Version no. 1

RRI Foundation Course

Participant handbook

ORBIT

Name

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Engineering and Physical Sciences Research Council

UNIVERSITY OF OXFORD

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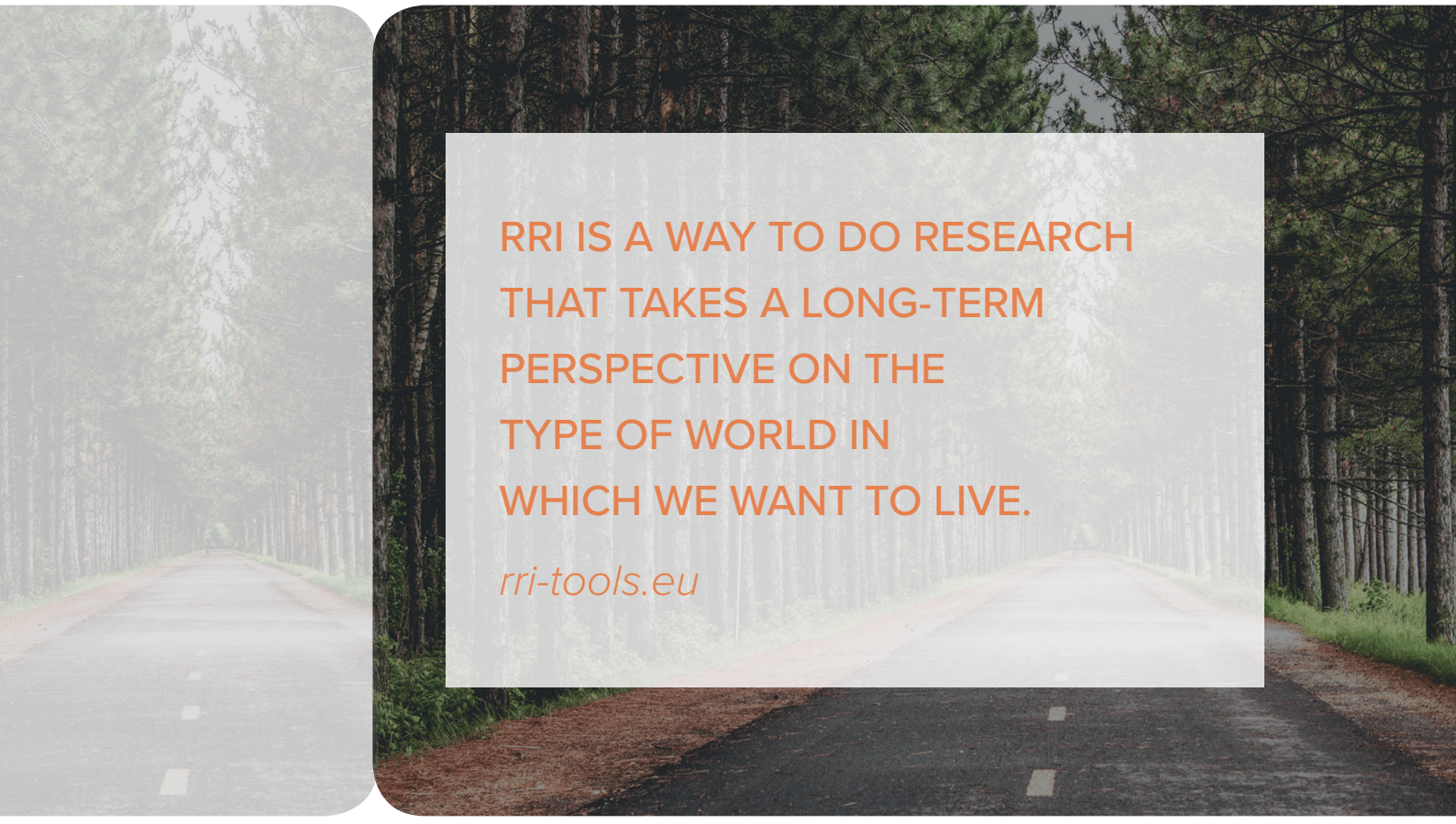
Purpose of this handbook

The ORBIT RRI Foundation course is an introductory training course that aims to provide you with a general overview of responsible research and innovation (RRI).

