12 RRI intensity

A proposed method of assessing the requirement for responsible innovation in ICT projects

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12.1 Introduction

The rapid pace of technological progress in recent decades has not, it is now widely acknowledged, been matched by a similar increase in society's ability to manage the level and variety of change that this progress has brought (Wadhwa, 2014). Although ICT technologies such as machine learning and robotics have vast potential, alongside nano- and bio-technologies, they are deeply pervasive and their effects – both positive and negative – are only just beginning to be understood.

12.1.1 Societal impact

The acceleration of technology-enabled transformation proliferating through society creates an ever-decreasing window of opportunity for society to adapt. Technologies evolve at a much greater pace than societies can, and so change has time to spread before its true systematic impact can be recognized, quantified and assimilated. In addition, ICT is now deeply embedded within society and its omnipresence – as well as the way in which it has supplanted older forms of technology (for example, navigation apps have transformed the way we consume geospatial data) – means that the issues it brings with it are also ubiquitous.

12.1.2 Possible responses: before and after impact occurs

An *ex post* response – reacting to impact that may already have occurred – is only one way of dealing with the broader implications of technology-enabled transformation. It is the main method that is open to governments, regulatory bodies and other agencies that consider the effects of technology on the societies of which they are a part. However, regulatory frameworks, laws and the passage of cases through the courts all take time. These mechanisms are often slow, unwieldy and may only be able to react a long time after impacts have already occurred. Even institutional bodies set up to examine particular issues, such as the Ada Lovelace Institute[1] and the Centre for Data Ethics and Innovation,[2] are responding only slowly to events. In the case of the Cambridge Analytica use of Facebook's data, the implications were only beginning to become clear over two years after the event, and as of December 2018, no prosecutions have taken place (though Facebook was fined £500,000 by the UK's Information Commissioner in October 2018 – the maximum possible[3]).

An alternative to mechanisms that are predicated on actual impact are mechanisms that act *ex ante*. This approach aims to act to anticipate impact. There are many ways of potentially doing this, but many focus on the actions of researchers, developers and other innovators at the design and development stages of new technologies. These approaches are often drawn together collectively under the banner of responsible innovation (RI) or Responsible Research and Innovation (RRI). However, it is crucial to consider that RRI is not just about maximising benefits and managing risks, but about integrating societal preferences and actors into research and innovation (R&I).

The UK's Research Councils, which fund much of the UK's academic research, have adopted the AREA (anticipate, reflect, engage, act) framework approach to RRI created by Stilgoe, Owen, and Macnaghten in 2013. RRI is sometimes regarded as a type of risk management, but its fundamental aim is to bring science and society closer together and to foster mutual learning by involving a range of stakeholders in the R&I process.

In this paper we go beyond the *'why'* of RRI to consider the qualitative features and quantitative parameters which could help to guide researchers in making a case for *how* and *how much* RRI should be undertaken to create the best outcome for society. We introduce the concept of RRI intensity level (RIL) as a method of evaluating what type of and how much RRI activity is meaningful, useful, sensible and effective (MUSE). We calculate the RIL based upon assessments of two parameters – the anticipated technology readiness level (TRL) and the novel concept of innovation potential. We define innovation potential here as an indicator of the potential breadth and depth of societal impact of a technology, and suggest that this is a crucial parameter to consider when determining the choice and scale of the RRI activities to be undertaken.

In calculating this anticipated impact, it is necessary to use some agreed goal against which to measure the impact, and we utilise the United Nations (UN) sustainable development goals (SDGs), as these represent the best current approximation for what the representatives of a significant proportion of humanity regard as important.

12.1.3 Research gap

The academic discourse around RRI is now well established, with numerous academic papers (e.g. Jirotka, Grimpe, Stahl, Eden & Hartswood, 2017;

Martinuzzi, Blok, Brem, Stahl, & Schönherr, 2018; Stahl, Obach, Yaghmaei, Ikonen, Chatfield & Brem, 2017; von Schomberg, 2013) and even a dedicated academic journal (the *Journal of Responsible Innovation*). There are also many dedicated projects funded by the European Commission (EC) and others looking at RRI in different disciplines and fields of industry. These include: education (Ark of Enquiry, HEIRRI, IRRESISTABLE); industry (Responsible-Industry, COMPASS); research-funding organisations (RRI-Practice) or the application of RRI in specific areas of R&I, such as synthetic biology (Zhang, Marris, & Rose, 2011) or ICT (Jirotka, Grimpe, Stahl, Eden, & Hartswood, 2017). This volume of research work demonstrates that RRI has taken its place as an established and reputable means of maximising the benefits of technology transformation whilst minimising the potentially harmful associated outcomes.

