible aspects of technology 'in the public domain', nor does it apply to 'basic scientific research' or "the minimum necessary for patent applications." This is a very complicated statement of control, and I have graphically represented it in Figure 7.3.

When controls were only (or mainly) about the tangible aspects of technology, the primary way to resolve anomalies in the classification system was to make the list more defined by adding more parameters of the technology through a process of monster-adjustment, and specifying what is not controlled through a process of exception-barring. When addressing the intangible aspects, however, there is a limit to how defined one can get on the list. To make the tangible aspect of the technology requires access to the resources, the equipment needed to manipulate the resources into the final product, and the knowledge of how to design and produce the technology. The list does not provide the resources nor the equipment needed to make the tangible aspects of a technology, but it *does* give information about the parameters of that technology that members of Wassenaar believe are militarily significant. If a person or

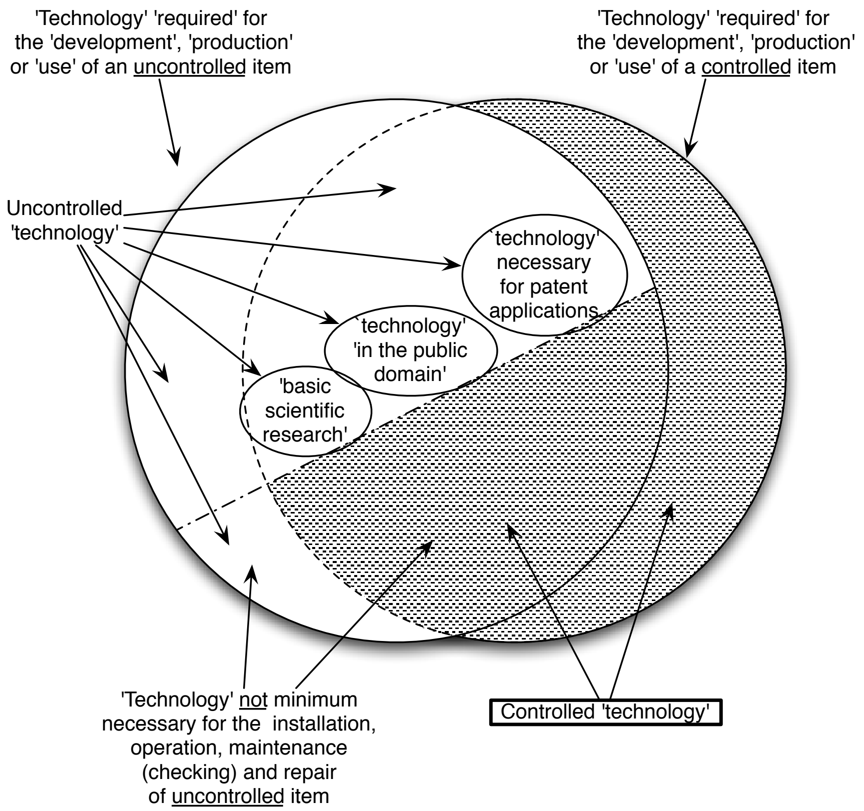

Figure 7.3: *Graphical representation of intangible technology controlled by the Wassenaar Arrangement*

group had access to resources and equipment (or even just resources), the lists may provide them with enough knowledge to create the technology themselves. *The lists, therefore, are themselves intangible aspects of the technologies they control.*

A very rudimentary example may help the reader understand how the line is drawn on controlled technology. Say it is the year 2007 and you are in a company that is within a Wassenaar Participating State and is exporting three computers to three different customers, one rated with an Adjusted Peak Performance of 0.01 Weighted TeraFLOPS (WT), one with 0.1 WT, and the other with 1.0 WT, but in other respects they are identical. Dual-use computers were defined in 2007 as "exceeding 0.75 Weighted TeraFLOPS" (Wassenaar Arrangement, 2007*b*, p. 66). The 'technology' associated with computers, however, is controlled if it can be used to 'develop' or 'produce' a computer with

0.04 WT, and is controlled on the Sensitive List if it can be used to 'develop' or 'produce' a computer capable of 0.1 WT.

You are allowed (subject to national discretion to export the tangible aspect of the 1.0 WT computer) to provide all customers with information ('intangible aspects of the technology') about how to install, operate, maintain, and repair their computer. You are also allowed to share with the customer receiving the 0.01 WT (uncontrolled) computer information on how to develop and produce that uncontrolled computer, but only if that information is different than the information needed to produce either the 0.1 or the 1.0 WT computer. You are not allowed to provide similar information to the customer receiving the 0.1 WT computer without an export license, even though the export of the tangible aspect of the technology is not controlled.

If the only physical difference between the two computers is, say, an extra processor and the connection of that processor to the others, there is essentially no difference in the intangible aspects of the technologies. One can then argue which pieces of intangible technology are 'required', i.e. "peculiarly responsible," (see Figure 7.2) for achieving or exceeding the controlled performance level. All the time, of course, keeping in mind that there may be other aspects of the technology that a government may not wish to be exported, but could not put on the lists without giving the aspect away. Thus we see a key difference between trying to define tangible and intangible aspects of technology. In a much stronger sense than with the tangible aspects, *the text of the definitions of intangible aspects actually constitutes the technology itself.* The technology here is embodied in the text.

Another difficulty in defining the intangible aspects of technology in order to control them is that this implies that knowledge is divisible. It is a matter of asking, "Without which part will the whole not work?" This question assumes that intangible aspects of technology—the practices and knowledge of interacting with human constructions—are discrete entities, and that you can break them into bits. Both of these difficulties arise because the hierarchical framing provides the institutional context for the controls. This framing focuses on the need to find ways of making technologies controllable. Both of the difficulties noted above hint at a different way of understanding technology; a way that emphasises how the interconnectedness of knowledge is a desirable aspect rather than a troubling one.

I argue below that a hierarchical framing of intangible aspects of technology provides a false sense of assurance that the assumptions used to control the tangible aspects of technology are adequate for controlling the intangible aspects as well. First, however, we turn to the development of the controls on transferring intangible aspects of tangible technology.

Development of controls on intangible transfers of technology

While the Wassenaar Arrangement controls intangible aspects of technology, agreement on how to implement controls on the *intangible transfers* of the intangible aspects has been very hard to reach. A primary reason for this, as I show in this section, is that several Participating States' have argued that their internal legislation does not distinguish between in-country transfers and freedom of speech. This debate occurred mainly within the General Working Group rather than the Expert Group, which is where the changes were made to control the intangible aspects of technology discussed above.

The tangible aspects of tangible technologies can be transferred only by tangible means. This may seem obvious on the outset, but it is important to note that, if one is only trying to control the tangible aspects of technology, one need only control the things one can see and touch. *Intangible* aspects of tangible technology, however, can be transferred by tangible *or* intangible means. The difference between a tangible and intangible transfer has not been fully agreed by Wassenaar Participating States.

The first statement of the control of intangible transfers was in the 1966 British version of the CoCom lists (British Government, 1966). Following the statement, which we looked at on page 173, about how the purpose of the controls would be defeated if technical information or 'know-how' were revealed to controlled destinations, the preamble continues, "[a] particular danger arises when technicians or students from these countries are visiting or are being trained at British factories." More of a warning than an actual attempt to control, this preamble existed on all lists until the 1991 Core List revision.

With the advent of an entire section of each category devoted to 'technology' controls after the Core List review, apparently little need was seen for a statement that the items were controlled regardless of the way they were transferred. As CoCom disbanded and the New Forum evolved into the Wassenaar Arrangement, a Statement of Understanding (SOU) was appended to the General Technology Note, shown in Figure 7.4. It states that governments are to control the intangible transfer of intangible aspects of tangible technology "as far as the scope of their legislation will allow."

General Technology Note (WG2 GTN TWG/WP1 Revised 2)

It is understood that Member Governments are expected to exercise controls on intangible "technology" as far as the scope of their legislation will allow.

Figure 7.4: *Statement of Understanding on intangible technology (Wassenaar Arrangement, 1996)*

Most of the arguments for taking a stronger stance on controls over intangible transfers came from the American delegation. However, other delegations were also very supportive of making such controls explicit (e.g. Bohm et al., 1999). During the New Forum negotiations, one delegation, in a proposal[4] for much stricter controls on the intangible aspects of technology related to 'production' and 'development', argued that

> a release of production or development technology could significantly undermine the New Forum's ability to control future exports of these strategic dual-use goods. In some instances, this type of

[4] This proposal was given to me on condition of anonymity.

technology transfer could provide indigenous production and development, which would be tantamount to foreign availability, and potentially cause the removal of the goods from the Basic List.

Intangible Transfers* of Software and Technology (WA-PLM (99) DE 1 Revised)[1]

Participating States recognise that it is important to have comprehensive controls on listed "software" and "technology", including controls on intangible transfers. Participating States also recognise that it is important to continue deepening WA understanding of how and how much to control those transfers. Those countries currently not having legislation to permit control should consider whatever action is necessary to address this issue.

* Transfer in this context is understood in the sense of the Initial Elements.

Figure 7.5: *Statement of Understanding on intangible technology (Wassenaar Arrangement, 1999)*

Continued persistence from several delegations led, in 1999, to the adoption of a more elaborated SOU, shown in Figure 7.5. This SOU, which sat above the earlier one, shows two things. First, that there is a need to "continue deepening WA understanding of how and how much to control" intangible transfers suggests that current understanding is not adequate to manage effective controls. Second, it shows that many Participating States do not have "legislation to permit control." It is clear, then, that several Participating States made a distinction between tangible and intangible transfers of technology.

The SOU was further elaborated in 2003, as shown in Figure 7.6. Here we see much stronger language, stating that "legislation should permit controls of listed 'software' and 'technology' irrespective of the way in which the transfer takes place." As with many definitions, the note that defines the minimum types of intangible transfers to be controlled is perhaps more illuminating in what it leaves off than in what it includes. By delimiting transfers "by electronic media, fax, or telephone," the definition explicitly does not include face-to-face interactions.

Many countries controlled (and still control) the transfer of knowledge through a verbal dialogue, different from the transfer of knowledge through

Intangible Transfers* of Software and Technology (WA-GWG (01) DE 7 Version 2.0)

Participating States recognise that it is important to have comprehensive controls on listed "software" and "technology", including controls on intangible transfers. National export control legislation should therefore permit controls on transfers of listed "software" and "technology" irrespective of the way in which the transfer takes place.** Participating States also recognise that it is important to continue the mutual exchange within the Wassenaar Arrangement on the experiences gained concerning the implementation and enforcement of these national provisions on the control of intangible transfers. New developments should thus be taken into account in order to meet all risks connected with this issue.

* "Transfers" in this context is understood in the sense of the Initial Elements. The term covers exports from one country to another.

** "irrespective of the way in which the transfer takes place" means, at a minimum:
- tangible transfers
- intangible transfers via transmission of listed software and technology by electronic media, fax or telephone.

Figure 7.6: *Statement of Understanding on intangible technology (Wassenaar Arrangement, 2003)*

textbooks or blueprints, though both represent intangible aspects of technology. Countries also had different controls for transfers to foreign nationals that occurred within the borders of a country versus across the border. For some Participating States, no export license was required for the transfer of intangible aspects of controlled technology by, for instance, verbal means to a foreign national within their borders. Such a transfer, called an 'in-country transfer' or a 'deemed export', is still causing significant contention within and between many Participating States.

The US continued to strive for stronger controls within Wassenaar on intangible aspects of technology

> because while the General Technology Note on the Dual-Use List specified that Participating States are committed to controlling technology as well as the tangible manifestations of that technology (and in certain cases the machines and materials needed, etc), it was clear that not all were doing so and there were wide discrepancies among the practices of those who were.[5]

Work on developing controls on intangible transfers continued between 2003 and 2006, resulting in a document entitled *Best Practices for Implementing*

[5]Interview with US State Department Official A, 7 February 2009.

Intangible Transfer of Technology Controls, shown in Appendix I. In the two-page document, which outlines broadly how countries can develop controls on intangible transfers, we can see a significant shift in the tone of the controls. Controlling intangible transfers is no longer just "important", but now "critical to the credibility and effectiveness of [a Participating State's] domestic export control regime." At the same time, there is an explicit statement that there are "inherent complexities of export control regulation for ITT." The Best Practices document does not try to define in any detail what constitutes an intangible transfer, or when such a transfer occurs, but instead states that Participating States "support" designing national laws and regulations which define what intangible transfers are and when they occur.

Perhaps most significantly, the Best Practice document also includes a section "recognizing that national export control authorities benefit from the co-operation of industry, academia, and individuals in the regulation of ITT." In this section, the Arrangement specifically supports "promoting self-regulation by industry and academic institutions that possess controlled technology." This is the first instance of recognition on the part of a multilateral export control regime that controlling intangible transfers cannot be wholly achieved by the government alone, and is a shift that I discuss in the analysis below.

What is it about intangible transfers of dual-use technology that make them difficult to control? Commenting on this during an interview, a member of a national delegation pointed out that

> One country raised the point that, yes, it's important, but it's also very very problematic. An intangible transfer goes to first amendment rights and everything else. It's freedom of speech. It's violating... but at the same time, you don't want sensitive information being transferred. But you know what? It's a larger issue than export controls. It doesn't live in the export control arena.[6]

Many reports point out that the advancement of communications technology, particularly the internet, has allowed for global technology development,

[6]Interview with US Commerce Department Official B, 29 January 2007.

within or across companies, and that this situation strains current export control frameworks (Fischer, 2005; Fisher, 2001; Gahlaut et al., 2004). Another critique of the current system of controls on intangible aspects of technology is that it stifles the innovation process by e.g. adding excessive delays to visa applications and maintaining controls on more than only the most militarily significant technology, especially controls on the intangible aspects of those technology (Committee on a New Government-University Partnership for Science and Security, 2007; Committee on Science, Security, and Prosperity et al., 2009; Deemed Export Advisory Committee, 2007). Knowledge flourishes through interaction, these reports argue, and the US and other Wassenaar Participating States are no longer the only leaders in developing areas of controlled technology.

While exports are supposed to be controlled regardless of the means of transfer, even the United States—the government pushing the hardest for intangible transfers controls at Wassenaar—has had a difficult time controlling tangible and intangible transfers similarly (National Academy of Sciences et al., 1987). For instance:

> [the Department of] Commerce's and [the Department of] State's export control requirements and processes provide physical checkpoints on the means and methods companies use to export-controlled goods [i.e. the tangible aspects of technology] to help them ensure such exports are made under license terms, but the agencies cannot easily apply these same requirements and processes to exports of controlled information [i.e. the intangible aspects] (GAO, 2006*a*, p. 3).

We now turn to some of the reasons instituting controls on intangible transfers has been difficult in the United States to see if it may be the case that there is an egalitarian framing emerging in the discourse on dual-use technology.

DEAC & ETRAC: US attempts to include a new framing

In the US, the major shift towards controlling intangible transfers happened as a result of a 1976 report by the Defense Science Board Task Force on Export of

U.S. Technology, known as "The Bucy Report" after the name of its Chairman. The first finding of the report was that "design and manufacturing know-how are the principal elements of strategic technology control." The Report identifies three levels of technology transfer. The least significant transfer is of the tangible aspects of a technology along with "extensive operating information, application information, or sophisticated maintenance procedures." This information is mainly related to the particular configuration of a technology, and therefore the likelihood that it could result in the transfer of production and development capabilities is limited. Mid-level transfers involve the tangible aspects of technology needed to manufacture controlled technology, along with "the necessary 'point design' information." While providing the recipient with the ability to make controlled technology, the transfer does not necessarily provide the recipient with the ability to *develop* the technology further. The most significant level of transfer is the "export of an array of design and manufacturing information plus significant teaching assistance which provides technical capability to design, optimize, and produce a broad spectrum of products in a technical field." Moreover, transfer is much more likely to be successful, the Report found, if there is "an iterative process: the receiver requests specific information, applies it, develops new findings, and then requests further information. This process is normally continued for several years, until the receiver demonstrates the desired capability." This prolonged, iterative interaction between sender and recipient is one of the key differences between intangible and tangible transfers of technology. We will return to this point in the next section.

The US formally controlled in-country intangible transfers (i.e. 'deemed exports') from 1979 through the Export Administration Act, which is enforced through the Department of Commerce's Export Administration Regulations (EAR). Deemed exports are transfers within a country between a citizen of that country and a foreign national. Many concerns about the extent of these controls[7] were alleviated in 1985 with the issuing of the National Security Deci-

[7] These concerns were expressed in the "Corson Report" on *Scientific Communication and*

sion Directive (NSDD) 189, which decontrolled 'fundamental research', defined as

> basic and applied research in science and engineering, the results of which ordinarily are published and shared broadly within the scientific community, as distinguished from proprietary research and from industrial development, design, production, and product utilization, the results of which ordinarily are restricted for proprietary or national security reasons.

Because of NSDD 189, any area of science that could be classified as 'fundamental research' was generally considered to be exempt from export controls. In 2004, however, the Office of the Inspector General of the Department of Commerce recommended expanding the control of these deemed exports by changing a single word in the definition of information for the 'use' of controlled technology within the EAR. This is the same definition of 'use' that is found in the Wassenaar Arrangement control lists. The definition comprises six components (operation, installation, maintenance, repair, overhaul, refurbishing) which are connected by an 'and' conjunction.[8] The Inspector General recommended changing this to an 'and/or' conjunction. Such a change would cause a dramatic shift in the license exceptions for 'use' of controlled technology, and an export license would be required for the in-country transfer of information (the intangible aspects of the technology) connected with any of the six components of 'use', instead of only information pertinent to *all* six components. A company or academic institution engaged in fundamental research with foreign nationals, and using export controlled equipment, would then be required to obtain an export license for every foreign national working on any piece of equipment if that foreign national's work satisfied *any* of the 'use' criterion, instead of *all* of them. The justification of such a change was simply to close a loophole in the control system:

National Security (Panel on Scientific Communication & National Security Committee on Science, Engineering, and Public Policy, 1982). The report suggested a graduated approach to controlling university research depending on how militarily significant it was.