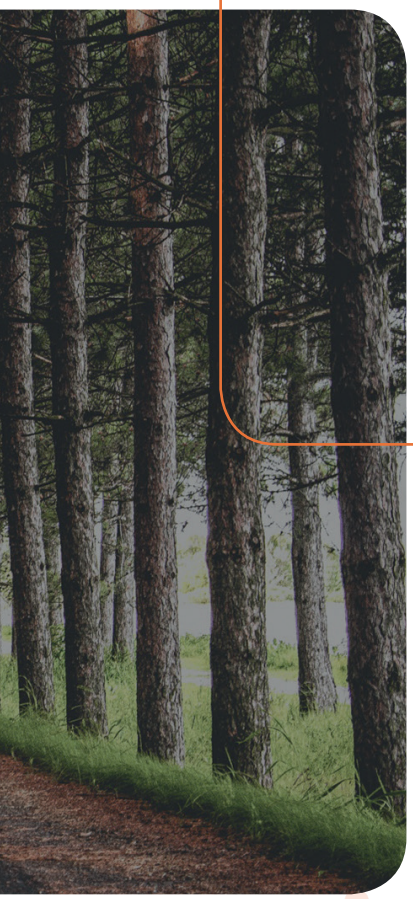
The purpose is to explain the concept and show that RRI is interesting and fun to engage with. It also allows you to take a different perspective on your work, which will help to improve it. RRI is a requirement of research funders, who expect all researchers to undertake RRI training. But more importantly, RRI is a way to reflect on your own research, in particular the way it is undertaken and the consequences it can have. This, in turn, can help improve the research approach as well as possible and expected outcomes, thereby improving the quality of the research itself.

The Foundation course provides a brief overview of the conceptual and theoretical background of RRI. It then provides the space and the content to help you engage with it in more detail. The delivery builds heavily on case study examples allowing you to bring in your own expertise and experience. This handbook will guide you through the training course, encourage you to engage and collaborate and will act as a reminder of some of the basic ideas and principles which you can draw on after the event.

The one-day Foundation course is a taster that will allow you to undertake an RRI analysis of your own work and projects. It provides tools for you to question and analyse your own practice. For those of you who enjoy the critical enquiry of your work it points the way to further resources and possibilities to engage with the subject more deeply.



Contents



Expert perspectives

Dr Abigail Sellen

Deputy Director, Microsoft Research Cambridge University

"We are faced with ethical challenges that we have never had to face before. And many have happened in the last couple of years. It's very important for us to work with academia, and to work with government in order to share our challenges and share the ways in which we are addressing them. That's one of the reasons why ORBIT is so important to us here in the UK and that's one of the reasons I am keen to be involved."

Professor Bernd Stahl

Director of the Centre for Computing and Social Responsibility De Montfort University

"Digital technologies at the start of the third decade of the 21st century have an unprecedented potential reach and impact. The effects of emerging technologies can be hugely beneficial but also detrimental to human life and well-being, society or the environment. Responsible research and innovation aims to sensitise all individuals, groups and organisations involved in creating and shaping these technologies to these potential impacts. It is a crucial approach and will need to be embedded in all research and innovation activities if we are to benefit from new technologies and mitigate their risks and disadvantages."

Professor Marina Jirotka

Professor of Human Centred Computing Oxford University

"Researchers should try to prevent their research having negative consequences on society and should actively promote and protect human values. Responsible research and innovation (RRI), in its most ambitions interpretation, not only seeks to mitigate the risks arising from research, it also tries to ensure that every research and innovation activity takes into account societal needs and values."

Dr Neil Viner

Director of Programme Delivery EPSRC

"We want to be, if not the best, one of the best funding agencies in the world. In doing so the notion of creating a strong RRI culture is crucial to enable the best Research and Innovation and to retain public trust."

History of RRI

Human beings are not the only animals that use tools, but tools have a special importance for us. Key innovations, such as the mastery of fire, the invention of the wheel or the introduction of agriculture, made us what we are today. Despite the important role technology has played in human development, for most of our history, inventions and innovations have been the result of serendipity. However, as a result of the increasing interaction between science and technology dating from the Enlightenment, there has been a greater focus on developing a steady flow of new tools and innovations.

Traditionally, the development of new knowledge and ways of manipulating our environment had been seen as positive and desirable. However, at some point it became clear that that is not always the case. The detrimental effects of innovation became too obvious to ignore, e.g. the impoverishment that went alongside industrialisation, the destructive consequences of modern warfare or the occurrence of large-scale industrial accidents from Bhopal to Chernobyl.