What is less clear, however, is the degree to which it is necessary to realise and implement RRI to optimise its beneficial effects. We therefore use this chapter to discuss the following research question:

- How can the level of RRI activity be optimised to suit the characteristics of an individual project?

Given the variety of projects where RRI is mandated by funding bodies, the range of technology stages that may be covered and the relative experience of the project investigators in implementing RRI, this is a critical question that needs to be answered appropriately in order for practical RRI activities to be developed and implemented in a manner that suits the project variables.

In order to answer this research question, we first review the definitions and current discourse on RRI. This is followed by the introduction of the concept of RIL. We show how this concept can be extended from the literature and which factors would be important to consider. We then develop this into a formal structure of RIL. The chapter closes by suggesting further research that would help to validate this idea.

12.2 Responsible Research and Innovation (RRI)

12.2.1 Definitions and foundation

RRI has been described as a "way of thinking more systematically about the public benefits of science and technology-based research" (Nuffield Council on Bioethics, 2013), though in the same document the council points out the number of other definitions and factors to be considered. Since then, the RRI community has largely coalesced around this broad view, with a lengthier definition, from von Schomberg, now being widely cited. This sees RRI as a:

> transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view to the (ethical)

> acceptability, sustainability and societal desirability of the innovation process and its marketable products (in order to allow a proper embedding of scientific and technological advances in our society).
>
> (von Schomberg, 2013, p. 63)

This definition is in accordance with the aforementioned broad description, but it is crucial to consider that RRI is not just about managing risks and maximising benefits, but about integrating societal preferences and actors into the R&I process.

In the same vein, Stilgoe, Owen, and Macnaghten (2013) proposed a framework for RRI that focuses on four integrated dimensions to be adopted when carrying out responsible research activities. These are anticipation, reflexivity, inclusion and responsiveness. This framework was adapted and adopted by the UK Engineering and Physical Sciences Research Council (EPSRC) to form the AREA framework (Owen, 2014).

Another highly influential contribution to the RRI discourse comes from the EC that, as the largest funder of research in Europe, has a significant influence on research policy. The EC has adopted RRI as a cross-cutting activity that informs all aspects of its Horizon 2020 research framework programme in the years 2014 to 2020. In the EC's view, RRI consists of a number of pillars that correspond to established research policy areas. These are civil society engagement, gender equality, science education, open access, ethics compliance and governance.

12.2.2 Development and implementation

The overall aim for RRI is to promote the consideration of the effects of R&I on the environment and society before, during and after a particular project. While several studies have focused on RRI in the broad theoretical sense, few have detailed the specifics of the ways in which those RRI concepts can be applied to actual projects. The practical reflections in this chapter will enrich the further development of the RRI framework, thereby contributing to its wider use.

RRI principles allude to Latour's observation that "there [is] no direct connection between scientific results and the larger context of society, which could do no more than slow down and speed up the advancement of an autonomous science" (Latour, 1998, p. 208). The discourse around RRI has now reached a significant level of maturity. Following initial attempts to define the term and promote it as a relevant aspect of research governance, there is now growing agreement on key aspects of RRI and possible means of implementation. This does not mean, however, that RRI is unproblematic. There are deep-seated contradictions and problems that can limit the potential success of RRI. One example is the desire of RRI to broaden the conversation about R&I to include wider stakeholder groups; this sits very uneasily with the traditionally tightly focused definition of excellence in research. Another challenge for RRI is that much of the academic discourse centres around the carrying out of publicly funded research. However, a significant amount of research, and a large proportion of innovation activities, are conducted by privately funded organisations. It is not immediately obvious whether the arguments in favour of RRI are relevant to companies, or whether the incentive structures that are being put in place resonate with companies' R&I processes. There is, therefore, a significant need for investigation of the relevance and potential role for RRI in industry.