[8] 15 CFR 772

> Other academic representatives we met with contend that in the context of fundamental research, technology relating to the 'use' of controlled equipment is also exempt under the EAR fundamental research exemption. However, according to BIS, technology relating to controlled equipment—regardless of how 'use' is defined—is subject to the deemed export provisions even if the research being conducted with that equipment is fundamental (Office of the Inspector General, 2004, p. 15).

In addition to modifying the definition, the Inspector General said that industry and academic institutions should only be notified after the modification had taken place. The Department of Commerce, however, decided to solicit comments on the recommendation[9] before it was implemented, as is common policy when the Department believes these communities might be significantly affected by the change.[10] There was significant outcry from the academic and industrial communities, with the Department receiving 310 replies (Cook, 2005),[11] mostly pointing out that "the 'or' interpretation would capture too many routine operations carried out by foreign national students and employees, and that the proposed rules would constitute a large (and, it was asserted, generally unnecessary) compliance burden on affected organizations" (Deemed Export Advisory Committee, 2007, p. 41–42).

The strongest arguments were often about the need for research to be open, both in its generation and in its communication. This was succinctly stated in a section entitled "The underlying issue: the importance of openness" in a White Paper by the Center for Strategic and International Studies' Commission on Scientific Communication and National Security, composed of, *inter alia*, Nobel Laureates, former senior civil servants (Secretary of Defense, Attorney General, heads of NASA centres, etc.), and heads of universities and research centres within industry:

[9] Federal Register: March 28, 2005 (Volume 70, Number 58), Proposed Rules, Page 15607-15609, http://www.gpoaccess.gov/fr/index.html.

[10] Email conversation with US Commerce Department Official C, 18–19 May 2009.

[11] Replies are available to view on BIS's electronic Freedom of Information webpage: http://efoia.bis.doc.gov/pubcomm/revision-to-the-deemed-export-regs-2005/final-document.pdf

> When research and education are not free to draw on the world's brightest minds, to invite any and all to critique and validate research results, and to foster the dynamic and often serendipitous interactions from which successive innovations can arise, excellence will suffer. Practices that limit the open interchange of ideas or open participation in research and educational activities—in other words, policies that compartmentalize ideas, findings, or research approaches and limit their access to certain categories of student or researcher—will limit the effectiveness of our research and educational system, impairing its ability to serve national needs (Cook, 2005, p. 1155).[12]

The proposed changes to the control of intangible transfers of dual-use technology were seen to have several adverse consequences, including: only modest security benefits; the hindrance of important discoveries; lost research talent; and a reduction of contact with cutting edge science (Cook, 2005, p. 1163–5). It is important to point out here that this is a very different argument than any that we have so far seen in this thesis. The problem of dual-use technology is here seen not as a problem of controlling access or use, nor as a problem of allowing competition between companies for the non-military applications of the technology. Rather, it is a problem of maintaining the openness of research, of preventing the division of knowledge into categories of access. This is a strong expression of an egalitarian framing of the problem of dual-use technology, with its emphasis on equality of access. In the analysis below, we will see just how different this framing of the problem of dual-use technology is from that of the control or competitive framing.

That the academic and industrial communities were even able to find out about such proposed changes before they occurred, and, more importantly, that they were able to comment on these changes means that there exists the space, if only in principle, for these framings to be heard. This fact alone represents one of the most important steps in the whole deliberation process, because it gives non-governmental viewpoints a seat at the table. However, allowing for

[12] Also published independently through the Center for Strategic and International Studies (Commission on Scientific Communication and National Security, 2005, p. 2).

these framings to be expressed does not mean that they have to be listened to, or that their views need to be incorporated into the policy system.

The Department of Commerce's Bureau of Industry & Security actually worked through these comments and decided on two courses of action. The first was not to adopt the recommendation of the Inspector General, a move that demonstrated that not only were these framings heard but they were also responded to. The second was to establish the Deemed Export Advisory Committee (DEAC) in May 2006 in order to come up with recommendations on how to improve the regulations on deemed exports (Secretary of Commerce, 2006).

This happened at the same time as a more general raising of awareness among the academic community about the role that it might play in addressing the problem of dual-use technology. For instance, a statement issued by a group of editors and authors of top academic journals acknowledged that there were possible security concerns from publishing some research openly, but there were also significant benefits:

> Fundamental is a view, shared by nearly all, that there is information that, although we cannot now capture it with lists or definitions, presents enough risk of use by terrorists that it should not be published. How and by what processes it might be identified will continue to challenge us, because—as all present acknowledged—it is also true that open publication brings benefits not only to public health but also to efforts to combat terrorism (Journal Editors and Authors Group, 2003).

Proposed solutions to this framing of the problem of dual-use technology, particularly in the area of biotechnology, have been to strengthen further the self-governance systems already in place within the scientific communities, and to supplement further them with some (but not too much) regulatory oversight (National Research Council (U.S.), 2004, 2005).

The DEAC was composed of a dozen high-ranking members of academia and industry and published its findings in a 2007 report called *The deemed* *export rule in an era of globalization* (the "DEAC Report"). The main finding (p. 14) of the Report was that

> the erection of high "walls" around large segments of the nation's science and engineering knowledge base has become not only increasingly impracticable, but that attempts to build such walls are likely to prove counterproductive—not only to America's commercial prowess but also, in balance, to America's ability to defend itself. Again, the latter is the case because (1) the lack of access to much of the world's scientific and technologic knowledge reduces America's ability to maintain a modern defense establishment, and (2) a substantially weakened domestic economy diminishes the nation's ability to devote financial resources to national security.

The Report cited nine factors (p. 11–14)—each of which are also mentioned in at least one of the other reports cited above—that have changed in the commercial and national security environments since Deemed Export regulations were established:

1. Threats were identifiable, geographic, "self-isolated nations subject to deterrence through the threat of destruction." Today, threats are geographically diverse, non-governmental, and often suicidal (thus not subject to deterrence).

2. While the US was the primary leader in science and engineering in the latter half of the 20$^{\text{th}}$ Century, today it competes with other countries in most areas. "Any nation today seeking to remain at the forefront of science and technology must be an active participant in the global science and technology community if it is to be successful."

3. If the US denies access to knowledge, it can be obtained from other sources.

4. Knowledge is no longer predominantly created in self-contained units, but often the result of "multi-dimensional, often informal networks of individuals residing around the globe."

5. Knowledge in some spheres, such as computer chip manufacturing, is extremely perishable, having a useful life of often less than a year.

6. "Today's United States research enterprise would barely function without the foreign-born individuals, including foreign nationals, who contribute to it."

7. Instead of precluding the sales of a few technologies by a few companies to a few nations, controls now function more as a deterrent to foreign nationals engaging in partnerships with the US, thus assigning the US "to the fringes of the world's creative enterprise—with adverse consequences for both the nation's economy *and* national security" (emphasis original).

8. While leading-edge technology was often of military origin, it is now developed largely within academia and businesses.

9. Information cannot be nearly as easily controlled today because political borders are extremely porous, for both the movement of people and ideas.

As a result of this changed environment, the DEAC Report suggested replacing the current deemed export approval process with a new one that was more simplified and would "both enhance national/homeland security and strengthen America's economic competitiveness" (p. 24).

Heartened by the government's request for industry and academic input on the problem of intangible transfers of technology, these groups petitioned the government to set up a more permanent body to incorporate their input into this area of export control policy development. The government responded by creating the Emerging Technology and Research Advisory Committee (ETRAC), which had its first meeting on 23 September 2008.[13] The primary duties of the ETRAC are to consult with the Department of Commerce regarding questions on "(a) the identification of emerging technologies

[13] Minutes of the meeting can be found on the BIS site: http://tac.bis.doc.gov/

and research and development activities that may be of interest from a dual-use perspective; (b) the prioritization of new and existing controls to determine which are of greatest consequence to national security; (c) the potential impact of dual-use export control requirements on research activities; and (d) the threat to national security posed by the unauthorized exports of technologies" (US Department of Commerce, 2008).

With the advent of this body, there is a presence of an egalitarian framing of the problem of dual-use technology within the discourse. While there is clearly a desire for ETRAC to take on the rhetoric of a hierarchical rather than egalitarian framing, as shown by the desire to look at emerging technology "from a dual-use perspective" and a focus on prioritising controls, there is also room for a more egalitarian framing. In particular, by giving voice to the potential impact of export controls on research activities, ETRAC members can expound the benefits of allowing open access to the knowledge that underpins technological development.

Having provided an overview of the development of controls on the intangible aspects and intangible transfers of dual-use technology, we can now turn to analysing the impact of these developments on the overall wicked problem of dual-use technology and the viability of the institutions that claim to address it.

7.2 Dual-use technology: a shifting discourse

What does the development of controls on intangible technology transfers mean for the overall development of the international export control system? In this section, I break this question into several smaller questions, each of which is more generalised than the previous one. Why were controls on intangible technology transfers sought? Why were they difficult to develop? Why has the current export control system provided a space for a framing of the problem of dual-use technology that undermines its current institutional structure? How might the discourse on dual-use technology be further improved within the US? Is it likely that there will need to be a similar shift in the international development of the discourse on dual-use technology? Each subsection deals with a specific question.

We begin by looking at the question of why controls on intangible technology transfers were sought. When the issues of intangible transfers of technology came up at the Wassenaar Arrangement, it was clear that many states had interpreted the control lists to mean that only tangible transfers (of either tangible or intangible aspects) of technology were subject to export control. For those people who wanted to strengthen the framing of the problem of dual-use technology as one of control, this was a source of uncomfortable knowledge. Not only were intangible transfers not controlled, if knowledge of how to develop, produce, and use controlled technology was exported, controlling the tangible aspects of the technology would become pointless. This was stated succinctly by one of the government officials I interviewed: "fundamentally, if you control the transfer of a fish to someone, failing to control teaching him to fish is a fundamental failure."[14]

Lack of controls on intangible transfers very much undermined all of the other efforts of control. This point came to the fore after the rise of the internet and the concurrent Wassenaar debate on encryption controls in the late 1990s (Muldonian, 2005).[15] All officials I interviewed about intangible transfers recognised that implementation of controls was very difficult—for political, cultural, and institutional reasons as well as technical—but that such controls were central to an effective export control system. Some of those interviewed stated that a government can employ the same mechanisms for controlling intangible transfers as it can for controlling tangible transfers. A US Commerce Department official made this point clearly in an interview:

[14]US State Department Official A, 7 February 2009.
[15]See also The Monitor, Vol. 6 No. 3.

> I remember one of the first [Wassenaar Arrangement Licensing and Enforcement Officers Meeting] presentations, everyone was saying, "Well, we have stuff that goes in the air, it's gone! How can you enforce that?" It's basic. The same old way you do it for other things. Hard work and informants.[16]

These mechanisms have seemed to help with the technical aspects of control. Another US Official pointed out that companies often already have control systems in place to monitor the transfer of trade secrets, and this can be naturally extended to include export controlled technology as well.[17] There is also the argument put forward by several researchers (McLeish & Nightingale, 2007; Reppy, 1999) that the transfer of the skills, or 'tacit knowledge', of how to employ controlled technology is often a prolonged effort, which means that it may be easier to detect.

But is it all just business as usual in extending controls to cover intangible transfers of technology? We already saw some of the new issues that the US has addressed with the development of the DEAC and ETRAC. There appears to be a new balance that must be struck between the old framings of the problem of dual-use technology as one of control or competition (security or economy) and the new framing of the problem as one of maintaining open access to research. We turn now to an exposition of how the assumptions that underlie the problem of open access are counterpoised with the assumptions that underlie the other problem framings. In doing so, we can see whether the inclusion of this new framing is likely to unsettle the institutionalisation of the control and competition framings.

A difference of assumptions

Earlier in this thesis (Section 4.1) I outlined three framings of the problem of dual-use technology that the theory of sociocultural viability suggests may be present in any debate about the issue. Throughout this thesis, we have

[16] Interview with US Commerce Department Official B, 29 January 2007.
[17] Interview with US State Department Official A, January 19, 2007.

seen a continual interplay between two of these framings. One of them, the hierarchical framing, sees the problem as one of controlling the access to and use of dual-use technology, and therefore rests on the assumption that it is possible to define and enforce an adequate level of control. The other, competitive, framing sees the problem as the marketability of technology. Being labelled as 'dual-use' makes technology more difficult to export, and therefore more difficult for companies to compete in a global market.

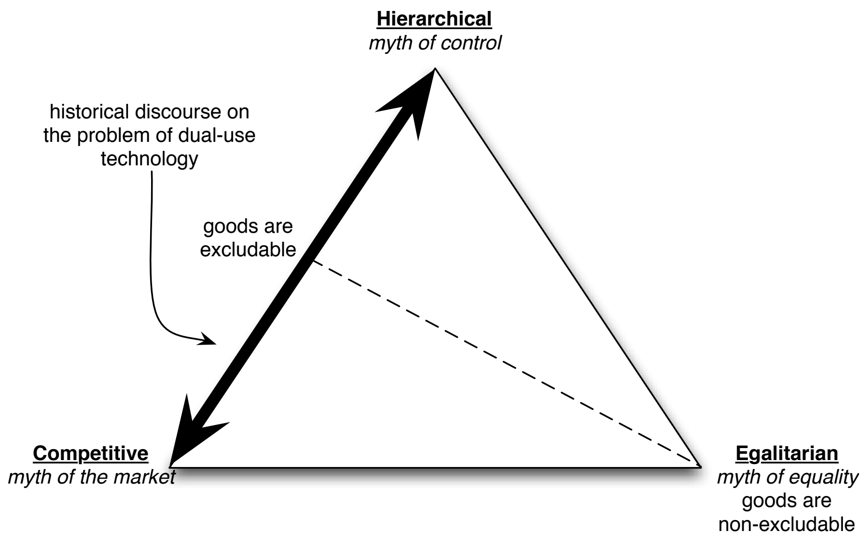

Figure 7.7: *Historical discourse of dual-use technology*

Both of these framings share a common assumption that has largely gone unacknowledged within the discourse on dual-use technology: they both assume that technology is an *excludable good*. In Figure 7.7, I have overlaid this point on the 2-dimensional map of social solidarity underlying human values preferences (Figure 2.4, page 65). Economists traditionally distinguish between excludable goods, the distribution of which is controllable, and non-excludable goods, which are freely available. A shop keeper generally thinks that the things he sells are excludable, i.e. they will be his until he sells them, at which point they become the buyer's. He owns the good and the buyer does not, until a transaction is made, usually involving money. Thus, excludability is the basis of the concept of property, of ownership. Non-excludable goods, in contrast, are generally considered to be things like air or language or public roads. Controlling access to such things is not thought to be possible and/or desired.

Both the hierarchical and competitive framings benefit from goods being excludable. From within the hierarchical framing, being able to govern the distribution of goods allows for that distribution to be "allocated in accordance with an administrative determination of rank, contribution or need" (Rayner, 1999). This is called the principle of proportionality, which is one of the ways to provide a fair allocation of resources outlined by Young (1994) and adapted for the theory of sociocultural viability by Thompson & Rayner (1998). In the case of export controls, the access to a dual-use technology that a foreign national can expect is proportional to the relationship between that person/organisation/country and the exporting country.

This is contrasted with the competitive framing, in which the excludability of goods allows them to be distributed based on the principle of priority, where the first in line is the first to be served. The excludability of a good is the basis of a market economy. If a company has control over a particular technology, say because they have some kind of intellectual property claim, they control the market for it.

But it is also possible for us to view technology as a non-excludable good. The guiding principle behind this view is that there should be an equal distribution of, or at least access to, the good for all. The good, in other words, should be free. We are all free to use public roads, for instance, or public libraries. This equality is a mark of the egalitarian framing, which views the problem of dual-use technology in a much more holistic way than either the hierarchical or competitive framings do. The problem is not one of control or ensuring a competitive environment, but rather one of the need for a more fundamental change in the way goods are valued in society. Both the hierarchical and competitive framings only value excludable goods, and therefore all goods of value—in order to have a place within the classification system of these framings—must be seen to be excludable. But there are some very important goods, according to the egalitarian framing, that are not excludable and derive their value from being so. Some, like air, water, or food, are not generally seen as 'technologies',[18] but others, such as encryption algorithms on the internet, and even the internet itself, are very much human constructions. Seeing something as a technology, actors expressing this framing argue, does not mean that it is *de facto* excludable. We can see this framing appearing in the dual-use discourse through the argument from academic establishments that basic scientific knowledge is a non-excludable good that should be freely available to anyone and not placed under export controls.

The theory of sociocultural viability asserts that people who take up the rhetoric of the egalitarian framing will also seek to institutionalise a form of organisation that is tightly bounded but loosely structured (and likewise, people who find themselves in such an institutional structure are likely to adopt an egalitarian rhetorical style). The academic community, as it has so far been constructed within the dual-use discourse, has been doing just this.

The community of academics is a community of equals, this argument goes, who share a common plight—the infringement of export controls on their ability to produce (and have access to) the knowledge and tools needed to advance the state of the art in their field. The open access of research holds an almost sacred position within the academic community, and anything which threatens it is seen to threaten the community as a whole. While this argument is pervasive in arguing for the value of government funding for science and prevent government control of science, there have been strong critiques of viewing science as a public good. Callon (1994), for instance, argues that it takes a great deal of effort for scientific research to be mobilised such that it is open

[18] Whether air, water, or food are either excludable or technologies is a moot point in this case. Much of the air in office buildings is recycled, and only by passing through a series of devices is it deemed to be of an acceptable quality to be re-circulated. The oxygen in the air on submarines is actually generated from the surrounding sea-water. What constitutes an acceptable level of cleanliness for air, water, or food (e.g. organic, non-genetically modified) is a matter of culture and preference. See Douglas et al. (1998).

to all. Moreover, there is significant value to privatising science, e.g. through patenting. The point here, though, is that arguments were presented in favour of viewing basic scientific research as a non-excludable good within the context of export controls. There is another discourse, on intellectual property, that shares remarkable similarities with the discourse on dual-use technology.

The relationship between intangible technology transfers and TRIPS

The Wassenaar Arrangement is not the only international arrangement trying to control the international distribution of intangible aspects of technology. The other major player in this field is the World Trade Organization's (WTO) Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS). Unlike the rest of the WTO, which focuses on liberalising trade among its members, TRIPS is focused on "establishing rules for the appropriation of intellectual assets and the control over the production and trade of the products derived therefrom" (Correa, 2007, preface). Defining intellectual property, like defining dual-use technology, is not a process of creating new knowledge as it is a process of recognising "conflicting rights and attempting to find a just solution in light of the values and interests at stake" (Hilgartner, 2002, p. 945).

TRIPS, like the Wassenaar Arrangement, is based on the idea that goods are excludable and that rights can be conferred on those who have the goods such that others may not have them except through a legitimate transaction. While the effects of intellectual property rights on basic scientific research are still not clear (Murray & Stern, 2007; Walsh et al., 2003), there are certainly calls for the need to understand that intellectual property is not the only way to provide a strong market, just as export controls are not the only way to prevent the malicious use of technology. Speaking specifically on the topic of intellectual property, James Boyle (2008, p. xv) argues "we need a movement. . . to preserve the public domain."

Both TRIPS and Wassenaar assume that the goods to be controlled, either to aid the market or to aid security, are excludable. TRIPS has already received significant attention for this view, and analysing the similarities between TRIPS and Wassenaar is likely to be a very fruitful line of future research.

While the egalitarian framing may be dominant within the academic community involved in the dual-use discourse, this community, like all others, is likely to be a mix of the different framings. The academic community also needs to adopt at least some aspects of a hierarchical rhetoric to be able to engage in the current dual-use discourse, as the hierarchical framing is hegemonic. We can see these points within the US, where there is recognition within the academic community that a balance is necessary between security and openness (Journal Editors and Authors Group, 2003).

Having to contend with the argument that the technologies that governments and companies are trying to control should in fact be non-excludable public goods undermines not only the hierarchical and competitive framings of the problem of dual-use technology, but also the balance that has been achieved between those two framings. This is a significant reason why it has been so difficult for these framings to develop controls on intangible technology transfers. There has been no space in the discourse to date to question whether or not the goods should be controlled at all, only whether they should be controlled for economic or security reasons.

To the degree to which the egalitarian framing is able to guide the discourse on dual-use technology, the debate will switch from being about an adequate level of control to one about carving out entire areas of technology that are not to be controlled at all. But why would an export control system that has existed for many decades want to include such a disruptive framing?

Why allow a space for other framings?

One reason why a discourse between two framings might specifically make space for a framing that could undermine them both is suggested by Christopher Hood and Henry Rothstein, who have explored this facet of public organisations through their work on blame and accountability (Hood, 2002, 2007; Hood &

Rothstein, 2001; Hood et al., 2001). Hood & Rothstein look at risk regulation regimes (RRRs) that are under pressure to have increased openness, where increased openness consists of three elements: "(a) greater transparency in organizational procedure; (b) wider participation in some or all elements of an RRR; and (c) heightened accountability in the sense of increased obligations on the part of those responsible for regulating and managing risks to explain and justify their behavior to others" (Hood & Rothstein, 2001, p. 22). We can see at least the last two of these elements in the intangible transfers issue within the US export control system. Calls for wider participation in making decisions on the scope and structure of export controls were the reasons the DEAC was set up. Moreover, Wassenaar has in the past felt the need to explain and justify the control system in place through its two outreach seminars in 2003 and 2004. Calls for greater transparency in organisational procedures have been made informally by companies and academics either effected by or studying the export control system, but there has also been a general drive in the US, Britain, and Wassenaar to make their operating procedures more transparent.

The drive for increased openness often involves accusation of blame for why the RRR is not as open as it should be. One option for responding to these accusations is simply to ignore them, but openness and transparency in regulation systems is generally thought to increase the legitimacy of the system (Bentham et al., 1931, 1983; Brin, 1998). Hood & Rothstein suggest that institutional responses to calls for increased openness take on various 'blame prevention re-engineering' strategies, which seek "to transfer or dissipate the increased blame or liability that increased transparency or new information requirements might bring" (p. 40). If one believes that the institution is motivated to act through the avoidance of blame, the initial strategy that was employed was a 'protocolization' of accepting input from the public, i.e. the original notice for comments on the Inspector General's report in the Federal Register. When that resulted in an extensive set of comments, the government shifted strategies and initiated an 'organisational reorientation' by appointing the DEAC, thereby placing some of the responsibility for coming up with a workable solution on the shoulders of the academic and business communities. This shared responsibility was further institutionalised with the creation of the ETRAC. It should be noted, however, that neither the DEAC nor the ETRAC have authority to make any decisions for the government. If the government were not to accept the recommendation of these bodies, it would be held solely to blame.

Another reason to allow space for other framings is to allow for what Sunstein (1996) calls 'moral evolution over time'. He argues that completely theorised agreements are "unable to accommodate changes in facts or values" (p. 41). While he did not go into great detail about what this means, I suggest that complete theorisation means an agreement contains a coherent and rigid set of facts and values, and is temporally locked. Any future decision, regardless of a change in circumstances, must adhere to the prior agreement. Incomplete theorisation, on the other hand, serves to *temporally unlock* the agreement, focusing on it not as an event, a list, a document, but as a process. This serves the Wassenaar Arrangement very well when trying to develop consensus on control over something that none of the Participating states has an effective way of controlling, such as intangible transfers of technology. At the moment, for example, there is agreement to treat tangible transfers and intangible transfers similarly. As more discussions take place within Wassenaar and more attempts are made within Participating States to develop control mechanisms, that agreement may shift. That said, however, the Wassenaar Arrangement, like an incompletely theorised agreement, is "well-adapted to a system that should or must take precedents as fixed points" (p. 42). That the Participating States agreed to decontrol computers, for instance, does not necessarily mean that they must also decontrol other things.

Creating a clumsy solution space for dual-use technology

Regardless of the reasons for reaching agreement on intangible technology transfers, the current state of the development in this area is one that has at least begun to co-opt the other framings into the discourse. In doing so, it displays some key characteristics of a type of settlement (6, 2007), called a 'clumsy solution', between the different framings.

Characteristics of a clumsy solution

A 'clumsy solution' is a term used within the theory of sociocultural viability to describe a solution where each of the active framings is heard and responded to by all the others (Verweij et al., 2006*a*). This does not mean that actors have made compromises. Clumsy solutions have two key features. The first is that the policy system must be accessible to each of the framings that cultural theory articulates. The more framings that are included in the generation of a solution to a problem, the more likely that solution will be able to adjust to the inevitable changes in the future environment in which it will sit. This is because each of the framings provides a compelling and coherent, but incomplete, picture of the issue and what should be done about it. There needs to be space for contradictory value systems and forms of organisation to come up against one another. Following Ney (2006, p. 326), we can divide the accessibility into three levels based on the number of framings that are represented in the discourse: monocentric, bi-polar, and triangular.

Throughout this thesis I have documented the long-standing bi-polar interplay between the hierarchical framing, driving for developing adequate levels of control for dual-use technology, and the competitive framing, driving for the development of a vibrant market for the non-military uses of dual-use technology. With the efforts of the United States in the last decade to solicit the opinion of the academic community on the topic of intangible technology transfers, we can see at least initial attempts to include the egalitarian framing within a now triangular discourse on dual-use technology.

The second key feature of clumsy solutions is that they depend on high quality deliberation between each of the actors. When the quality of deliberation is low, it is likely that positions will become or remain polarised, creating a deadlock where no agreement is possible. Clumsy solutions must emerge from the deliberative process; they cannot be formulated ahead of time in their complete form. But how likely is a clumsy solution to emerge within the discourse on dual-use technology?

When a clumsy solution is likely to emerge

Lach, Ingram & Rayner (2006, p. 236–238) suggest there are at least four conditions that are conducive to a clumsy solution emerging from a deliberative process, each of which I explore below.

The first is that there are accumulating problems; a situation I liken to the abundance of uncomfortable knowledge for each of the framings. Each actor recognises that the current or proposed future environment will likely further undermine its framing of the problem. This is certainly the case with the intangible transfer of technology issue. Uncomfortable knowledge for the hierarchical framing began when anomalies in the classification system—restructured at the end of World War II—concerning the intangible aspects of technology had to be continually resolved into the classification system through equating it with the tangible aspects of technology. This was (and still is) a continual practice of conferring sameness (Douglas, 1986) that institutionalises the place of intangible aspects of technology within the overall system. The anomaly has resurfaced many times, and has needed frequent re-resolution, either by stipulating that intangible transfers are controlled in the preamble to the list, by creating an entire section of every Category dedicated to intangible aspects of technology, or by generating documents stating the importance of the control of intangible aspects of technology.

These re-resolutions, however, have been achieved by reiterating the original assumption of sameness between the tangible and intangible aspects of technology. One could say that at each iteration the export control system has come closer actually to controlling the technology. This may be true, but as the DEAC Report pointed out, *by controlling the transfer of intangible aspects of dual-use technology, export controls may actually undermine the security that they are supposed to be strengthening.*

This is a significant piece of uncomfortable knowledge for the hierarchical framing, which has dominated the construction of the current institutional framework for export controls. Moreover, exception-barring does not seem like a viable strategy here, as it has been clearly stated on many occasions that "you can release the equipment, but if you release the technology, then there's really no need to control anything anymore, because it's gone. It's gone forever."[19] The control of the intangible aspects of technology, particularly those aspects needed for the design and production of the tangible aspects, is a fundamental aspect of the entire export control system. Undermining the ability to control the intangible aspects is tantamount to undermining the entire system, both from the view of the hierarchical framing and from the view of the others.

The hierarchical framing is not the only one with uncomfortable knowledge, however. The competitive framing and egalitarian framing both have much to lose if the hierarchical framing decides to resolve the anomaly by including elements of basic research in the definition of intangible aspects of controlled technology. The competitive framing would lose the ability to compete on the global market, and the egalitarian framing would lose the ability to benefit from collaborations with other researchers in the global scientific community.

The second condition is that each of the actors has more to lose by inaction than they do by acting. I believe I have made the plight of the hierarchical framing clear above. If those espousing it do not act on controlling intangible

[19] Interview with Former British Government Official, 8 November 2007.

transfers, the very foundations of the export control system may be undermined. Similarly, the competitive and egalitarian framings would be much worse off if actors espousing the hierarchical framing decided to control intangible transfers in an overly restrictive fashion.

Precedence is a very strong tool in creating clumsy solutions, and an actor's prior experience in creating clumsy solutions in other policy areas makes it more likely that one will emerge on the topic of dual-use technology. While there is some history in the US of collaborations on export control policy framing between the hierarchical (government) and competitive (industry) framings, such as the Department of Commerce's Technical Advisory Committees, there is little experience in including the egalitarian (academic) framing. Such experience, while not necessary for the emergence of a clumsy solution, certainly can aid the development of a reflexive deliberation space, keeping actors from polarising into their preferred framings rather than developing common understandings. This is where the concept of an 'incompletely theorised agreement' is useful. By generating shared consensus on particular outcomes, even without breaching the topic of conflicting general principles, mutual trust is built up between the framings that can then be capitalised upon when general principles do come into debate.

The factor most likely to prevent a clumsy solution from emerging on the topic of dual-use technology is the lack of a willingness of leadership to act:

> The kind of leadership needed to craft clumsy solutions is different from that usually found in bureaucracies. What characterizes 'clumsy' leaders is not their roles, positions or access to resources, but their willingness to take risks that appear to challenge alternative perspectives. The motivations for risk-taking are hard to generalize, as they arise out of particular contexts... In face-to-face encounters they hear other values articulated and realize that their own answers are not satisfactory to their collaborators (Lach et al., 2006, p. 238).

It is not clear whether or not such leadership exists within the US or at the Wassenaar Arrangement at the moment. However, the keenness of the Department of Commerce to create a substantive input body for emerging technology and research, and the Outreach Seminars at Wassenaar in 2003-2004, suggest that there may be someone working there to draw together genuinely the incommensurable value sets that characterise the difference framings.

Shifting the discourse

A clumsy solution to the wicked problem of dual-use technology depends on high quality deliberation among the different framings of the wicked problem. Ney (2006, p. 323–324 & Appendix F) divides deliberation quality into three types of increasing merit: assertive, strategic, and reflexive. Assertive deliberations are ones where there is little sensitivity to finding areas of mutual agreement between framings. Instead, focus is placed on emphasising the areas of intractable disagreement. Strategic deliberations are where the people or organisations representing each framing constructively interact to find areas of mutual agreement while not addressing each framing's value system. This is similar to Sunstein's (1996) notion of an incompletely theorised agreement where general principles are set aside and the focus is on finding agreement on particular outcomes, or mid-level policies. Each actor may pursue the policy objective for a particular framing while agreeing with the other actors on common means to reach those different objectives. Reflexive deliberation occurs when each actor is cognisant of its own preferred framing and the debate is about both the means to achieve a particular objective and a balance between the different objectives as well.

CoCom and the Wassenaar Arrangement have vacillated between assertive, strategic, and reflexive deliberative styles in a *bi-polar* discursive space. With the possible exception of the debate on encryption controls in the late 1990s, neither organisation has ever come across an actor that espoused an egalitarian framing. At times, the hegemonic hierarchical framing would assert its dominance in controlling both the acceptable goals to be reached and the means to reach them. In such assertive deliberations, no room is made for alternative goals (it is all about control, not creating markets for technology). Most of the time, however, decisions on maintaining the Dual-Use List have been made through a discussion on the means of control rather than by asking if control is a thing to be desired. As such, this allows for both the hierarchical and competitive framings to be engaged in a technical exercise while avoiding difficult normative questions. There have been some rare examples of reflexive deliberation; the two most striking are the Core List review and the discussions in the New Forum before Wassenaar began. In both of these cases, there were admissions that controlling the export of dual-use technology and creating markets for non-military use were policy objectives that needed to be balanced.

With the emergence of an egalitarian framing within the academic community and its institutionalisation in the US through the DEAC and ETRAC, I propose that there needs to be an institutionalised ability for the discourse on dual-use technology to occur on both the strategic and reflexive levels of deliberative quality within a *triangular* rather than bi-polar discursive space.

In much of the work needed to maintain a list of dual-use technology, there does not necessarily need to be explicit deliberation on the divergent goals that the actors involved are likely to have. Some will be there because they are seeking an adequate level of control, some to try to develop market incentives for non-military use of technology, and some to advocate for the non-excludability of certain types of technology. Neither these different reasons for being there, nor the difference in underlying preferences they represent, should prevent them from agreeing on particular outcomes for many of the definitions of technology on the Dual-Use List. The Wassenaar Arrangement, and the internal national processes used to generate list-modifications, should therefore continue to strengthen this 'incompletely theorised agreement' between different actors who hold different framings of the problem of dual-use technology. While this means creating a space for input from an egalitarian framing, it can be done in much the same way as space was created for the competitive framing, because technical expertise, rather than policy goals, are the focus in these deliberations.

As we have seen many times, it is often difficult for experts to find a common ground on which to agree on an adequate definition of a dual-use technology. What often happens is that deliberations break down because the divergent goals that different actors are trying to achieve dictate different values for the same parameter. Sometimes, such as in the case of computers, the discourse moves from one parameter to another, from processors to memory to interconnects to software. This hopping between parameters is likely to become exponentially more difficult as a third framing becomes more involved in debate, particularly because actors espousing the egalitarian framing are likely to argue for the importance of seeing technology as a non-excludable good, and therefore no parameter would be an adequate one for control.

Where strategic deliberation is not possible, *there needs to be an institutionalised ability to deliberate reflexively on the balance between the policy goals of each actor*. This has happened in an ad hoc fashion in the past when two framings were present, but nevertheless resulted in drastic changes to the system of control. With three framings present, conflict between them is likely to become endemic as each can undermine assumptions that the other two make, thereby making space where all three can agree much more constrained than the space where only two of them agree. When only two framings were present, getting into the solution space was easy and much of the deliberative effort could be spent on settling the particular outcome rather than on the balance of general principles. When three framings are present, however, the solution space is so small that much of the deliberative effort will be spent getting into that space. This means that it is likely the Wassenaar Arrangement (and national efforts at modifying the Dual-Use List) will in the future spend more time trying to balance different policy goals before they are able to deliberate specific outcomes.

In order to effectively deliberate a balance of policy goals, the dual-use discourse as a whole must be able to pursue each of those goals, be they developing adequate levels of control (hierarchical), market incentives for non-military uses of technology (competitive), or creating barriers around areas of technology deemed to be non-excludable (egalitarian). This will likely mean that the hierarchical framing will need to relinquish some of its hegemonic status within the discourse, which correlates with export controls being seen on a more equal footing with market incentives and the preservation of open access to basic scientific research. Rather than destroying the export control system, this shift will actually make it more likely that the system will survive at all. Were the hierarchical framing to try to maintain its hegemonic status in a triangular policy space (a complex wicked problem), it would necessarily resort to an assertive deliberative style, becoming uncompromising in its views and, in time, losing its legitimacy from the perspective of the other framings. With loss of legitimacy comes loss of participation, and without participation by actors taking up egalitarian or competitive framings—which are the actors who own or create nearly all dual-use technology—control is no longer possible. The export control system would therefore collapse.

Recognition that there is a triangular policy space, that the problem to be addressed is a complex wicked problem, is the first step towards the creation of a clumsy solution space. It is a step that at least one country, the United States, has taken, and the sooner that other countries and the Wassenaar Arrangement do the same, the more likely that the export control system as a whole will survive and continue to fulfil its vital role of helping to prevent the malicious use to technology.