Using the core concept of responsibility in RRI as a point of departure, Stahl (2013, p. 3) suggests that RRI could be further refined "as a higher-level responsibility or meta-responsibility that aims to shape, maintain, develop, coordinate and align existing and novel research and innovation-related processes, actors and responsibilities with a view to ensuring desirable and acceptable research outcomes". Stahl also viewed RRI as a space defined by activities, actors and norms, thus emphasising the need for a systemic approach to determine the acceptability and desirability of R&I.

12.2.3 RRI as an extension of prior methods

For innovations in ICT, the introduction of RRI may be viewed as a reinforcement and extension of existing models and conceptual frameworks, such as user acceptance models (Davis, 1989) and participatory action research approaches (Baskerville, 1999). While these models emphasise user involvement for increasing the acceptance of technology products and services, the Scandinavian research on information system development stresses workplace democracy as a driver for involving users and giving them power over design decisions (Bjerknes and Bratteteig, 1995). However, the discussions around user involvement and participation have been limited to the organisational level. Participatory approaches have also been used mainly to promote the traditional view of using participation for "right impact" and risk mitigation (Owen, Macnaghten, & Stilgoe, 2012). The concept of engagement in RRI expands the discourse of user engagement to the societal level for critically investigating the social, economic and ethical dilemmas and opportunities surrounding the decisions, actions and outcomes related to R&I. RRI, however, is more than a theoretical debate. It has become an overarching practical R&I governance approach for ensuring the desirability, acceptability and sustainability of ICT-based innovations (Jirotka et al., 2017).

12.2.4 Balancing creativity and compliance

The discourse on the nature, justification and outcomes which might be expected of RRI has stimulated many research projects. However, when it comes to the practicalities of implementing RRI as part of an R&I activity the discourse has bifurcated into two distinct strands: one which favours detailed methodologies akin to those developed in projects such as COMPASS and RRI Tools, and the other which suggests that researchers looking to implement RRI in their projects draw upon their innate creativity in defining how RRI should be implemented for a particular project in a particular field.

We recognise that the discourse on RRI has, with the best of intentions, focused on avoiding being seen as a constraint on innovation and curiosity, but this has arguably come at the cost of making the scoping, design, management, costing and justification of RRI activities in research projects difficult for researchers not experienced in RRI. Thus, the appeal to creativity rather than compliance has stimulated innovation, but could be seen as a contributing factor to the inconsistent approach in the adoption of RRI in ICT projects in particular.

We recognise that an overly prescriptive and formulaic approach to how RRI is implemented could be seen as confining the freedom of the ICT research community; however in other fields where structured processes have been implemented for simple elements of highly complex tasks, these simple procedures have been found to yield significant benefits. A good example of this is the use of checklists in surgical procedures. Such checklists were trialled in surgical procedures and found to significantly reduce clinical error, and improve patient outcomes, despite the initial resistance and scepticism of the surgical community (Gawande, 2010). Checklists have also been used in the aviation sector for many years, for example in pre-flight checks, as a way of avoiding simple mistakes within the context of a complex set of tasks. These findings demonstrate that highly experienced professionals can avoid simple but important errors by the use of prescriptive procedures which, rather than constraining their creativity, liberate them from the risks associated with systematic error, and allow them to focus on areas where creativity rather than compliance will yield the greatest outcome.

We are not suggesting that RRI needs to be implemented in the form of checklists. The example of such checklists is used to show the importance of taking seriously the question of implementation of generally accepted, socially beneficial processes, and how a relatively structured approach can be valuable. While there has been much discussion of ways of "doing" RRI in the literature and while there are numerous case studies, there is at present no clear view on which RRI-related processes or activities would be required or appropriate in a particular situation. This is a clear gap in the literature, as it is intuitively plausible that different types, levels and sizes of projects will require different responses. So far, however, there has been little discussion of how a decision on the appropriate implementation of RRI in a particular case should be made. In order to address this gap, we propose the idea of RIL.

12.3 Responsible Research and Innovation intensity level

This methodology is intended to be applied during a project definition process, most likely as part of an application for funding. The RIL process is an

RRI activity in its own right in as much as it helps to define the intensity of RRI which should take place in the future, should the project be carried out.