7.3 Conclusion

The problem of dual-use technology does show signs of shifting from a simple to a complex wicked problem. In this chapter, we have explored this shift through an analysis of the development of controls on intangible technology transfers, both within the Wassenaar Arrangement and within the United States.

For centuries, the apparatus of export controls has turned on the point of a list. In addition to the lists, the basis of export controls rests on controlling the transfer of the items on the lists. The most important aspects of the items to control are the intangible aspects—the information and knowledge—related to the development, production, and use of the items.

Export controls have always focused on technologies with tangible aspects, but increasingly they have been concerned with both the tangible and intangible aspects of those technologies. I provided a history of the development of controls on both the tangible and intangible transfers of the intangible aspects of technology. I showed how, over the course of the history of export controls, there have been two significant shifts in the types of things that were put on the control lists: the first being a shift away from 'unmanufactured' items; and the second a shift towards intangible aspects of technology.

Including intangible aspects of technology on the control lists was seen as necessary because the intangible aspects, namely the knowledge and skills needed to produce the technology, were (and still are) seen as most vital to the viability of the export control system as a whole. There are several problems that CoCom and the Wassenaar Arrangement came across when trying to define the intangible aspects of technology on the Dual-Use List. One of these problems was that any text that they put down would itself be an export of the technology, as the lists are publicly available. Another problem was that, in order to define the intangible aspects of technology, they need to be treated as discrete entities.

Controlling the intangible transfers of the intangible aspects of technology was more effort to develop, because several Participating States argued that their internal legislation does not distinguish between in-country transfers and freedom of speech. Controls developed gradually, from a short Statement of

Understanding to longer ones, and finally to a Best Practices document on implementing intangible transfer of technology controls.

I provided a case study on the development of intangible technology transfer controls within the US to show one way countries may be able to address the development of a third framing of the problem of dual-use technology. The US ran into difficulty in creating and strengthening its in-country transfer controls, called 'deemed exports', because members of the academic and industrial research communities believed the controls would significantly affect their capacity to advance research in their fields. This led to the development of the Deemed Export Advisory Committee and, following on from that, the Emerging Technology and Research Advisory Committee.

The problem is still very much present, however, and I argued that one reason for this is the emergence of a new framing of the problem of dual-use technology; an egalitarian framing that sees the problem as one of ensuring that export controls are aware that there are types of technology that are not controllable because they are non-excludable goods, i.e. the control of them is neither desirable nor possible. The egalitarian framing has been adopted by the academic community, and was likely allowed into the debate through a blame avoidance strategy of the hegemonic hierarchical framing.

Regardless of how the egalitarian framing got into the discourse on dual-use technology, that it is there suggests that the problem has shifted from being a simple to a complex wicked problem. As such it is now possible for the US, as well as the Wassenaar Arrangement, to develop a 'clumsy solution space' within which the different framings of the problem can agree on particular outcomes, be they list modifications, the development of market incentives, or the recognition of certain types of technology as being non-excludable goods.

Clumsy solutions are emergent phenomena wherein all of the framings that the theory of sociocultural viability stipulates should be present are present and responded to by the others. This requires high quality deliberation among different actors, both at the strategic level, where agreements are incompletely theorised agreements on particular outcomes, and at the reflexive level, where the deliberation is about the balance of the different policy goals of each of the framings rather than a particular outcome.

The DEAC Report discussed above points out that "resolving the problems associated within the Deemed Export regime will have only limited impact absent an effort to address the shortcomings of the overall export regulatory system in today's technical and geopolitical environment" (p. 24). Similarly, speaking about the difficulties of deemed exports, one US official said, "It's a larger issue than export controls. It doesn't live in the export control arena."[20] The environment in which export controls sit has changed, but the control system itself has not been modified sufficiently, according to those who actually want the controls. These arguments, save a few, are not for the entire disbandment of export controls on the intangible aspects of technology, but rather for a reshaping of the institutional structure for a changed environment.

Creating a triangular discursive space that is able to address the complex wicked problem of dual-use technology through strategic and reflexive deliberation will likely require significant shifts in the current export control system. The US has already begun some of these shifts, and other countries as well as the Wassenaar Arrangement should seriously consider the need to make this shift as well. However, I should note, along with a recent National Research Council Report, that "[a]n important caveat attaches to any discussion of changes in the current system of export controls: there is no 'risk free' solution. Today's system is not risk-free either; in fact, it is arguably becoming more and more dangerous because the inclination to equate control with safety gives a false sense of security" (Committee on Science, Security, and Prosperity et al., 2009, p. 4). I am not suggesting that this shift in the export control system will make the problem of dual-use technology any easier to deal with. I am suggesting, however, that such a shift will make the continuance of the export control system more likely.

[20]Interview with US Commerce Department Official B, 29 January 2007.

8

Conclusions

Throughout this thesis, I have asked three primary questions:

- How are dual-use technologies defined?
- What is the Wassenaar Arrangement trying to do?
- How is the Wassenaar Arrangement trying to achieve its goals?

A brief answer to the first question is that the definitions of dual-use technologies that are inscribed on the Wassenaar Arrangement Dual-Use List emerge from a discourse among different framings of the problem of dual-use technology. The hierarchical framing has been hegemonic throughout the lifetime of both CoCom and Wassenaar, but for the entire history of export controls, competitive framings of the problem have always been part of the discourse as well. The problem of dual-use technology, therefore, has always been a wicked problem. To answer the second question, I have argued that the Arrangement, in framing the problem as one of control, has sought to maintain a classification system for dual-use technology. This process—indeed, it is a process and not a one-off occurrence—involves continually resolving anomalies. While some of the anomalies occur as a normal part of making a well-defined list, others have been shaped by alternative framings and have the propensity to undermine the hierarchical framing's preferred form of organisation. In response to the third question, I have argued that the Wassenaar Arrangement has maintained a discourse between hierarchical and competitive framings by remaining an incompletely theorised agreement, where emphasis has been placed on reaching agreements on particular outcomes rather than general principles. With calls to strengthen controls on intangible technology transfers, the Arrangement is likely to see the rise of a third, egalitarian, framing of the problem of dual-use technology like that already taking place within the United States. By incorporating this third framing, the Arrangement will acknowledge that the wicked problem is actually a complex wicked problem that does not sit solely within the field of export controls. In so doing, it can also create a clumsy solution space where each of the framings has a voice and is responded to by the others. In this concluding chapter, I review each of these arguments in detail.

Multiple framings of the wicked problem of dual-use technology

To answer the first question, I drew upon more general arguments within the field of Science & Technology Studies (STS) to show how dual-use technology is defined through its enactment in various communities of practice. The final text on the Wassenaar Arrangement Dual-Use List for something like a focal plane array is the outcome of a long series of negotiations between alternative framings of the technology. The text is the result of the political, economic, and social contexts in which it was created as much as the technical contexts.

We saw this first with the history of the term 'dual-use'. There are multiple ways that the term is understood, and these relate to which technologies get defined as dual-use. The term is employed differently by academics and by practitioners. It has different connotations in WMD contexts from those it has in conventional contexts. It can be understood either in terms of 'spin-off', if the military is seen as having technology with non-military uses, or 'spin-on' if the opposite is thought to be the case. Within export controls, the term has a historical grounding in the term 'contraband', which was used to describe controlled items in trade as early as the 16^{th} Century. Different perceptions of dual-use technologies see them as only being of concern when they are in certain contexts, or used by certain users... though some also contend that dual-use is an inherent characteristic of technology. The Wassenaar Arrangement has no official definition of the term 'dual-use' and I argue that this is to its advantage, because it allows significant degrees of interpretative flexibility in enacting the term. This interpretive flexibility is necessary when trying to create a text that is acceptable to a wide variety of communities of practice, from industries to militaries to political bodies.

To speak of 'a' dual-use technology, is to become embedded in a set of social and technical relations. Thus there is the corporate engineer who sees a focal plane array as a tool to measure pedestrian traffic in a supermarket versus the military engineer who sees a focal plane array as a critical component in night vision systems versus the company executive who sees a focal plane array as a closed path of development because of export restrictions. Each of these actors, however, is enacting different characteristics within an ever-changing definition a focal plane array. While a single artefact may take on the form of an immutable mobile, most of the time discussions over the tangible aspects of technology do not have the artefact present, and rightly so, if the goal is to be able to cover a range of artefacts when companies apply for export licenses. There is no objective technology which people within the Wassenaar Arrangement can look at and say "Yes, that's dual-use." That is not to say that there are never occurrences of someone bringing an artefact into a meeting and demonstrating its military significance. Rather, the point I made was that the definition on the Dual-Use List will cover many more artefacts than just the one shown in the meeting, and the goal of the Arrangement is to constrain the ambiguity of the definition enough to satisfy those who wish to control the technology while leaving it open enough for those who do not wish for control.

When controlling technology transfers, it is useful to divide the technology into two parts, the items that are transferred, and the definitions of those items on the Dual-Use List. The items that are transferred can be thought of as "relatively robust pockets of interpretation in a sea of interpretively flexible texts" (Woolgar, 1991, p. 39). In enforcing export controls, licensing and enforcement officers must make a determination as to whether the items transferred should or should not be classified as dual-use technology. The question asked in this environment is, "Is this item an example of a dual-use technology?" In order to ask this question, however, there must be a definition of dual-use technology to which the item can be compared. Such a definition comes about by asking a very different question: "How can we resolve/maintain the ambiguities around the definition of dual-use technology?"

Whereas the first question takes an item and tries to find a classification for it, the second develops a classification in order to include (and exclude) a certain range of items. In doing so, it also includes and excludes certain framings of the problem of dual-use technology. This second question is what occupies most of the Wassenaar Arrangement's time.

In focusing my research on this question, Woolgar's (1991) phrase of viewing 'technology as text' takes on a literal meaning—the technologies, for the purposes of my analysis, *are* texts. One of the reasons I take this view is to show that technologies, like languages, evolve over time based on the things that we try to make them do. What constitutes a dual-use technology is very different from what it was fifty years ago, and will likely be very different from what it will be fifty years from now. This does not happen because the technology is continually advancing, but rather because people are trying to make the classification do different things. Mastanduno gave much weight to the argument that CoCom shifted between periods of using the Industrial List for strategic embargo, for economic containment, and for cooperation. The Wassenaar Arrangement has not so far been characterised by such over-arching motivations for modifying its lists. The text of the Dual-Use List reflects this by sometimes controlling more technology, sometimes letting more go.

For most of the history of export controls, dual-use technology has been defined through a discourse between two framings of the problem. Within the hierarchical framing, the problem is constructed as one of control, which can be resolved by systematically developing a classification of technology as either military, dual-use, or neither, and then employing a set of routines and procedures to ensure that technology which should be controlled, is controlled. This framing rests on three assumptions, which form its 'myth of control': that it is possible to control the flow of dual-use technology; that it is possible to know from whom dual-use technology should be kept; and that it is possible to define what is and is not dual-use technology. These are the assumptions upon which modern export control systems are based.

The alternative framing, however, views the problem not as one of control, but as one of competition and the marketability of technology. When addressing the problem of dual-use technology, the myth of the competitive framing is that a market exists and that, if you meet or develop a new need in the market with a technology, that technology will be taken up, as long as it is priced appropriately and is perceived as better than any competitors. Within the Wassenaar Arrangement, the hierarchical framing has hegemonic status, and actors expressing other framings of the problem of dual-use technology must employ the rhetoric of the hierarchical framing in order to engage in the discourse.

Having two framings within the discourse on dual-use technology suggests that it is a simple wicked problem. It is a persistent problem that is multiply framed, and each framing has its own solution which is often in contradiction to solutions offered by other framings. The problem of dual-use technology is itself a symptom of other wicked problems, such as those of creating a vibrant economy and ensuring national security. While each of these framings has a partial view on the problem of dual-use technology, neither of them has a complete view. Too much institutionalisation of either of these framings has led in the past either to increased propensity of wars to break out because of the increased access to militarily significant technology, or to too much control resulting in the stifling of the economy of exporting countries.

Anomaly-handling & uncomfortable knowledge

Through an extensive review of the history and structure of the Wassenaar Arrangement, we saw how the hierarchical framing became hegemonic with the development of CoCom and has remained so within Wassenaar. While modifying the Dual-Use List, Participating States of the Wassenaar Arrangement may argue that a definition of a technology should be modified because of (a) foreign availability; (b) it lacks a clear and objective definition; (c) it lacks military significance; (d) it is controlled by another regime; or (e) it is uncontrollable. Each of these arguments creates an anomaly for the hierarchical framing, and actors trying to maintain this framing's hegemonic status engage in two types of anomaly-handling strategies to resolve anomalies into (or out of) the classification system: monster-adjustment and exception-barring. Occasionally, these strategies are unsuccessful, in which case the anomaly works to undermine the form of organisation upon which the framing is based, creating 'uncomfortable knowledge'. For the hierarchical framing, uncomfortable knowledge is knowledge that technologies which should be controlled cannot be controlled.

The case studies I have used in this thesis demonstrate the varying degrees to which actors expressing the hierarchical framing are successful in carrying out these anomaly-handling strategies. Quantum cryptography was a case of monster-adjustment where the anomaly was quickly resolved through normal bureaucratic procedures. The focal plane array case saw the anomaly resolved as well, though with a much higher degree of contention. The monster-adjustment and exception-barring strategies were both employed, though in some cases the result was not to control some technology that actors—taking a polarised hierarchical view on the issue—thought should be controlled, thereby creating uncomfortable knowledge for those actors. In the case of computers, the hierarchical framing used exception-barring to narrow the scope of the control list from controlling hardware to primarily controlling software. This was a case where actors expressing the competitive framing were very effectively able to 'steal the rhetoric' of the hierarchical framing to show how computers were not controllable by the hierarchical framing's own metrics, and therefore that they should be decontrolled, regardless of their perceived military significance.

Incomplete theorisation & shifting to a clumsy solution space

By focusing on maintaining the List of Dual-Use Goods and Technologies, the Wassenaar Arrangement functions as an incompletely theorised agreement, where effort is made to reach particular outcomes—the list modifications—thereby allowing a space for actors with widely different assumptions on what aspects of technology are important or what to do with that technology. There are many positive features of incompletely theorised agreements. Reaching agreement when and where the Arrangement can allows for decisions to be made which can then be referred back to in subsequent rounds. Without such decisions, no precedent is created and no institutionalisation takes place. With such decisions, however, future discussions can have a common starting ground for arguing for or against an issue.

These agreements may be small, such as one involving a single change on the Dual-Use List, but the smallness is also a virtue in that it reduces the cost of political disagreement. If a Participating State does not want a particular list modification to go through, it may accept it anyway if it looks like that will also mean another modification that it wants will go through. Agreements can become more political within Wassenaar, as shown in the focal plane array case. When they do, however, positions tend to become more polarised, making the costs of disagreeing higher, but at the same time possibly creating a more significant change in the lists. Such change, however, due to its dominance of a single framing, is likely to have less legitimacy with the other framing, as we saw with the loss of trust that came out of the focal plane array case. There will also be more susceptibility to surprise from changes in the environment. This situation arose during the discussion on computer controls, and rather than continually pushing for greater control, those espousing the hierarchical framing agreed with those espousing the competitive framing that controls on hardware were no longer practical.

Such a debate can only happen in an arena that allows for multiple framings of a common wicked problem. The decision gave something to each of the framings, but neither framing got all that it wanted. By viewing it as a single decision in a long process of decision-making, each of the framings knew that they would have an opportunity again in the future to try and strengthen their form of organisation through future decisions.

The debates on computers and focal plane arrays, along with almost all of the earlier debates on list modifications, only involved two framings of the wicked problem. In contrast, discussions on intangible transfers of technology have included a third, egalitarian framing. We explored this shift through an analysis of the development of controls on intangible technology transfers, both within the Wassenaar Arrangement and within the United States. Controls on intangible technology transfers have only begun to be institutionalised in the last few decades, and many countries have encountered difficulties in developing controls because actors expressing both the hierarchical and competitive framings have come up against a framing that questions the assumption of technology upon which both of these framings are based: that technology, and knowledge of how to design, produce, and use that technology, is an excludable good which cannot be clearly differentiated.

Both the hierarchical and competitive framings benefit from technology being excludable. The hierarchical framing is able to define technology in need of control and establish routines and procedures to control that technology. The excludability of a technology is the basis of a market economy. If a company has control over a particular technology, say because they have some kind of intellectual property claim, they control the market for it.

But it is also possible for us to view technology as a non-excludable good. The guiding principle behind this view is that there should be an equal distribution of, or at least access to, the good for all. The problem is neither one of control nor of ensuring a competitive environment, but rather concerns the need for a more fundamental change in the way goods are valued in society. This egalitarian framing of dual-use technology has been expressed by academic establishments within the United State, which argue that basic scientific knowledge is a non-excludable good that should be freely available to anyone and not placed under export controls. This community has found a voice within the discourse on dual-use technology through the Deemed Export Advisory Committee and the Emerging Technology Research Advisory Committee within the Department of Commerce.

With the emergence of the egalitarian framing, the problem of dual-use technology has shifted to being a complex wicked problem. In this situation, agreement on particular outcomes (list modifications) is likely to be more contentious as actors expressing the egalitarian framing are likely to see the whole idea of list-maintenance as anathema. It will therefore become increasingly difficult to avoid discussions on the values that underlie each of the framings. As such, I have argued that efforts to created a 'clumsy solution space' where actors supporting each of the framings can debate both particular outcomes and general principles. There is a possibility that this will result in the destabilisation of the hierarchical framing's hegemonic status, but at the same time it is more likely to make the international export control system as a whole more legitimate as the egalitarian framing continues to gain strength.