Any assessment of RI requirements must gauge not only what RRI must be undertaken (what is *necessary*) but also how much is enough (*sufficient*). These two questions must both be answered correctly in order to ensure that the right balance is found. An appropriate pathway must be followed between a zealous approach to RRI that could be seen to be a constraint on curiosity as well as potentially a misuse of public research funding, or an overly *laissez-faire* approach that could put society at risk from innovation that has not been carefully considered.

The questions of *whether* and *why* RRI is carried out must therefore be extended to include the concepts of when, *how* and *how much* RRI should be undertaken. Utilising and integrating the concept of the RRI maturity model proposed by Stahl et al. (2017), the authors are therefore proposing this new concept aimed at the assessment of this measurement. This method seeks to gauge how much RRI is both *necessary* and *sufficient*. This assessment is a crucial precursor to the actual carrying out of RRI activities, which cannot be undertaken without reference to the context and development of a particular project.

This novel method is being termed RIL. It is a method of evaluating a research project (with a particular focus on ICT projects) and then selecting how much and what type of RRI activity is feasible, appropriate and effective.

We propose an approach to establishing the RIL based upon a matrix that takes into account its position along two axes: the TRL, and the innovation potential level. Innovation potential is a hybrid scale intended to indicate in what manner and to what degree a technology might affect wider humanity. The result of a given project's position along these two axes results in an RIL score. The score provides a measurement of when, how and how much RRI should be undertaken before and during the project. For example, a high RIL score may indicate very significant stakeholder involvement, perhaps even at policy-making level, as well as other governance measures such as a series of agreed "stage-gates" (cf. Stilgoe et al., 2013). Conversely, a low RIL may only require involvement of the researcher's broader team or department and sufficient departmental or supervisory oversight.

12.3.1 Technology readiness and innovation potential

The selection of these two dimensions is based on the recognition that RRI practice is related to at least two aspects of a research or innovation project.

The first of these is the project's *readiness*. This links to Collingridge's famous dilemma of control (Collingridge, 1981). As Collingridge showed, at an early stage of development it is relatively easy to change the trajectory and thus the outcomes of a particular technology. However, at such an early stage it is difficult to predict what exactly the outcomes will be. During the development process, as a piece of innovation or technology matures, its consequences become clearer but the trajectory is more difficult to change. Another analogy would be that of stem cells, that in their initial state may develop into many different forms, but once that development matures, the earlier options become closed off. This shows the need for RRI along the entire life cycle of an innovation but also demonstrates that more mature technologies need to be covered in more depth, as their consequences can be understood better, not only by their developers but by other stakeholders in society. Therefore, in order to measure this developmental stage of a project, we propose using a well-established indicator (Olechowski et al., 2015) of maturity of a technology, the TRL. TRLs were originally developed by NASA[4] as a method of measuring the maturity of space exploration technology. A variety of different industries now use the same approach and utilising this measure provides a cross-platform, consensus-based measure that can be understood across both academia and industry. It did not appear to be valuable to create a new measure of assessing a project's developmental phase.

The second aspect that affects RRI decisions is the *impact* and *reach* of a project. Technology readiness is important, but it is easy to see that on its own it is not sufficient to provide accurate information about the amount of effort that needs to be invested into RRI in a particular instance. A technology may have a high TRL and be close to market, but could have very little societal impact, thus the TRL measure alone is insufficient to determine the level of RRI activities which are appropriate. We therefore need an indication of the *type* (impact) and *level* (reach) of social change that the technology may create. There are various indicators for the level of disruption that can result from the deployment of a technology, such as those from KPMG,[5] Gartner,[6] Cisco[7] and other professional service organisations, but these do not concern themselves with social disruption. Their focus is on disruptive impact on business and therefore seek to find ways to manage risk. These may, therefore, be sufficient for the risk management part of RRI.

However, it is crucial to consider that RRI is not just about managing risks and maximising benefits, but about integrating societal preferences and actors into R&I. If RRI is to incorporate and take into account societal values, then it is vital to understand the level to which these are likely to be affected by an innovation, in order to determine the scope and scale of RRI-related efforts. There is much debate within the RRI community about the types and instantiations of these values that R&I are meant to promote. Suggestions include philosophical ethics, more applied approaches such as research ethics or corporate social responsibility, or more politically oriented candidates such as human rights (Oftedal, 2014). We believe that all of these are valuable, but lack the specificity required to guide practical action. We therefore propose to rely on a set of normative aims that are now well established, build on and incorporate many of the earlier more abstract values, and that are internationally discussed and agreed. These are the UN's SDGs (United Nations, 2015), as we will show in more detail below. Relevance of a piece of research, innovation or technology to the

SDGs is therefore the second measure that we consider when determining the level of RRI that would be *necessary* and *sufficient* to ensure that societal needs and preferences are expressed.

12.3.2 Step 1: Axis 1 – technology readiness level

To be effective, RRI needs to be embedded in the research process, but we posit, at an appropriate level of intensity, proportional to the stage that the research is attempting to reach. For example, undertaking public engagement activities for basic research would pose significant challenges in defining any realistic scenarios for potential societal impacts, comprehensively identifying stakeholders or creating actionable insights. Broad public engagement work would, however, be entirely appropriate for work that anticipated a substantial impact and an imminently marketable result.

TRL is one development pathway for new technologies. These give a common reference point when considering the level of development a given technology has achieved. The journey of any given technology through the technology development pathway is rarely a simple linear progression; there are likely to be frequent forks in the path, dead ends or feedback loops where activities generate new avenues of research, invention and iteration, or where components of systems at higher readiness levels in their own right are considered to be at a lower level when integrated into a new system.

The TRL scale has its own challenges when it comes to using it as a predictor of how technologies may interact with marketplaces. The science 'push' model, which is predicated upon the suggestion that science leads market adoption, has limited predictive validity and ignores the vast range of activity that will never reach a marketplace. Conversely the technology 'pull' model – that the market pulls desired new technologies out of the laboratory – is also too simplistic. Neither model takes into account the range of complex ways in which new technologies may reach fruition. In addition, this has a consequentialist approach to harms which conflicts with the virtue-ethics approach that suggests responsible methods should be undertaken even if the development may never progress to a final, public, form. Pathways to widespread adoption may also vary by industry sector and technology domain.

Table 12.1 shows the increments of the TRL score. The TRL is the score that is aimed at for the *end* of the project. As noted above, the technology may develop through loops, or may not reach its targeted readiness level, so the score will undoubtedly be less than 100% accurate, but it is suggested that this is sufficient for our purposes.

12.3.3 Step 2: Axis 2 – innovation potential

As discussed above in considering the fundamental principles of RRI, one of the critical success factors for an RI approach is the consideration of societal

Table 12.1 Technology readiness levels (TRLs)

TRL 1	Basic principles observed
TRL 2	Technology concept formulated
TRL 3	Experimental proof of concept
TRL 4	Technology validated in lab
TRL 5	Technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)
TRL 6	Technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)
TRL 7	System prototype demonstration in operational environment
TRL 8	System complete and qualified
TRL 9	Actual system proven in operational environment

Source: NASA (2012).

impact – the manner and the level of impact are key pieces of evidence. The inclusion of civil society and a wide range of stakeholders is an integral part of the RRI process. It is, however, clearly neither necessary nor possible to include public engagement in every project. In addition to the practical issues, different societies will assign different levels of importance to societal goals. There is therefore a need, when proposing a new method for assessing RI, for a single, widely agreed metric against which to measure the interests of society in the proposed research, innovation or development.

The metric we propose for this axis of the RIL matrix is therefore achieved by creating a score on how and in what way the technology may affect society. Given the difficulty of formulating widely agreed, generally applicable societal measures, and subject to the reservations expressed previously, we are here proposing the use of the UN SDGs, and the governance schemes which surround them (Voegtlin & Scherer, 2017).

12.3.3.1 Sustainable development goals

The SDGs were created by the UN to be universal goals, targets and indicators that UN member states are expected to use to frame their agendas and political policies over the next 12 years. The SDGs follow and expand on the millennium development goals (MDGs), which were agreed by governments in 2001. Every country is expected to work towards achieving the SDGs. The goals are:

1. End poverty in all its forms everywhere.
2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture.
3. Ensure healthy lives and promote wellbeing for all at all ages.
4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.