Future areas of research & practice

There are several areas of future research worth noting in concluding this thesis. One of the most interesting is the relationship between international efforts to control intellectual property rights and the development of export controls on intangible technology transfers. Like the Wassenaar Arrangement, the TRIPS agreement tries to control the production and trade of products produced by employing certain knowledge. While TRIPS and Wassenaar differ on what constitutes important knowledge for control, they are likely to encounter similar problems in doing so. In particular, TRIPS already has an established history in dealing with egalitarian framings of the problem of intellectual property, raised for several communities of practice, including academic communities and proponents of sustainable development practices. In interviews that I conducted, I found that Wassenaar participants had little knowledge of the TRIPS agreement, and had not thought about the relationship between TRIPS and intangible technology transfer controls.

Another approach to the Wassenaar Arrangement that is very similar to the one I have taken would be to place an explicit emphasis on the role of technical expertise. The Arrangement is specifically divided into a General Working Group and an Expert Group, and I have shown how this distinction is blurred (a standard argument within Science & Technology Studies (STS)) but also how it is useful, as long as the participants acknowledge that the line between technical and political is socially constructed and constantly moving. The Wassenaar Arrangement draws a line between social and technical not to create a rigid categorisation, but rather to provide a framework within which to discuss and move that line. Might the Arrangement benefit from not only experts in the technologies under discussion, but also experts on analysing the integration of social and technical landscapes?

This question points to my desire to make scholars employing STS and the theory of sociocultural viability active participants in the topics they analyse.

These scholars will be the first to accept that they do not have the solutions to the problems they analyse, but the benefit of both STS and the theory of sociocultural viability is that they can help actors understand the assumptions on which their decision-making is based. These theories thereby allow for critical reflection on whether those assumptions are the ones that the actor actually wants to hold on the issue under concern.

Appendices

A
List of acronyms

ACF Advocacy Coalition Framework

AG Australia Group

ANT Actor-Network Theory

APP adjusted peak performance: used to measure computer performance in post-2005 Wassenaar lists; measured in weighted TeraFLOPS.

BWC Biological Weapons Convention

BST barium strontium titanate

CDC Control Data Corporation

CESG British Communications Electronic Security Group, part of GCHQ

CITS Center for International Trade and Security at the University of Georgia

CoCom Coordinating Committee for Multilateral Export Controls

CTP composite theoretical performance: used as a metric for measuring computer performance in post-1991 CoCom and pre-2005 Wassenaar lists; measured in MTOPS

CWC Chemical Weapons Convention

DARPA US Defense Advanced Research Projects Agency

DEAC Deemed Export Advisory Committee

DSTO Australian Ministry of Defence

EAR US Department of Commerce's Export Administration Regulations

EG Wassenaar Arrangement Expert Group

ETRAC Emerging Technology Research Advisory Committee

EU European Union

FLOPS floating point operations per second

GaAs Gallium Arsenide

GCHQ British Government Communications Headquarters

GWG Wassenaar Arrangement General Working Group

HIDAD high-density array development, a project by DARPA to develop uncooled focal plane arrays

HLM CoCom High Level Meeting

HPC high-performance computer

IAEA International Atomic Energy Agency

IBM International Business Machines

ICD International Classification of Disease

IL CoCom Industrial List

LEOM Wassenaar Arrangement Licensing and Enforcement Officers Meeting

MANPADS Man-Portable Air Defence Systems

Mbps millions of bits per second

MECRs Multilateral Export Control Regimes

MPP massively parallel processing

MTCR Missile Technology Control Regime

MTOPS millions of theoretical operations per second

NASA US National Aeronautics and Space Administration

NATO North Atlantic Treaty Organization

NPT Nuclear Non-Proliferation Treaty

NGO non-governmental organisation

NSG Nuclear Suppliers Group

NVESD US Army Night Vision and Electronic Sensors Directorate

OSCE Organization for Security and Cooperation in Europe

PDR processing data rate: used as a metric of computer performance in CoCom lists until 1991

QKD quantum key distribution

RMA Revolution in Military Affairs

SALW Small Arms and Light Weapons

SCOT social construction of technology

SIMD single instruction, multiple data

SIPRI Stockholm International Peace Research Institute

SL Wassenaar Arrangement Sensitive List

SMP symmetric multiprocessing

SOU Statement of Understanding

SST social shaping of technology

STS Science & Technology Studies or Science, Technology & Society

TeraFLOPS trillions of FLOPS

TRIPS Agreement on Trade-Related Aspects of Intellectual Property Rights

TWG Wassenaar Arrangement Technical Working Group

UAV unmanned (or uninhabited) aerial vehicle

UN United Nations

US United States of America

VO_x vanadium oxide

VPoCs Wassenaar Arrangement Vienna Points of Contact

VSL Wassenaar Arrangement Very Sensitive List

Redacted at request of the British Government
[redacted]

WHO World Health Organization

WMD Weapons of Mass Destruction

WT Weighted TeraFLOPS

WTO World Trade Organization

WWI, WWII World War I, World War II

ZC Zangger Committee

B
Public Documents & Structure of the Dual-Use List of the Wassenaar Arrangement

This Appendix is meant as a quick reference for documents produced by the Wassenaar Arrangement.

B.1 Dual-Use List structure

Below is the outline of the structure of the Dual-Use List as of 2007.

When citing the List in the text, I use the form 6.A.2.b, where 6 refers to the Category (in this case, Sensors and "Lasers"), A refers to the Section (Systems, Equipment, and Components), 2 refers to the subsection (Optical Sensors), and anything after refers to a part of the subsection. Where Notes are referenced, I append 'Note 1' or 'Technical Note 2' or 'N.B.' to the end of the reference to denote this.

Table B.1: *Categories of the Dual-Use List*

Category 1 – Advanced Materials
Category 2 – Materials Processing
Category 3 – Electronics
Category 4 – Computers
Category 5 – Part 1 – Telecommunications
Category 5 – Part 2 – "Information Security"
Category 6 – Sensors and "Lasers"
Category 7 – Navigation and Avionics
Category 8 – Marine
Cateogry 9 – Aerospace and Propulsion

Table B.2: *Sections of the Dual-Use List Categories*

A – Systems, Equipment, and Components
B – Test, Inspection, and Production Equipment
C – Materials
D – Software
E – Technology

B.2 Publicly available documents

These documents are available on the Wassenaar website: http://www.wassenaar.org. Here, they are ordered chronologically.

Table B.3: *Publicly Available Documents of the Wassenaar Arrangement*

Year	Document
1995	December 1995, Declaration at the Peace Palace, The Hague
	Lists of Dual-Use Goods and Technologies and Munitions List
1996	Press Statement, 12 July, 1996
	Press Statement, 13 December, 1996
	Lists of Dual-Use Goods and Technologies and Munitions List
1997	Public Statement, 10 December, 1997
	Lists of Dual-Use Goods and Technologies and Munitions List

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Table B.3 – *Continued*

Year	Document
1998	What is the Wassenaar Arrangement? Genesis of the Wassenaar Arrangement Elements for Objective Analysis and Advice Concerning Potentially Destabilising Accumulations of Conventional Weapons Public Statement, 3 December, 1998 Lists of Dual-Use Goods and Technologies and Munitions List
1999	Public Statement, 3 December, 1999 Lists of Dual-Use Goods and Technologies and Munitions List
2000	Best Practices for Disposal of Surplus/Demilitarised Military Equipment Extreme Vigilance: Sub-set of Tier 2 (VSL)items - 'Best Practices' Best Practices for Effective Enforcement Elements for Export Controls of MANPADS Lists of Dual-Use Goods and Technologies and Munitions List
2001	Statement of Understanding on Intangible Transfers of Software and Technology Public Statement, 7 December, 2001 Lists of Dual-Use Goods and Technologies and Munitions List
2002	Best Practice Guidelines for Exports of Small Arms and Light Weapons (SALW) Statement of Understanding on Arms Brokerage Public Statement, 12 December, 2002 Lists of Dual-Use Goods and Technologies and Munitions List
2003	Elements for Export Controls of Man-Portable Air Defence Systems (MANPADS) (This document is a revision of "Elements for Export Controls of MANPADS" adopted in December 2000) Statement of Understanding on Control of Non-Listed Dual-Use Items List of Advisory Questions for Industry Elements for Effective Legislation on Arms Brokering Ministerial Statement (December 2003) Public Statement, 12 December, 2003 Lists of Dual-Use Goods and Technologies and Munitions List
2004	Press Statement from Outreach Seminar 2004 Public Statement, 09 December, 2004 Lists of Dual-Use Goods and Technologies and Munitions List

Continued on Next Page...

Table B.3 – *Continued*

Year	Document
2005	New Participating States - Statement by the Plenary Chair of the Wassenaar Arrangement, 29 June, 2005 End-User Assurances commonly used - Consolidated Indicative List (This document is a revision of “End User Assurances commonly used - Indicative List” adopted in 1999) Control Lists – Criteria (This document is a revision of the Control Lists’ Criteria adopted in 2004) Lists of Dual-Use Goods and Technologies and Munitions List Summary of Changes – Lists of Dual-Use Goods and Technologies and Munitions List Corrigendum to the 2005 Lists Press Statement from Outreach Seminar, October 2005 Public Statement, 13 December, 2005
2006	Public Statement, 6 December, 2006 Best Practices for Implementing Intangible Transfer of Technology Controls Best Practice Guidelines for the Licensing of Items on the Basic List and Sensitive List of Dual-Use Goods and Technologies Press Release from 10th Anniversary Event Ministerial Statement (December 2006) Lists of Dual-Use Goods and Technologies and Munitions List Summary of Changes – Lists of Dual-Use Goods and Technologies and Munitions List
2007	Public Statement, 6 December, 2007 Updated Best Practice Guidelines for Exports of Small Arms and Light Weapons (SALW) (This document is a revision of the Best Practice Guidelines for Exports of Small Arms and Light Weapons (SALW) adopted in 2002) Updated Elements for Export Controls of Man-Portable Air Defence Systems (MANPADS) (This document is a revision of the Elements for Export Controls of Man-Portable Air Defence Systems (MANPADS) adopted in 2000 and amended in 2003.) Best Practices to Prevent Destabilising Transfers of Small Arms and Light Weapons (SALW) through Air Transport Statement of Understanding on Implementation of End-Use Controls for Dual-Use Items Lists of Dual-Use Goods and Technologies and Munitions List Summary of Changes – Lists of Dual-Use Goods and Technologies and Munitions List

Continued on Next Page…

Table B.3 – *Continued*

Year	Document
2008	Public Statement, 3 December, 2008 Summary of Changes - List of Dual-Use Goods and Technologies and Munitions List List of Dual-Use Goods and Technologies and Munitions List

C
Cross Reference Index

The Cross Reference Index was compiled by Britain to aid exporters in finding controlled technology on the newly structured CoCom lists in September 1991. It is an invaluable tool in tracing the transition from the old lists to the new ones.

Cross Reference Index

"Old" IL Item to "New" Category

These cross-reference lists are provided on an advisory basis only. They give an approximate indication of how the scope of the controls translates between the "old" and "new" Industrial Lists.

Note: Exporters are reminded that the requirement for an export licence is determined in law by the current Export of Goods(Control) Order, not by this booklet which lists the controls on exports to the proscribed destinations. Goods may require an export licence even if they are free from embargo.

"Old" IL Item number/sub-item	*"New" Category & clause*
1001(a(1),b(1))	no entry
no entry	2.E.3.a
1001(a(2-4),b)	2.E.3.b
1080	9.D.1,2
1080 etc	9.E.1,2
1080	2.E.3.c
1080(I)(a,f,g)	no entry
1080(I)(b-e,k)	9.B.1.a-c
1080(I)(h-j)	9.B.1.d-h
1080(I)(c,e,h-k)	9.D.1
1080(I)(d)	9.D.4.e
1080(I)(i)	9.B.9
1080(I)	9.D.4.f
1080(II)	no entry
1080 etc	9.E.1,2
1081	1.B.3
1081	1.D
1081	2.E.3.c
1086(a,b(3,4),c)	no entry
1086(b)	9.B.4
1086(b)	9.E.2
1086 etc	9.D.1,2
1088	2.B.3
1088	2.D.1
1091	2.D.1
1091	2.D.2.b
1091(a,b)	2.B.1
1091(d,e)	2.B.8,9
1091(c)	2.E.1,2,3.a
1099(a)	no entry
1099(b-d)	2.D.1
1099(b-d)	2.B.6.a,b,c
no entry	2.B.6.d
1131	no entry
1205(a)	3.A.1.e.1
1205(a)(1)	no entry
1205(a)(2,3)	3.A.1.e.1.a,b
1205(a)(4)	no entry
1205(b(1-3))	6.A.2.a.3
1205(b)(4)	3.A.1.e.1.c
1205(c)	no entry
1301	1.B.2
1310	1.B.2
1312	2.B.4
1312	2.D.1
1353(a-c)	5.B.1.a.2
1353(d)	5.B.1.a
1355	3.B.1,6
1355(b)	3.B.7.b
1355(b)(2)	3.B.7.a
1355(b)(2)	3.B.8
1355(b)(7)	3.B.9.a-c
1355(b)(9)	3.B.9.d
1355 etc	3.D.1,2
1355 etc	3.D.3
1355 etc	3.E.1,2
no entry	6.B.4
1357	1.B.1 a-e
1357	1.D
1357 etc	5.D.1.a
1358(a)	no entry
1358(b)	4.B.1
1358(c)	4.B.2,3
1358	4.E.1
no entry	9.B.8
1361(a-c)	no entry
1361(d)	9.B.2,5
1361(g)	9.B.3
1361(e)	9.E.3.b.1
1361 etc	9.E.1
1361	9.D.1
1362(a)	9.D.4.a
1361(d)	9.D.4.b
1362(b)	9.B.6
1362 etc	9.D.1
1362 etc	9.E.1
1363	8.B
1363	8.D.1
1364	8.A.2
1370	2.D.1
1370(a,b)	2.B.2
1370(a,b)	6.E.3.d
1370(c,d)	2.B.2.a
1370(c,d)	2.B.8
1371	2.A.1-4
no entry	2.A.5,6
1371	2.E.1,2
1385(a)	7.B.2
1385(b)	7.B.3
1388(a-f)	2.B.5.a-f
no entry	2.B.5.g
1388	2.D.1
1389	2.E.3.d
1389	6.D.3
1389 etc	6.E.1,2
1389	6.E.3.d
1391	2.D.1
1391(a(4,10))	8.A.2.h
1391(a,b)	2.B.7
1391(a)(4)	no entry
1401	9.E.3.e
1416	8.D.1
1416(a-c)	8.A.1.f-i
1416(d)	no entry
1416(e,f)	8.A.2.o.2
1416(f)(1,3)	8.A.2.o.1
1416(f)(4)	8.A.2.p
1416(g)	no entry
1416(h)(1)	no entry
1416(h)(2)	8.A.2.m
1416(h)(4)	8.A.2.k
1416(h)(5)	8.A.2.n
1416(h)(6-9)	8.A.2.o.2
1416(h)(10)	8.A.2.l
1416(h)(11)	8.A.2.p
1417(a)	no entry
1417(b)	8.A.2.b
1417(c)	8.A.2.d
1417(d)	8.A.2.i
1417(e)	8.A.2.e,f
1417(f)	8.A.2.g.1
1417(g)	no entry
1417(h)(1-3)	8.A.2.j
1417(h)(4)	no entry
no entry	8.A.1.b.1,2
no entry	8.A.1.e
no entry	8.A.2.g.2
1417 etc	8.A.2.o.3
1417 etc	8.E.2
1417	8.E.1
1417	8.D.1
1417 etc	8.D.2
1418(a)	8.A.1.a,c-e
1418(a)	8.A.2.a.1,2
1418(a)(3)	8.A.2.c
no entry	8.A.1.b.1,2
1418(b)	8.A.1.b.3
1431	9.A.2
1460(a)	no entry
1460(d)	9.A.1
1460(e)	9.A.3
1460	7.D.3.d
1460 etc	9.E.1,2
1460	9.E.3.a,c,d
1460	9.E.3.b.2
1460	7.E.4.b,c
1460	9.D.3
1460	9.D.4.c,d
1465	9.A.4-11
1465 etc	9.B.7
1465 etc	9.E.1,2
1485	7.D.1,2
1485	7.D.3.a,b
1485	7.E.3
1485	7.E.4.a
1485(a)	no entry
1485(b,e)	7.A.3
1485(c)	7.A.4
1485(f,h)	7.A.1
1485(g)	7.A.2
1485(j)	7.B.1
1485 etc	7.E.1
1501(b)(1)(C)	7.A.6
1501(b)(4,5)	7.A.5
1501(c)	6.A.8