5. Achieve gender equality and empower all women and girls.
6. Ensure availability and sustainable management of water and sanitation for all.
7. Ensure access to affordable, reliable, sustainable and modern energy for all.
8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.
9. Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation.
10. Reduce inequality within and among countries.
11. Make cities and human settlements inclusive, safe, resilient and sustainable.
12. Ensure sustainable consumption and production patterns.
13. Take urgent action to combat climate change and its impacts (taking note of agreements made by the UN Framework Convention on Climate Change forum).
14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development.
15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification and halt and reverse land degradation and halt biodiversity loss.
16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.
17. Strengthen the means of implementation and revitalise the global partnership for sustainable development.

Within the goals are 169 targets that expand on the main overall goal to provide more specific and measurable targets for countries to aim at. Targets under goal 1, for example, include reducing by at least half the number of people living in poverty by 2030, and eradicating extreme poverty (people living on less than $1.25 a day). The targets thus lend themselves to being tailored to the specific sets of circumstances prevailing in individual countries.

This proposal does not seek to argue that the SDGs are a perfect set of societal goals. The RIL method uses them as a widely adopted measure of social "goods" and therefore a useful metric against which to measure the potential impact of a technology and assess the level of required RI work. The "impact" encompasses both positive and negative impact; for example, genetically modified crops that are beneficial for increasing food supply but may have a negative impact on the environment.

12.3.3.2 Establishing the innovation potential score

Recognizing that there is potential for different ICT technologies to impact either none or many SDG indicators we needed to introduce a measure of the consolidated impact, to permit comparison, and ultimately to gauge granularity in scaling of appropriate RRI activities. This was given the title innovation potential. The innovation potential score is formulated based on the impact on the SDGs. It is necessary for the researcher to assess the size of the potential impact of a technology on one or more of the SDGs. This can range from *no clear impact* to formally *quantifiable impact*.

12.3.3.2.1 EXAMPLE

The technology for the purposes of this example is a tool to allow parents, teachers and care-givers to find out how many data trackers or harvesters are contained within a tablet game aimed at children. This could have an impact against SDG 3 – promoting wellbeing for all at all ages. This type of tool will clearly have some impact, given the problematic nature of data-harvesting, storage and re-use and its effects on people's lives, but it could be difficult to quantify without other research. We therefore use Table 12.2 to gather the innovation potential score. One SDG is affected, and there is an unquantifiable impact, giving an innovation potential score of 2.

12.3.4 Step 3: assessing RIL

Assessing a project's RIL is the final stage in the assessment process. Once the TRL and the innovation potential are established, the project's RIL can be found using the matrix in Table 12.3. The higher the innovation potential, and the higher the TRL, the higher the RIL. Using our example of the parental tool above, which would need very little additional development to reach the marketplace (and therefore is being given a TRL of 8), we can see, using the matrix, that this gives an overall RIL of 4.

RIL is founded on the principle that, in order to be effective, RRI needs to be appropriate to the stage that the research has reached. For example, undertaking public engagement activities for basic research would pose significant challenges in terms of defining any potential societal impacts, comprehensively identifying stakeholders or creating actionable insights. This would be especially true when research is being undertaken for the sake of pure knowledge. This method is predicated upon assumptions such as

Table 12.2 Innovation potential (IP)

Number of sustainable development goals affected	*Impact of the technology*		
	No clear impact	*Unquantified impact*	*Quantified impact*
1	IP1	IP2	IP4
2 or more	IP1	IP3	IP5

Table 12.3 Finding the Responsible Research and Innovation intensity level (RIL)

Technology readiness level	9	RIL3	RIL4	RIL5	RIL5	RIL5
	8	RIL2	RIL4	RIL4	RIL4	RIL5
	7	RIL2	RIL3	RIL4	RIL4	RIL5
	6	RIL2	RIL3	RIL4	RIL4	RIL5
	5	RIL2	RIL3	RIL4	RIL4	RIL5
	4	RIL2	RIL2	RIL3	RIL3	RIL5
	3	RIL2	RIL2	RIL3	RIL3	RIL5
	2	RIL1	RIL1	RIL2	RIL2	RIL5
	1	RIL1	RIL1	RIL2	RIL2	RIL5
		1	2	3	4	5
	Innovation potential					

the concept that any kind of transformative technology or research should *always* have a high RIL. By contrast, very basic or conceptual research that will have little direct impact on society should still have some RI work, but this can be relatively low key.