"Old" IL Item number/sub-item	"New" Category & clause	"Old" IL Item number/sub-item	"New" Category & clause	"Old" IL Item number/sub-item	"New" Category & clause
1501(c)	6.B.8	1529(e)	3.A.2.d	1567(a)	5.A.1.c.8
1501(c)	6.D.1,2,3	1529(f)	3.A.2.f	no entry	5.A.1.c.9
1501 etc	7.E.2	1529(g)	no entry	1567(b)(2)	5.A.1.c.1,3
1502	6.A.2.b,c,d	1529(h)	no entry	1567(b)(4)	5.A.1.c.2
1502 etc	6.C.4.a-f	1529(i)	5.B.1.b.1,2	1567(b)	5.A.1.c.7
no entry	6.C.4.g	1529(j)	3.A.2.f,h	1567(b)	5.A.1.c.11
1502 N 4	5.A.1.b.11	1529	3.D.1	1567(b)	5.A.1.d
1510(a)	6.A.1.a	1531 etc	5.D.1.c.2	1567	5.A.1.c.10
1510(a)	6.D.3.a	1531 etc	5.E.1.b.7	1567 etc	5.A.2.f
1510(b)	6.A.1.b	1531(a)	3.A.2.g	1567 etc	5.B.1.a
no entry	6.A.1.c	1531(b-d)	3.A.2.b	1567 etc	5.D.1.a,b
1516(a)	5.A.1.b.9	1533(a)	3.A.2.c.1	1567 etc	5.D.1.c.1
1516(b)	5.A.1.b.8	1533(b)	3.A.2.c.2	1567 etc	5.E.1.a
1516(b)	5.A.2.e	1533(c,d)	5.B.1.a	1567	5.E.1.b.4,5
1516 etc	5.E.1.a	1533(d)	3.A.2.e	1567 etc	5.E.1.b.6
1517	5.A.1.b.7	1534	no entry	1567(b) etc	5.E.1.b.8
1517(c)	5.A.1.b.8	1537(a,f)	3.A.1.b.6,7	1568(a,b)	4.A.3.b
1517(c)	5.A.2.e	1537(d)	5.A.1.f	1568(a,b)	4.A.3.j
1517 etc	5.E.1.a	1537(f,h)	3.A.1.b.2	1568(c)	4.A.2.b
1518	no entry	1537(g)	3.A.1.b.5	1568(d)	3.A.1.f
1519 etc	5.B.1.a	1537(h)	3.A.1.b.4	1568(e)	no entry
1519 etc	5.D.1.a	1545	3.A.1.b.3	1571(a,b)	6.A.6.a-d
1519	5.D.1.c.3	1548(b-d)	6.A.2.a	no entry	6.A.6.e, f
1519	5.E.1.b.1	1548(d)	6.A.2.b	1571(c)	6.A.6.g
1519(a)	5.A.1.b.1-3	no entry	6.A.2.a.1	1571(c)	6.D.3.f
1519(a)	5.A.1.c.11	1548 etc	6.D.2	no entry	6.E.3.f
1519(b)	5.A.1.b.4.a-d	1549	6.A.2.a.2	1572(a)	3.A.2.a
1519(c)	5.B.1.a	1553 a	3.A.1.e.5	1572(d)	no entry
1519(c)	5.B.1.b.1	1555(a)	6.A.2.a.2	1573(a,b)	3.A.1.e.3
1519 etc	5.E.1.a	1556(a-c)	6.A.2.a.2	1574(b)	3.A.1.d,e.4
1520(a)	5.A.1.b.5	1556(d)	no entry	1574	3.E.2.c
1520(a)(2)(C)	5.A.1.b.6	no entry	6.A.4.a-e	1574	6.A.6.h
1520(a,b)	5.B.1.a,b	1556	6.E.3	1585(a-e,g,j)	6.A.3.a
1520(c)	5.B.1.b.3	1558	3.A.1.b.1	1585(i)	no entry
1520 etc	5.D.1.a	1560	3.A.1.e.2	1586	3.A.1.c
1520 etc	5.E.1.a	1561	1.C.1.a	1586(c)	3.A.1.c.3
1522 etc	5.E.1.b.2	no entry	1.C.1.b	1588	4.E.1
1522	6.A.5	1564	3.A.1.a	1595	6.A.7
no entry	6.A.5.a.2.d	1564(a)(13)	3.A.1.b.2	1595	6.B.7
no entry	6.A.5.a.5.c.2	1565(d)(2,3)	4.A.2	1602 etc	4.C
no entry	6.A.5.f	1565(f)(1)	4.A.1.a.1	1610(a)	1.C.2.a.2
no entry	6.A.5.g	1565(f)(2,5)	4.A.1.b	1610(b,c)	1.C.2.b,c
1522	6.B.5	1565(f)(2)	5.A.2.d	1610	1.C.2.a,b
1522	6.C.5.a	1565(f)(3)	5.A.1.a.1,2	1610	1.C.4
no entry	6.C.5.b	1565(f)(3)	4.A.1.a.2	1631	1.C.3
1522	6.D.1	1565(f)(5)	5.A.2.f	1648	1.C.3
no entry	6.E.3.e.1,2	1565(h)(1,2)	4.A.3	1661	1.C.3
1526(b)(1,3,4)	5.A.1.e	1565(h)(1)	4.A.4	1672	1.C.2.a.1
1526(b)(2)	no entry	1565 etc	4.E.1	1675	1.C.5
1526(b)(5)	5.A.1.a.1,2	1565(j)	4.E.2	1702	1.C.6.a.1,2
1526(d)	5.A.2.g	1565(h)(2)(f)	5.A.1.b.3.c	1710(a-c)	1.C.6.a-c
1526 etc	5.B.1.a	1565(h)	5.A.1.b.10	1710(d)	no entry
1526 etc	5.E.1.b.3	1565(h)(2)(F)	5.A.1.c.8	1715(a)	no entry
1526(c)	6.A.2.d.3	1565 etc	5.E.1.b.6	1715(b)	1.C.7.a,b,d
no entry	6.A.4.f	1566(b)(5)	2.D.2.a	1733	1.C.7
1526(a) etc	8.A.2.a.3	1566	4.E.1	1733	1.E.2.c
1527	5.A.2.a-c	1566	4.D.1,2	1746(a)	1.E.2
1527	5.A.2.e	no entry	4.D.3.a	1746(d,i)	1.E.2.a
1527	5.B.2.a,b	1566(b)(4,5)	4.D.3.b-f	1746	1.A.3
1527	5.D.2.a-c	1566 etc	5.D.1.c.4	1746	1.C.8
1527	5.E.2	1566	5.D.1.c.5	1746 etc	1.E.1
1527 etc	5.E.1.a	1566(a)(5)	5.D.2.a	1746 (c)	1.E.2.d
1529 etc	5.B.1.a	1566(a(2,4))	5.D.2.a-c.2	no entry	1.E.2.e,f
1529	5.A.1.a.3	1566	6.D.3	1754(a)	1.C.9
1529(b)	no entry	1566 etc	7.D.3.c	1754(a)	1.E.2.b
1529(c,d)	3.A.2.g	1567(a)	5.A.1.c.4-6	1754(a)(3)	no entry

"Old" IL Item number/sub-item	"New" Category & clause
1754(b(1,4))	no entry
1754(b(2,3))	1.A.1.a,b
1754(b)(2)	1.A.1.a,c
1755	1.C.6.b.2
1757(a,b,c,e-i,k)	no entry
1757(e)	6.C.2.a,b
1759	8.C
1763(d)	1.A.2
1763	1.B.1.f
1763	1.C.10
1767	5.C.1
1767	6.C.2.c
1781(a)	no entry
1781(b)	1.C.6.b.1

"New" Category to "Old" IL Item

"New" Category & clause	"Old" IL Item number/sub-item
no entry	1754(b(1,4))
1.A.1.a,b	1754(b(2,3))
1.A.1.a,c	1754(b)(2)
1.A.2	1763(d)
1.A.3	1746
1.B.1.a-e	1357
1.B.1.f	1763
1.B.2	1301
1.B.2	1310
1.B.3	1081
1.C.1.a	1561
1.C.1.b	no entry
1.C.2.a,b	1610
1.C.2.a.1	1672
1.C.2.a.2	1610(a)
1.C.2.b,c	1610(b,c)
1.C.3	1631
1.C.3	1648
1.C.3	1661
1.C.4	1610
1.C.5	1675
1.C.6.a-c	1710(a-c)
no entry	1710(d)
1.C.6.a.1,2	1702
1.C.6.b.1	1781(b)
no entry	1781(a)
1.C.6.b.2	1755
1.C.7	1733
no entry	1715(a)
1.C.7.a,b,d	1715(b)
1.C.8	1746
1.C.9	1754(a)
no entry	1754(a)(3)
1.C.10	1763
1.D	1081
1.D	1357
1.E.1	1746 etc
1.E.2	1746(a)
1.E.2.a	1746(d,i)
1.E.2.b	1754(a)
1.E.2.c	1733
1.E.2.d	1746(c)
1.E.2.e,f	no entry
2.A.1-4	1371
2.A.5,6	no entry
2.B.1	1091(a,b)
2.B.2	1370(a,b)
2.B.2.a	1370(c,d)
2.B.3	1088
2.B.4	1312
no entry	1131
2.B.5.a-f	1388(a-f)
2.B.5.g	no entry
no entry	1099(a)
2.B.6.a,b,c	1099(b-d)
2.B.6.d	no entry
2.B.7	1391(a,b)
2.B.8	1370(c,d)
2.B.8,9	1091(d,e)
2.D.1	1088
2.D.1	1091
2.D.1	1099(b-d)
2.D.1	1312
2.D.1	1370
2.D.1	1388
2.D.1	1391
2.D.2.a	1566(b)(5)
2.D.2.b	1091
2.E.1,2	1371
2.E.1,2,3.a	1091(c)
2.E.3.a	no entry
no entry	1001(a(1),b(1))
2.E.3.b	1001(a(2-4),b)
2.E.3.c	1080
2.E.3.c	1081
2.E.3.d	1389
3.A.1.a	1564
3.A.1.b.1	1558
3.A.1.b.2	1537(f,h)
3.A.1.b.2	1564(a)(13)
3.A.1.b.3	1545
3.A.1.b.4	1537(h)
3.A.1.b.5	1537(g)
3.A.1.b.6,7	1537(a,f)
3.A.1.c	1586
3.A.1.c.3	1586(c)
3.A.1.d,e.4	1574(b)
3.A.1.e.1	1205(a)
3.A.1.e.1.a,b	1205(a)(2,3)
3.A.1.e.1.c	1205(b)(4)
3.A.1.e.2	1560(a,b)
3.A.1.e.3	1573(a,b)
3.A.1.e.5	1553(a)
3.A.1.f	1568(d)
no entry	1205(a)(4)
no entry	1205(c)
no entry	1205(a)(1)
no entry	1568(e)
no entry	1572(d)
3.A.2.a	1572(a)
3.A.2.b	1531(b-d)
3.A.2.c.1	1533(a)
3.A.2.c.2	1533(b)
3.A.2.d	1529(e)
3.A.2.e	1533(d)
3.A.2.f	1529(f)
3.A.2.g	1529(c,d)
3.A.2.g	1531(a)
3.A.2.f,h	1529(j)
no entry	1529(b)
no entry	1529(g)
no entry	1529(h)
3.B.1,6	1355
3.B.7.a	1355(b)(2)
3.B.7.b	1355(b)
3.B.8	1355(b)(2)
3.B.9.a-c	1355(b)(7)
3.B.9.d	1355(b)(9)
no entry	1757(a,b,c,e-i,k)
3.D.1	1529
3.D.1,2	1355 etc
3.D.3	1355 etc
3.E.1,2	1355 etc
3.E.2.c	1574
4.A.1.a.1	1565(f)(1)
4.A.1.a.2	1565(f)(3)
4.A.1.b	1565(f)(2,5)
4.A.2	1565(d)(2,3)
4.A.2.b	1568(c)
4.A.3	1565(h)(1,2)
4.A.3.b	1568(a,b)
4.A.3.j	1568(a,b)
4.A.4	1565(h)(1)
4.B.1	1358(b)
4.B.2,3	1358(c)
no entry	1358(a)
4.C	1602 etc
4.D.1,2	1566
4.D.3.a	no entry
4.D.3.b-f	1566(b)(4,5)
4.E.1	1358
4.E.1	1565 etc
4.E.1	1566
4.E.1	1588
4.E.2	1565(j)
5.A.1.a.1,2	1526(b)(5)
5.A.1.a.1,2	1565(f)(3)
5.A.1.a.3	1529
5.A.1.b.1-3	1519(a)
5.A.1.b.3.c	1565(h)(2)(f)
5.A.1.b.4.a-d	1519(b)
5.A.1.b.5	1520(a)
5.A.1.b.6	1520(a)(2)(C)
5.A.1.b.7	1517
5.A.1.b.8	1516(b)
5.A.1.b.8	1517(c)
5.A.1.b.9	1516(a)
5.A.1.b.10	1565(h)
5.A.1.b.11	1502 N 4
5.A.1.c.1,3	1567(b)(2)
5.A.1.c.2	1567(b)(4)
5.A.1.c.4-6	1567(a)
5.A.1.c.7	1567(b)
5.A.1.c.8	1565(h)(2)(F)
5.A.1.c.8	1567(a)
5.A.1.c.9	no entry
5.A.1.c.10	1567
5.A.1.c.11	1519(a) etc
5.A.1.c.11	1567(b)
5.A.1.d	1567(b)
5.A.1.e	1526(b)(1,3,4)
no entry	1526(b)(2)
5.A.1.f	1537(d)
5.A.2.a-c	1527
5.A.2.d	1565(f)(2)
5.A.2.e	1516(b)

"New" Category & clause	"Old" IL Item number/sub-item
5.A.2.e	1517(c)
5.A.2.e	1527
5.A.2.f	1565(f)(5)
5.A.2.f	1567 etc
5.A.2.g	1526(d)
5.B.1.a	1353(d)
5.B.1.a	1519(c)
5.B.1.a	1519 etc
5.B.1.a	1526 etc
5.B.1.a	1529 etc
5.B.1.a	1533(c,d)
5.B.1.a	1567 etc
5.B.1.a,b	1520(a,b)
5.B.1.a.2	1353(a-c)
5.B.1.b.1	1519(c)
5.B.1.b.1,2	1529(i)
5.B.1.b.3	1520(c)
5.B.2.a,b	1527
5.C.1	1767
5.D.1.a	1357 etc
5.D.1.a	1519 etc
5.D.1.a	1520 etc
5.D.1.a,b	1567 etc
5.D.1.c.1	1567 etc
5.D.1.c.2	1531 etc
5.D.1.c.3	1519
5.D.1.c.4	1566 etc
5.D.1.c.5	1566 etc
5.D.2.a	1566(a)(5)
5.D.2.a-c	1527
5.D.2.a-c.2	1566(a(2,4))
5.E.1.a	1516 etc
5.E.1.a	1517 etc
5.E.1.a	1519 etc
5.E.1.a	1520 etc
5.E.1.a	1527 etc
5.E.1.a	1567 etc
5.E.1.b.1	1519
5.E.1.b.2	1522 etc
5.E.1.b.3	1526 etc
5.E.1.b.4,5	1567
5.E.1.b.6	1565 etc
5.E.1.b.6	1567 etc
5.E.1.b.7	1531 etc
5.E.1.b.8	1567(b) etc
5.E.2	1527
6.A.1.a	1510(a)
6.A.1.b	1510(b)
6.A.1.c	no entry
6.A.2.a.1,3	1548(b-d)
6.A.2.a.2	1555
6.A.2.a.2	1556(a-c)
6.A.2.a.2	1549
6.A.2.a.3	1205(b(1-3))
6.A.2.b	1548(d)
6.A.2.b,c,d	1502
6.A.2.d.3	1526(c)
6.A.3.a	1585(a-e,g,j)
no entry	1585(i)
no entry	1556(d)
6.A.4.a-e	no entry
6.A.4.f	no entry
6.A.5	1522
6.A.5.a.2.d	no entry
6.A.5.a.5.c.2	no entry
6.A.5.f	no entry
6.A.5.g	no entry
6.A.6.a-d	1571(a,b)
6.A.6.e,f	no entry
6.A.6.g	1571(c)
6.A.6.h	1574
6.A.7	1595
6.A.8	1501(c)
6.B.4	no entry
6.B.5	1522
6.B.7	1595
6.B.8	1501(c)
6.C.2.a,b	1757(e)
6.C.2.c	1767
6.C.4.a-f	1502 etc
6.C.4.g	no entry
6.C.5.a	1522
6.C.5.b	no entry
6.D.1	1522
6.D.1,2,3	1501(c)
6.D.2	1548 etc
6.D.3	1389
6.D.3	1566
6.D.3.a	1510(a)
6.D.3.f	1571(c)
6.E.1,2	1389 etc
6.E.3	1556
6.E.3.d	1370(a,b)
6.E.3.d	1389
6.E.3.e.1,2	no entry
6.E.3.f	no entry
no entry	1518
7.A.1	1485(f,h)
7.A.2	1485(g)
7.A.3	1485(b,e)
7.A.4	1485(c)
7.A.5	1501(b)(4,5)
7.A.6	1501(b)(1)(C)
7.B.1	1485(j)
7.B.2	1385(a)
7.B.3	1385(b)
7.D.1,2	1485
7.D.3.a,b	1485
7.D.3.c	1566 etc
7.D.3.d	1460
7.E.1	1485 etc
7.E.2	1501 etc
7.E.3	1485
7.E.4.a	1485
7.E.4.b,c	1460
8.A.1.a,c-e	1418(a)
8.A.1.b.1,2	no entry
8.A.1.b.3	1418(b)
8.A.1.e	no entry
8.A.1.f-i	1416(a-c)
8.A.2	1364
no entry	1391(a)(4)
8.A.2.a.1,2	1418(a)
8.A.2.a.3	1526(a) etc
8.A.2.b	1417(b)
8.A.2.c	1418(a)(3)
8.A.2.d	1417(c)
8.A.2.e,f	1417(e)
8.A.2.g.1	1417(f)
8.A.2.g.2	no entry
8.A.2.h	1391(a(4,10))
8.A.2.i	1417(d)
8.A.2.j	1417(h)(1-3)
8.A.2.k	1416(h)(4)
8.A.2.l	1416(h)(10)
8.A.2.m	1416(h)(2)
8.A.2.n	1416(h)(5)
8.A.2.o.1	1416(f)(1,3)
8.A.2.o.2	1416(e,f)
8.A.2.o.2	1416(h)(6-9)
8.A.2.o.3	1417 etc
8.A.2.p	1416(f)(4)
8.A.2.p	1416(h)(11)
8.B	1363
8.C	1759
8.D.1	1363
8.D.1	1416
8.D.1	1417
8.D.2	1417 etc
8.E.1	1417
8.E.2	1417 etc
no entry	1086(a,b(3,4),c)
no entry	1460(a)
9.A.1	1460(d)
9.A.2	1431
9.A.3	1460(e)
9.A.4-11	1465
9.B.1.a-c	1080(I)(b-e,k)
9.B.1.d-h	1080(I)(h-j)
no entry	1361(a-c)
9.B.2,5	1361(d)
9.B.3	1361(g)
9.B.4	1086(b)
9.B.6	1362(b)
9.B.7	1465 etc
9.B.8	no entry
9.B.9	1080(I)(i)
9.D.1	1080(I)(c,e,h-k)
9.D.1	1361
9.D.1	1362 etc
9.D.1,2	1080
9.D.1,2	1086 etc
no entry	1080(I)(a,f,g)
9.D.3	1460
9.D.4.a	1362(a)
9.D.4.b	1361(d)
9.D.4.c,d	1460
9.D.4.e	1080(I)(d)
9.D.4.f	1080(I)
9.E.1	1361 etc
9.E.1	1362 etc
9.E.1,2	1080 etc
9.E.1,2	1460 etc
9.E.1,2	1465 etc
9.E.2	1086(b)
no entry	1080(II)
9.E.3.a,c,d	1460
9.E.3.b.1	1361(e)
9.E.3.b.2	1460
9.E.3.e	1401
no entry	1416(d)
no entry	1416(g)
no entry	1416(h)(1)
no entry	1417(a)
no entry	1417(g)
no entry	1417(h)(4)
no entry	1485(a)
no entry	1534

D
Category 5 – Part 2 “Information Security”

On the following pages is the text of the 2004 Category 5 – Part 2 “Information Security” section of the Wassenaar Arrangement’s Dual-Use List. This was the List as it existed the year of the debate about quantum cryptography.

Part 2 - "INFORMATION SECURITY"

Note 1 *The control status of "information security" equipment, "software", systems, application specific "electronic assemblies", modules, integrated circuits, components or functions is determined in Category 5, Part 2 even if they are components or "electronic assemblies" of other equipment.*

Note 2 *Category 5 – Part 2 does not control products when accompanying their user for the user's personal use.*

Note 3 *Cryptography Note*

5.A.2. and 5.D.2. do not control items that meet all of the following:

a. Generally available to the public by being sold, without restriction, from stock at retail selling points by means of any of the following:
  1. Over-the-counter transactions;
  2. Mail order transactions;
  3. Electronic transactions; or
  4. Telephone call transactions;

b. The cryptographic functionality cannot easily be changed by the user;

c. Designed for installation by the user without further substantial support by the supplier; and

d. Deleted;

e. When necessary, details of the items are accessible and will be provided, upon request, to the appropriate authority in the exporter's country in order to ascertain compliance with conditions described in paragraphs a. to c. above.

Technical Note
In Category 5 - Part 2, parity bits are not included in the key length.

5. A. 2. SYSTEMS, EQUIPMENT AND COMPONENTS

a. Systems, equipment, application specific "electronic assemblies", modules and integrated circuits for "information security", as follows, and other specially designed components therefor:

N.B. *For the control of global navigation satellite systems receiving equipment containing or employing decryption (i.e. GPS or GLONASS), see 7.A.5.*

5. A. 2. a. 1. Designed or modified to use "cryptography" employing digital techniques performing any cryptographic function other than authentication or digital signature having any of the following:

Technical Notes

1. *Authentication and digital signature functions include their associated key management function.*
2. *Authentication includes all aspects of access control where there is no encryption of files or text except as directly related to the protection of passwords, Personal Identification Numbers (PINs) or similar data to prevent unauthorised access.*
3. *"Cryptography" does not include "fixed" data compression or coding techniques.*

Note *5.A.2.a.1. includes equipment designed or modified to use "cryptography" employing analogue principles when implemented with digital techniques.*

5. A. 2. a. 1.
a. A "symmetric algorithm" employing a key length in excess of 56 bits; or
b. An "asymmetric algorithm" where the security of the algorithm is based on any of the following:
    1. Factorisation of integers in excess of 512 bits (e.g., RSA);
    2. Computation of discrete logarithms in a multiplicative group of a finite field of size greater than 512 bits (e.g., Diffie-Hellman over Z/pZ); or
    3. Discrete logarithms in a group other than mentioned in 5.A.2.a.1.b.2. in excess of 112 bits (e.g., Diffie-Hellman over an elliptic curve);

2. Designed or modified to perform cryptanalytic functions;

3. Deleted;

4. Specially designed or modified to reduce the compromising emanations of information-bearing signals beyond what is necessary for health, safety or electromagnetic interference standards;

5. Designed or modified to use cryptographic techniques to generate the spreading code for "spread spectrum" systems, including the hopping code for "frequency hopping" systems;

6. Designed or modified to use cryptographic techniques to generate channelizing or scrambling codes for "time-modulated ultra-wideband" systems;

7. Deleted

8. Communications cable systems designed or modified using mechanical, electrical or electronic means to detect surreptitious intrusion.

Note *5.A.2. does not control:*

a. "Personalised smart cards":

1. Where the cryptographic capability is restricted for use in equipment or systems excluded from control under entries b. to f. of this Note; or

2. For general public-use applications where the cryptographic capability is not user-accessible and it is specially designed and limited to allow protection of personal data stored within.

N.B. *If a "personalised smart card" has multiple functions, the control status of each function is assessed individually.*

b. Receiving equipment for radio broadcast, pay television or similar restricted audience broadcast of the consumer type, without digital encryption except that exclusively used for sending the billing or programme-related information back to the broadcast providers.

c. Equipment where the cryptographic capability is not user-accessible and which is specially designed and limited to allow any of the following:

1. Execution of copy-protected software;

2. Access to any of the following:

a. Copy-protected contents stored on read-only media; or

b. Information stored in encrypted form on media (e.g. in connection with the protection of intellectual property rights) when the media is offered for sale in identical sets to the public; or

3. Copying control of copyright protected audio/video data.

d. Cryptographic equipment specially designed and limited for banking use or money transactions.

Technical Note

'Money transactions' in 5.A.2. Note d. includes the collection and settlement of fares or credit functions.

e. Portable or mobile radiotelephones for civil use (e.g., for use with commercial civil cellular radiocommunications systems) that are not capable of end-to-end encryption.

f. Cordless telephone equipment not capable of end-to-end encryption where the maximum effective range of unboosted cordless operation (i.e., a single, unrelayed hop between terminal and home basestation) is less than 400 metres according to the manufacturer's specifications.

5. B. 2. TEST, INSPECTION AND PRODUCTION EQUIPMENT

a. Equipment specially designed for:
   1. The "development" of equipment or functions controlled by Category 5 - Part 2, including measuring or test equipment;
   2. The "production" of equipment or functions controlled by Category 5 - Part 2, including measuring, test, repair or production equipment.

b. Measuring equipment specially designed to evaluate and validate the "information security" functions controlled by 5.A.2. or 5.D.2.

5. C. 2. MATERIALS - None

5. D. 2. SOFTWARE

a. "Software" specially designed or modified for the "development", "production" or "use" of equipment or "software" controlled by Category 5 - Part 2;
b. "Software" specially designed or modified to support "technology" controlled by 5.E.2.;
c. Specific "software", as follows:
   1. "Software" having the characteristics, or performing or simulating the functions of the equipment controlled by 5.A.2. or 5.B.2.;
   2. "Software" to certify "software" controlled by 5.D.2.c.1.

Note *5.D.2. does not control:*
a. "Software" required for the "use" of equipment excluded from control under the Note to 5.A.2.;
b. "Software" providing any of the functions of equipment excluded from control under the Note to 5.A.2.

5. E. 2. TECHNOLOGY

a. "Technology" according to the General Technology Note for the "development", "production" or "use" of equipment or "software" controlled by Category 5 - Part 2.

E
Interviews conducted

Interviews for this thesis occurred over three and a half years between September 2005 and May 2009 and took place in Oxford, London, Vienna, Brussels, and Washington, DC. Interviews were conducted in person and not recorded unless otherwise noted. They are listed here in chronological order.

2005

1. Cevasco, Frank (26 September) *Independent consultant.*

2. British Government Official C (2 December) *Foreign and Commonwealth Office.*

2006

3. Export Control Lawyer, Bryan Cave and former Deputy Assistant Secretary of Commerce, US Department of Commerce (5 January).

4. Swedish Former Government Official (6 January) *Ministry of Foreign Affairs.* Recorded.

5. British Government Official A & British Government Official B (9 February) *Ministry of Defence and Department of Trade & Industry.* Recorded.
6. Wassenaar Secretariat Official A & Wassenaar Secretariat Official B (1 March)
7. EU Export Control Official (22 March) *Office of the Personal Representative of the High Representative on Non-proliferation of Weapons of Mass Destruction, Council of the European Union.*
8. EU Export Control Official (20 April) *Office of the Personal Representative of the High Representative on Non-proliferation of Weapons of Mass Destruction, Council of the European Union.*
9. British Government Official B (29 June) *Department of Trade & Industry.* Recorded.
10. Swedish Former Government Official (19 July) *Ministry of Foreign Affairs.*
11. Former Assistant Director for Nonproliferation and Regional Arms Control of the U.S. Arms Control and Disarmament Agency (ACDA) (2 August).
12. US Defense Department Official A (8 August) *Defense Technology Security Administration.* Recorded.
13. US State Department Official A & US State Department Official B (11 September) Recorded.
14. Swedish Former Government Official (14 September) *Ministry of Foreign Affairs.*
15. Senior Analyst at the Center for Defense Information (19 September).
16. Senior Research Analyst, Institute for Defense Analyses (25 September).

17. Research Director, Arms Control Association (27 September).

18. Senior Project Director, National Academy of Sciences (US) (27 September).

19. US State Department Official A (28 September) Recorded.

20. British Government Official B (21 December) *Department of Trade & Industry.*

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21. US State Department Official A (9 January) Recorded.

22. Export Control Lawyer, Powell & Goldstein (10 January).

23. US State Department Official B (19 January) Recorded.

24. US State Department Official A (19 January) Recorded.

25. US State Department Official C (19 January)

26. US Commerce Department Official B (29 January) Recorded.

27. US State Department Official D (29 January)

28. Sensors and Instrumentation Technical Advisory Committee (30 January) *Department of Commerce meeting with Industry.*

29. Senior Research Analyst, Institute for Defense Analyses (30 January).

30. Swedish Former Government Official (30 January) *Ministry of Foreign Affairs.* Recorded.

31. US Defense Department Official A & US Defense Department Official B (5 February) *Defense Technology Security Administration.* Recorded.

32. Senior Consultant, Institute for Defense Analyses (6 February).

33. Swedish Former Government Official (6 February) *Ministry of Foreign Affairs.*

34. US State Department Official E (7 February)

35. US Commerce Department Official C (8 February) *Person responsible for translating the Wassenaar Lists into the US control lists.*

36. British Government Official B (22 February) *Department of Trade & Industry.* Recorded.

37. British Government Official B, British Government Official E, & British Government Official F (22 February) *Department of Trade & Industry and Ministry of Defence.*

38. British Former Government Official (8 March) *Ministry of Defence.* Recorded.

39. British Former Government Official (22 March) *Ministry of Defence.*

40. (22 March) *British conference organised by Barry Fletcher and David Hayes for Industry concerned with export controls.*

41. (26 March) *Dinner with the British delegation to the Wassenaar Experts Group.*

42. German Government Official (27 March) *Federal Office of Economics and Export Control, BAFA.*

43. Swedish Government Official (27 March) *Inspectorate of Strategic Products.*

44. German Government Official (28 March) *Federal Office of Economics and Export Control, BAFA.*

45. Russian Government Official & British Government Official F (28 March) *Russian Ministry of Foreign Affairs and British Department of Trade and Industry.*

46. Wassenaar Secretariat Official D (28 March)
47. British Wassenaar Industry Consultant A for low-light sensing technology (28 March) *Project Manager, e2v.*
48. British Former Government Official (4 June) *Ministry of Defence.*
49. Wassenaar Secretariat Official C (13 June)
50. (13 June) *Dinner with US delegation to Wassenaar Expert Group.*
51. Canadian Government Official A & Canadian Government Official B (15 June) *Export Controls Division, Department of Foreign Affairs and International Trade.*
52. British Wassenaar Industry Consultants A & B for low-light sensing technology (17 June) *e2v and Andor Technology.*
53. Japanese Government Official (19 June) *Permanent Mission of Japan to the International Organizations in Vienna.*
54. Swedish Former Government Official (10 July) *Ministry of Foreign Affairs.* Video conference.
55. British Former Government Official (13 July) *Ministry of Defence.* Phone meeting.
56. Swedish Former Government Official (10 August) *Ministry of Foreign Affairs.* Video conference.
57. US State Department Official A (22 August) Phone meeting.
58. British Government Official B (15 October) *Department of Trade and Industry.* Phone Meeting.
59. British Former Government Official (8 November) *Ministry of Defence.*
60. US State Department Official B (13 December)

61. US State Department Official A (13 December)

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62. British Former Government Official (19 March) *Ministry of Defence.* Phone meeting.

63. British Former Government Official (20 March) *Ministry of Defence.* Email correspondence.

64. Senior Consultant, Institute for Defense Analyses (24 March - 1 April). Phone and Email Correspondence.

65. British Wassenaar Industry Consultant A for low-light sensing technology (14 May) *Project Manager, e2v.* Phone Meeting.

66. British Former Government Official (3 June) *Ministry of Defence.*

67. British Wassenaar Industry Consultant C for thermal sensing technology (5 June) *Chief Engineer, InfraRed Intergrated Systems Ltd (British).* Recorded.

68. US Emerging technology and research advisory committee (23 Sept) *Department of Commerce.* Teleconference.

2009

69. US Emerging technology and research advisory committee (6 April) *Department of Commerce.* Teleconference.

70. Email exchange with US Commerce Department Official C (18–19 May)

F
Membership in Wassenaar & other multilateral export control arrangements

This appendix serves as a reference for when countries became members of Wassenaar. It also contains a chart from Anthony & Bauer (2006, p. 776), citing the membership in each of the Multilateral Export Control Regimes as of 1 January 2006. For a graphical representation of the Participating States of the Wassenaar Arrangement, please see Figure 4.1 on page 143.

In the table below, the dates in parentheses are the dates when the State joined the New Forum, and the States in italics were CoCom members. For the date of formation, I take the date of the first Plenary meeting of the operational Arrangement (i.e. after the 'Initial Elements' had been agreed), 12–13 December 1996. For a discussion of the progression of dates from the New Forum to Wassenaar, see Wassenaar Arrangement (2008*b*).

Table F.1: *Participating States of the Wassenaar Arrangement and when they joined*

Date Joined	Participating State	Date Joined New Forum
12–13 December 1996	Argentina	(2–3 April 1996)
	Australia	
	Austria	(31 March 1994)
	Belgium	
	Bulgaria	(11–12 July 1996)
	Canada	
	Czech Republic	(11–12 September 1995)
	Denmark	
	Finland	(31 March 1994)
	France	
	Germany	
	Greece	
	Hungary	(11–12 September 1995)
	Ireland	(31 March 1994)
	Italy	
	Japan	
	Luxembourg	
	Netherlands	
	Norway	
	Poland	(11–12 September 1995)
	Portugal	
	New Zealand	(31 March 1994)
	Republic of Korea	(2–3 April 1996)
	Romania	(2–3 April 1996)
	Russian Federation	(11–12 September 1995)
	Slovak Republic	(11–12 September 1995)
	Spain	
	Sweden	(31 March 1994)
	Switzerland	(31 March 1994)
	Turkey	
	Ukraine	(11–12 July 1996)
	United Kingdom	
	United States	
9–10 December 2004	Slovenia	
April–June 2005	Croatia	
	Estonia	
	Latvia	
	Lithuania	
	Malta	
13–14 December 2005	South Africa	

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Table 16.1. Membership of multilateral weapon and technology transfer control regimes, as of 1 January 2006

State	Zangger Committee[a] 1974	NSG[b] 1978	Australia Group[a] 1985	MTCR 1987	Wassenaar Arrangement 1996
Argentina	x	x	x	x	x
Australia	x	x	x	x	x
Austria	x	x	x	x	x
Belarus		x			
Belgium	x	x	x	x	x
Brazil		x		x	
Bulgaria	x	x	x	x	x
Canada	x	x	x	x	x
China	x	x			
Croatia		x[c]			x[c]
Cyprus		x	x		
Czech Republic	x	x	x	x	x
Denmark	x	x	x	x	x
Estonia		x	x		x[c]
Finland	x	x	x	x	x
France	x	x	x	x	x
Germany	x	x	x	x	x
Greece	x	x	x	x	x
Hungary	x	x	x	x	x
Iceland			x	x	
Ireland	x	x	x	x	x
Italy	x	x	x	x	x
Japan	x	x	x	x	x
Kazakhstan		x			
Korea, South	x	x	x	x	x
Latvia		x	x		x[c]
Lithuania		x	x		x[c]
Luxembourg	x	x	x	x	x
Malta		x	x		x[c]
Netherlands	x	x	x	x	x
New Zealand		x	x	x	x
Norway	x	x	x	x	x
Poland	x	x	x	x	x
Portugal	x	x	x	x	x
Romania	x	x	x		x
Russia	x	x		x	x
Slovakia	x	x	x		x
Slovenia	x	x	x		x
South Africa	x	x		x	x[c]
Spain	x	x	x	x	x
Sweden	x	x	x	x	x
Switzerland	x	x	x	x	x
Turkey	x	x	x	x	x
UK	x	x	x	x	x
Ukraine	x	x	x[c]	x	x
USA	x	x	x	x	x
Total	**35**	**45**	**39**	**34**	**40**

NSG = Nuclear Suppliers Group; MTCR = Missile Technology Control Regime

Figure F.1: *Multilateral Export Control Regime membership (Anthony & Bauer, 2006)*

G
Guidelines for the Drafting of Lists

The *Guidelines for the Drafting of Lists* was a document produced by the Drafting Group of the New Forum, as an aid to those who maintained the lists. While it was used, it was never formally adopted by the Arrangement. It is reproduced in full here. This is an exact copy of the Guidelines. In 2007–2008, it was revised and formally adopted. The revised Guidelines appear second.