Following this through with our worked example, its RIL score of 4 might indicate RRI activities such as parents' and children's focus groups or juries during the development process, as well as possible co-ordination with games manufacturers. The inclusion of an appropriate group of stakeholders is a key part of all RRI activity.

12.3.5 Operationalising RRI intensity level

We have proposed RIL as a scale of the intensity of RRI activities for a particular ICT research project, but we must then consider the characteristics of the organisation proposing to undertake such a project, and the experience and capabilities necessary in the design and delivery of RRI in an ICT research context.

When considering suitable candidates, the work done by Stahl et al. on RRI maturity modelling (Stahl et al., 2017) presents a body of evidence of the observed RRI capabilities of organisations delivering ICT R&I projects. This work proposes a scale of organisational maturity in the undertaking of RRI activities based on a substantial body of evidence, which can be applied as a structured approach to evaluating an organisation's alignment to RRI practices, and their suitability to deliver different levels of RRI intensity.

Maturity modelling has its origins in software engineering, but has evolved into other applications such as project management, with a notable example being P3M3. The Portfolio, Programme and Project Management Maturity Model (Young & Conboy, 2013) was developed by the UK's Office of Government Commerce. The purpose of P3M3 is to provide a frame of reference that can be used to baseline an organisation's capabilities in project, programme and portfolio management.

With P3M3 the intention is to use past performance in project delivery as a predictor of the future outcome of projects, and to then use this measure as an important factor in evaluating a particular organisation's suitability to deliver projects of a particular type or level of importance.

Once the RIL required for a particular project has been established by a research actor, be they prospective researcher or funding body, the question then comes as to what type of research project organisation has the right characteristics to deliver such an initiative. Clearly this evaluation covers a very wide range of parameters associated with research excellence, and so forth, but we propose that these parameters be extended to include due consideration of the RRI maturity level of the organisation.

The objectives of RRI are to ensure the acceptability, desirability and sustainability of research outcomes, and reaffirming the assertion (Stahl et al., 2017) that RRI should be considered a meta-responsibility, we propose the use of RRI maturity level as a justifiable proxy for RIL.

This approach could go some way to answering the question: "From an RRI perspective, what type of research organisation is best suited to undertake research of different RILs?" Table 12.4 proposes a conversion from RRI maturity to RILs.

12.3.6 Other factors

12.3.6.1 Research portfolios

For projects with a low RIL but which form part of a portfolio of research (such as quantum computing), the researcher must ensure that at the portfolio

Table 12.4 Conversion table for Responsible Research and Innovation intensity level (RIL) to Responsible Research and Innovation (RRI) maturity

RRI maturity level	*Maturity definition*	*RRI intensity level*
1	Organisation is unaware of RRI or its components and does not incorporate it in its processes	RIL 1
2	Organisation reacts to external pressures concerning aspects of RRI and experiments concerning appropriate processes	RIL2
3	Organisation has a definition of RRI and has integrated these into its processes	RIL3
4	Organisation realises the benefits of RRI and seeks to proactively and increasingly integrate these into its processes	RIL4
5	Organisation has adopted RRI as a component of its strategic framework and aims to ensure all R&D activities cover all RRI components	RIL5

Note: R&D, research and development.

level an RRI exercise has been undertaken, and that the implications of their work on that portfolio have been properly considered. To do this the researcher should produce a written assessment of the potential implications of their work on the portfolio as a portfolio impact report for the portfolio manager, and get positive assurance that the implications of this have been considered in the portfolio-level RRI work.

If the portfolio-level RRI activity has not been considered then the RIL for the assessed research should be increased to take account of this lack in the overall portfolio, and provision needs to be made for the appropriate cost and time implications.

12.3.6.2 Significant risks

There are some technologies and developments that – regardless of how many SDGs they affect and whether that impact is quantifiable – must be subject to the maximum level of RRI and therefore incur an RIL 5 score. This includes technologies that are only in relatively early stages such as quantum computing. It is anticipated that relatively few technologies will fall into this "significant risk" category.

12.3.6.3 Alternative applications

Where an alternative application for the research with a higher innovation potential has been identified, but this alternative application is outside the expertise of the principal investigator, then external advice should be sought from an RRI adviser.