GUIDELINES FOR THE DRAFTING OF LISTS

TO: DRAFTING GROUP MEMBERS

These Guidelines have been developed with the Dual-use List in mind. Not all sections of these Guidelines will necessarily apply to the drafting of the munitions List.

VINCE HATHWAY
Chairman Drafting Group.
12th February 1996

GUIDELINES FOR THE DRAFTING OF LISTS

GENERAL FRAMEWORK

1. **<u>Introduction</u>**

To ensure consistency in the format, wording and interpretation of the entries in the Lists. The entries will follow a. common layout as far as possible. This should assist in the clarity and transparency of the entries, as well as assisting licensing officials and enforcement officials in Participating Countries in thee uniform application of export controls. The objectives of the Drafting Group are reproduced in Annex 1 in draft form only.

All entries should be generated using the following framework specification:

2. **<u>Entry Structure</u>**

Each entry should comprise al1 or some of the following elements, as required:

a. Chapeau (or head) - identifies the broad types or ranges of items to be controlled;

b. Characteristics or Specifications - introduces where there is a need to identify that only a subset of the items in the chapeau are controlled (e.g., particular types exceeding specified performance levels or having certain listed characteristics);

c. <u>Notes</u>
- *used to exclude items from control (e.g. where a particular type of item should not be controlled);*
- *also used to clarify the scope of the control of the entry and provide additional information regarding the intent where this may not be clear.*
- *written in italics so as to stand out from the main entry text.*
- *within definitions, N.B. is used in preference to Notes.*

d. <u>Technical Note</u> - *used to provide additional or detailed technical information, specifications, test conditions and methods, etc. Also used for local definitions within entry, see 12.b. Written in italics so as to stand out from the main entry text. 2nd and subsequent lines of text are left justified under 'T' of 'Technical Note'.*

e. <u>N.B.</u> - *used when a '<u>Note</u>' is a required within a '<u>Note</u>' or 'Technical Note' within a definition, or to cross-refer to associated entries. Written in italics so as to stand out from the main entry text*

3. Chapeau

The Chapeau sets the scope of the entry. Where it is intended to cover all types of the item(s) identified, it should stand alone as the full extent of the control text
The chapeau may contain one general limiting characteristic; any more may lead to ambiguity in the intended scope of the entry.

4. Cascading Lists

Note Refer also to Section 13. for a summary of the entry structure.

a.1. Where it is necessary for an entry to comprise more than one of the elements in Section 2., then, as appropriate, the text of the Chapeau plus Characteristics or Specifications or exceptions should read through as a single sentence or paragraph in all cases by using semicolons, colons and full-stops as appropriate to separate the items in the List

2. Thus each of the elements 2.a. or 2.b. should read through as a single sentence with each element, or each item within each element, being terminated by a semi-colon with the final element being terminated by a full-stop.

3. Elements 2.c., 2.d. or 2.e. should always be terminated by a full-stop.

b. Paragraph numbering and indenting should follow the rules specified in Section 5.

c. It is essential that if any item is intended to be controlled it must first be identified in the Chapeau. The Chapeau is to: first 'controlled/not controlled check' that has to be gone through in order for am item to be controlled. Listed specifications or characteristics are the second 'controlled/not controlled check', exceptions the third, and so on.

d. Where an entry consists of a list of several items, characteristics or specifications, in order to simplify the entry, the Chapeau should introduce the List by words such as "… as follows:" or " ...designed to have all/any of the following:" or some variation of these. Thus, an item identified in the Chapeau will only be controlled if it is of a type listed after the chapeau and exceeds the listed specifications or has the listed attributes.

e. Conversely, any text in a Chapeau after a list has been introduced (e.g., text following "as follows") will have the effect of controlling any items described by that text without need for the described items to be separately listed.
A good example of this is where a Chapeau reads " ...as follows, and specially designed components therefor:". This indicates that any component specially

designed for the items in the list is also controlled, even though such components are not on the list following the Chapeau.

f. Where a list of items is first identified in the Chapeau, (before "as follows:” for example), an “and” -list of construction should be used. The understanding of our "and"-list construction is that "a11 or any of" the items listed are in the scope of the chapeau.

e.g., Optical fibre communication cable, optical fibres and accessories, as follows:

For the use of the comma in such cases, refer to section 8.

5. Sub-entry References

Presentationally, the standardised layout is that each of the elements required should start on a new line, with indenting and numbering as shown below.
After the entry reference, levels of cascading should alternate between alpha and numeric characters as shown below, starting with an alpha character.
Each new line should commence with an upper case letter as shown below.

e.g., a. Upper case
    1. Upper case ...;
    2. Upper case ...;
        a. Upper case...;
            1. Upper case...; etc.,

6. Lists of Characteristics/Specifications

Cascading characteristics or specifications should be linked with an explicit 'and' or ‘or’ before the last entry in the list, in order to clarify the intent of the entry.
(Lists without 'and' or ‘or’ can be ambiguous.)

7. Lists of Items

Cascading Lists of items do not need to be linked by an 'and' or ‘or’, as the intent of the control is clear.

8. Use of the Comma in Lists

In a list of three or more items such as:

a, b, c, d, e and f.

the normal way of punctuating such a list is shown above with the commas between "a and b", "b and c", “c and d” and “d and e'" taking the place of "and" There is no comma after "e" because, with "and", it would normally serve no practical purpose, unless a comma is necessary in the particular context to make it clear that "e" and "f" are separate words and not a phrase. Thus where any ambiguity is possible the comma should be inserted.

Similarly with an 'or':

a, b, c, d, e or f.

9. Use of Illustrative Lists

The use of illustrative lists, typically headed by "e.g.", “including", “includes", "such as", etc.. in an entry should be avoided, and should be replaced by a more explicit entry. The long-term aim should be to replace illustrative lifts as far as possible, either by using exhaustive lists in an entry. or by clarifying the intent of the control text. Where an illustrative list is to occur, "e.g." is preferred.

NOTE: Where an "e.g. " occurs the "e.g. " and its related tax: shall be enclosed within parentheses, this is to clearly identify what: text relates to the "e.g. ". Parentheses should also be used fn similar circumstances.

10. Positioning of "Notes" "Technical Notes" and "N B."

The positioning of the above elements in an entry is particularly important and should be left-justified with the left-hand edge of the entry to which the element applies, and for "Notes" should contain a specific reference to the entry or sub- entry to which it is related. A specific reference is only recommended for "Technical Notes" and "N.B." if clarity is required.

11. Us: of the Singular/plural

It is generally accepted that the singular implies the plural, and the plural implies the singular. However, where the context results in the entry being open to alternative interpretations, the entry text should be explicit.

12. <u>Definitions</u>

Two types of definitions are used, either global or specific to a particular entry.

a. Some words and terms are defied for use throughout the Lists, all uses of a defined word will be used with that definition. As an assistance to the reader double quotes (") will be used throughout the Lists to enclose words or phrases which have an associated definition. Such definition will be listed in the section of the Lists entitled "Definition of Terms Used in These lists.

b. For definitions specific to a particular entry, single quotes (') will be used to enclose words or phrases used as a defined term within the entry, and such definitions will be included within a "Technical Note" to that entry.

NOTE: It is important that defined terms should never be used in their undefined form. (i.e. without use of double quotes).

13. <u>Summary of Entry Structure</u>

a. The general structure of an entry using "as follows" in the chapeau will be:

<item/sub-item descriptions>, <cone general limiting characteristics>.
<general extensions of the control$_1$>, <as follows>
<general extensions of the control$_2$>.
<*<u>N.B.</u>*.>.
<*<u>Notes</u>*>.
a. <item 1>;
b. <item 2>;
c. <item 3>.
<*<u>Notes</u>*>.
< <u>Technical Note</u>>.

Where;
<item/sub-item description>
means: equipment system, components, material, etc., separated by "," with an “and” between the last two items.

<one general limiting characteristic>|
means: “specially designed for...”, etc.

<general extensions of the control1>
means: “and components therefor”, etc., the specific components under control being specifically listed after the “as follows”.

<as follows>
means: indication that a list of items will follow.

<general extensions of the control$_2$>

means. "and components therefor", etc.. indicating that any components for the items described before the "as follows" are controlled even though not included or specified in the list following the "as follows".

<*N.B*.>.

means: Cross reference to related entry, Section 2.e. refers.

<*Notes* >.
means: Sections 2.c. and 2.e. refer.

< *Technical Note* >.
means. Sections 2.d. and 2.e. refer.

NOTE Items, (e.g., <item 1>) may also it structured in line with 13.a. (except that "Notes" and "Technical Notes" should be positioned after the sub-entry or specific text to which they apply).

b. The general structure of an entry when "as follows" is not used in the chapeau will be:

<items/*sub*-items descriptions>, <one general limiting characteristic>, <general extensions of the control>, <having all/any of the following ~~characteristics~~>
<*N.B*.>.
<*Notes*>
a. <attribute 1>;
b. <attribute 2>; and/or
c. <attribute 3>.

<*Notes*>.
< *Technical Note*>.

where:
<item/sub-item description>
means: equipment, system, components, material, etc., separated by "," with "and" between the last two items.

<one general limiting characteristic>

means: "designed for use "…", etc.

<general extensions of the control>
means: "and" components therefor", etc., indicating that any components for the items described are controlled.

<having all/any of the following attributes>
means: words that link the item to the attributes that follow.

<*N.B.*>.
means. Cross reference to related entry. Section 2.e. refers,

< *Notes* >.
means: Sections 2.c. and 2.e. refer.

<*Attributes*>
means: any characteristic, function or feature, etc.

< *Technical Note*>.
means: Sections 2.d. and 2.e. refer.

14. System of Units

a. The Lists will use the International System of Units (SI) in all cases, exception will be avoided if at all possible. The defining source for the appropriate SI unit will be ISO 31 of 1992 all parts (i.e. parts 0 to 13). A list of commonly used SI units is reproduced in annex 2.

b. Where an item is commonly sold using another measurement unit or is commonly used in commerce in some supplier countries, a second measurement unit may be given in parentheses after the SI quantity. In all cases the physical quantity defined in S1 units will be considered the official recommended control value, and accuracy values will be derived from the SI units

c. Temperatures will be defined in Kelvin (K) with the value in degrees Celsius (^{0}C) following in parentheses (e.g., 1573 K (130O^{0}C)).

d. Angular measurements will be defined in degrees (^{0}).

e. ln all cases where percentages are given, the intended denomination (weight, volume, etc.,) will also be specified.
(e.g., …made from more than 50% by weight of any of...).

f. Where a unit abbreviation appearing in text could cause confusion, the unit shall be spelt out.

EXAMPLE LIST OF
COMMONLY USED SI AND DERIVED SI UNITS AND ABBREVIATIONS

A	-	Ampere(s)	-	Electric current
^{o}C	-	Degree(s) Celsius	-	Temperature
cm^{3}	-	Cubic centimeter(s)	-	Volume (solids)
^{o}	-	Degree(s)	-	Angle
dB	-	decibel(s)	-	Sound or Power Ratio
dBm	-	decibel referred to 1 milliwatt	-	Sound or Power Ratio
g	-	grams(s)	-	Mass
	-	Acceleration of gravity (9.8 m/s^{2})	-	Acceleration
GBq	-	gigabecquerels(s)	-	Activity (radioactive)
GHz	-	gigahertz	-	Frequency
Gy	-	gray(s)	-	Absorbed ionising radiation
h	-	hour	-	Time
J	-	joule(s)	-	Energy, work, heat
keV	-	kiloelectron volt(s)	-	Energy, electrical
kg	-	kilogram	-	Mass
kHz	-	kilohertz	-	Frequency
kN	-	kilonewton(s)	-	Force
kPa	-	kilopascal(s)	-	Pressure
kT	-	kilotesla(s)	-	Magnetic flux density
kW	-	kilowatt(s)	-	Power
K	-	kelvin	-	Thermodynamic temperature
L	-	litre(s)	-	Volume (liquids)
m	-	metre(s)	-	Length
m^{2}	-	square metres	-	Area
mA	-	millamp(s)	-	Electric current
min	-	minute(s)	-	Time
ml	-	milliletre(s)	-	Volume (liquids)
MeV	-	million electron volt(s)	-	Energy, electrical
MHz	-	megahertz	-	Frequency
MPa	-	megapascal(s)	-	Pressure
MW	-	megawatt(s)	-	Power
µF	-	microfarad(s)	-	Electric capacitance
µm	-	micrometer(s)	-	Length
µs	-	microsecond(s)	-	Time
mm	-	millimeter(s)	-	Length
N	-	newton(s)	-	Force
nm	-	nanometer(s)	-	Length
ns	-	nanosecond(s)	-	Time
nH	-	nanohenry(s)	-	Electrical inductance
Ω	-	ohm(s)	-	Electric resistance
ps	-	picosecond(s)	-	Time
r	-	rad	-	Radian
rpm	-	revolution per minute	-	Angular velocity
rms	-	root mean square	-	Square root of the time average or the square of the quantity
“	-	second of arc	-	Angle
V	-	volt(s)	-	Electrical potential
W	-	watt(s)	-	Power

Annex 3

TERMINOLOGY - DRAFTING USAGE

Item:	Means anything which may be presented for export.
Entry:	Means referenced portion of text in a List.
Specially Designed for:	Means any object whose design includes particular features to achieve some particular purpose. This will typically involve extensive research and development activity.
Designed for:	Means any object whose design is general in nature to achieve some particular purpose. Typically extensive research and development will not be involved
Controlled:	Means any item within the intended control scope of a List.
Described:	Means any item in a List but which may or may riot be within the intended control scope of the List.
Component:	Means any physical item below the system or equipment level.

On the following pages is the 2007 version of the *Guidelines for Drafting the Lists*.

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H
Correspondence List

The Correspondence List is a list of items on the Dual-Use List and the Munitions List with similar functionality. It further shows the shading between what is and is not a dual-use technology. The 1997 version of the List is included on the following pages.[1]

[1] While it says "The text that differs from that in the List of Dual-Use Goods and Technologies is shaded," there is no shaded text in the document. I believe this may be due to how the document was reformatted when I received it. Originally a Microsoft Word document, I received it as a series of images.

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I
Best Practices for Implementing ITT Controls

The *Best Practices for Implementing Intangible Transfer of Technology Controls* was agreed at the 2006 Wassenaar Arrangement Plenary meeting, and signifies the most recent step of the Arrangement to harmonise efforts to control the intangible transfer of technology. This version is taken from Wassenaar Arrangement (2008*a*).

BEST PRACTICES FOR IMPLEMENTING INTANGIBLE TRANSFER OF TECHNOLOGY CONTROLS

(Agreed at the 2006 Plenary)

Ensuring that control is exercised over intangible transfers of both dual-use and conventional weapons technology[1] (ITT) and is recognized by Participating States of the Wassenaar Arrangement as critical to the credibility and effectiveness of their domestic export control regime. As clear and precise control requirements facilitate effective export control implementation, the Participating States have adopted the following "best practices" for the implementation of export controls over intangible transfers of WA-controlled technology.

A. Recognizing the inherent complexities of export control regulation for ITT, Participating States of the Wassenaar Arrangement support:

1. Designing national laws and regulations with clear definitions of ITT via both oral and electronic means of transmission; including,

   a) Determination of what constitutes an ITT export; and,
   b) Determination of when an ITT export occurs;

2. Specifying in national laws and regulations the intangible technology transfers which are subject to export control;

3. Specifying in national laws and regulations that controls on transfers do not apply to information in the public domain or to basic scientific research; and,

B. Recognizing that national export control authorities benefit from the cooperation of industry, academia, and individuals in the regulation of ITT, Participating States of the Wassenaar Arrangement support:

1. Promoting awareness of ITT controls by such means as publication of regulatory handbooks and other guidance material, posting such items on the internet, and by arranging or taking part in seminars to inform industry and academia;

2. Identifying industry, academic institutions, and individuals in possession of controlled technology for targeted outreach efforts and,

---

[1] "Technology"

Specific information necessary for the "development," "production" or "use" of a product. The information takes the form of technical data or technical assistance. Controlled "technology" for the Dual-Use List is defined in the General Technology Note and in the Dual-Use List. Controlled "technology" for the Munitions List is specified in ML22.

Technical Notes

1. 'Technical data' may take forms such as blueprints, plans, diagrams, models, formulae, tables, engineering designs and specifications, manuals and instructions written or recorded on other media or devices such as disk, tape, read-only memories.
2. 'Technical assistance' may take forms such as instruction, skills, training, working knowledge, consulting services. 'Technical assistance' may involved transfer of 'technical data.'

3. Promoting self-regulation by industry and academic institutions that possess controlled technology, including by assisting them in designing and implementing internal compliance programs and encouraging them to appoint export control officers.

C. Recognizing the importance of post-export monitoring and proportionate and dissuasive penalties to deter non-compliance with national ITT laws and regulations, Participating States support:

1. The imposition of a requirement on industry, academia, and individuals to keep records, for an appropriate period of time, that clearly identify all controlled technology transferred, the dates between which it was transferred, and the identity of the end-user of all intangible transfers of technology for which licenses have been issued that may be inspected by, or otherwise provided to, export control authorities upon request;

2. Regular compliance checks of those that transfer controlled technology by intangible means and,

3. The provision of training to export control enforcement authorities on appropriate investigative techniques to uncover violations of national controls on ITT exports or access to such specialist expertise;

4. Appropriate surveillance or monitoring, pursuant to national laws and regulations, of entities that are suspected by national export control or other relevant national government authorities of making unauthorized intangible transfers of controlled technology.

5. The sanctioning by national authorities of those under their jurisdiction that have transferred controlled technology by intangible means in violation of export controls.

D. Participating States also support:

1. The exchange of information on a voluntary basis concerning suspicious attempts to acquire controlled technologies, with appropriate authorities in other Participating States.

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