12.4 Conclusions

It will be noted that there is no RIL score of zero. This is because it is the position of these authors that *every* project requires RRI consideration. There is no stage of research or type of development that requires nil reflection, consideration of stakeholders or assessment of societal impact. An RRI mindset has already partially permeated the strata of research practice bedrock in many parts of the world – an ethical thread that runs throughout the research at every stage.

Once the appropriate RIL is established for a project, the next stage envisaged by the method proposed here is to use the EPSRCAREA framework[8] to formulate a range of activity types suitable to the individual requirements of the project. Formulating this range of activities is beyond the scope of this chapter, but the intention is to allow researchers to choose or create the most suitable RRI activities for their project, establish the type of team members to undertake those activities and the types of tools and resources which will be required to undertake them effectively. The aim for these activities is to optimise the value of RRI for that project, but equally to identify where significant uncertainties should and do exist which will require further analysis. It is envisaged that this self-critical and reflective process can only improve the project's work and its outcomes.

We have here outlined a method that aims to address the question identified as a lacuna within the current research. It will be recalled that our research question at the outset was "*How can the level of RRI activity be aligned with the requirements of the project?*" and we have attempted to demonstrate a method that we believe allows researchers to shape an appropriate level and type of RRI activity to the needs of their project. They can then move on to design RRI activities that incorporate the need for reflection and stakeholder involvement.

It is our belief that this method makes a much-needed contribution to the discourse on RRI and supplies a critical step in the process of applied (rather than theoretical) RRI.

12.4.1 Limitations of the method

The number of RILs is currently set at five; however it may prove in practice that this does not offer sufficiently nuanced grading and that there need to be more levels to respond not just to projects at different stages of the technology-readiness metric but also that affect more of the SDGs in possibly variable ways.

Secondly, funding of early-stage research may have little realistic prospect of correctly anticipating outcomes; however work that is highly conceptual in nature should not be regarded as being exempt from RI work. This is recognised currently in the EPSRC's People at the Heart of ICT[9] requirement which applies to all projects, even the strictly theoretical.

The limitations of the SDGs as one of the metrics for innovation potential are acknowledged, particularly at the granular level obtaining below the top-line measures.

The use of RRI maturity as a proxy for RIL shows some promise, but does have the limitation of looking at past RRI activities to determine maturity. Considering that RRI emerged as a term comparatively recently (2010), many research organisations will have limited track records.

12.5 Further research

The approach proposed here is as yet untested in real-world scenarios, although the authors are undertaking research to evaluate the method. It is also clear that, as well as evaluation of the method, real-world case studies would provide a valuable addition to the theory in this field.

We also propose developing the MUSE test for project RRI activities along the lines of the following definitions:

- Meaningful: Can a sufficiently broad range of stakeholders sufficiently appreciate what the potential impact of a novel technology is, based on its stage of development?
- Useful: Are we stifling creativity by demanding a statement of instrumental value too early?
- Sensible: What level of resources is it sensible to expend on RRI (based on stage, impact, importance, incremental/transformational)?
- Effective: Can we create sufficient evidence of potential impact to convince or effect changes in society or stimulate anticipatory regulation?

Further evaluation of the alignment between RRI maturity and RIL is required, as well as addressing the identified limitations of this approach.

Notes

1 www.adalovelaceinstitute.org/
2 www.gov.uk/government/consultations/consultation-on-the-centre-for-data-ethics-and-innovation/centre-for-data-ethics-and-innovation-consultation
3 https://ico.org.uk/about-the-ico/news-and-events/news-and-blogs/2018/10/facebook-issued-with-maximum-500-000-fine/
4 www.nasa.gov/directorates/heo/scan/engineering/technology/txt_accordion1.html
5 https://assets.kpmg.com/content/dam/kpmg/xx/pdf/2016/11/disruptive-technologies-barometer-tech-report.pdf
6 www.gartner.com/imagesrv/books/digital-disruption/pdf/digital_disruption_ebook.pdf
7 www.cisco.com/c/dam/en/us/solutions/collateral/industry-solutions/digital-vortex-report.pdf
8 https://epsrc.ukri.org/research/framework/area/
9 https://epsrc.ukri.org/research/ourportfolio/themes/ict/introduction/crossictpriorities/peopleattheheart/

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