Following the Second World War, most industrialised nations linked increased science funding to tangible improvements for society, ranging from consumer products to new medical therapies or devices. Part of this arrangement was a significant increase in funding for science and technological innovation. The broadening scope of science and innovation and the emphasis on their commercial application of transfer shaped our technologically enabled world. At the same time, these developments led to a rise in the public's scepticism and an increased willingness to challenge the scientists on the consequences of their actions. Public opinion did not always support innovation, as can be seen from cases such as genetically modified organisms or nuclear power. It was increasingly clear that innovations often have unintended and unforeseen consequences.

New fields of inquiry focused on this problem area. The philosophy of technology, for example, explores the conceptual basis of technical interventions. Science and technology studies take a social scientific approach to these questions, whereas technology assessment is focused strongly on policy advice and intervention. Responsible research and innovation (RRI), sometimes referred to as responsible innovation (RI) can be understood as the next step in this trajectory. It is an initiative that has very much been shaped by public research funders, such as the Netherlands Organisation for Scientific Research (NWO), UK's Engineering and Physical Sciences Research Council (EPSRC) and the European Commission, as the funder of the European Framework Programmes. Research funders have understood that they have an important role to play with regards to the societal consequences of the work they support.

RRI is based on the recognition that there is a complex network of responsibilities in research and technology innovations, but that these responsibilities do not always align, and do not always lead to desired outcomes. The scientific system can lack the connection with society that would allow it to understand societal needs and to respond to questions that citizens – as the ultimate funders of research – would like answers to. Furthermore, research institutions do not always pay sufficient attention to these questions and may have incentive structures that are not conducive to broad and transdisciplinary collaboration. In this context RRI can be understood as "the on-going process of aligning research and innovation to the values, needs and expectations of society." (Rome Declaration)

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Reflective Exercise

What does RRI have to do with you?

As a researcher, to what extent do you feel responsible for how your work is used by others in the future? Why?

As a citizen, to what extent do you feel that companies are responsible for how their products or services impact our well-being or way of life? Why?

As a researcher, to what extent do you feel that you are able to control how and by whom your work is used? Why?

In your work as a researcher, how do you think you could anticipate outcomes and include measures to minimise potential risks to society?

Why is RRI important?

RRI is gaining importance with policy makers and public funders of research. The risks of research and innovation divorced from any concept of responsibility have been highlighted by scandals such as those concerning Cambridge Analytica or the misuse of facial recognition software, or by the latest trends or media obsessions such as AI or big data.

EPSRC, part of UK Research and Innovation

The Engineering and Physical Sciences Research Council (UK-RI EPSRC) website states:

"Responsible Innovation creates spaces and processes to explore these aspects of innovation in an open, inclusive and timely way. This is a collective responsibility, where funders, researchers, stakeholders and the public all have an important role to play. It includes, but goes beyond, considerations of risk and regulation, important though these are.

As a public funder of research, we have a responsibility to ensure that our activities and the research we fund, are aligned with the principles of Responsible Innovation, creating value for society in an ethical and responsible way."

www.epsrc.ac.uk/research/framework

In 2018, the EPSRC – in addition to promoting RRI – went further to make RRI training mandatory for all PhD students in a 2018 CDT Call:

https://epsrc.ukri.org/files/funding/calls/2018/epsrc-cdt-full-call-document

The European Union

The present EU declaration builds on the 2009 Lund Declaration, which called for an emphasis on societal challenges, and on the 2013 Vilnius Declaration, which underlined that a resilient partnership with all relevant actors is required if research is to serve society:

"We believe the conditions are now right for responsible research and innovation to underpin European research and innovation endeavour and therefore call on all stakeholders to work together for inclusive and sustainable solutions to our societal challenges.

We call on European Institutions, EU Member States and their R&I Funding and Performing Organisations, business and civil society to make Responsible Research and Innovation a central objective across all relevant policies and activities, including in shaping the European Research Area and the Innovation Union".

EU Rome Declaration (November 2014)

Industry

YouTube CEO Susan Wojcicki highlighted the necessity of RRI:

"We have to recognize where we do live, in this time where there is really dramatic change from a technology standpoint and the innovations that we have, but that doesn't mean those innovations are going to stop. (...) Technology is going to continue, it is going to continue to move forward. You need to move forward with that technology responsibly."

Who has agency?

New technologies and innovations are being developed at such a rate that they are being embraced by society before their true systematic impact can be recognised, quantified and assimilated. This is particularly true in the area of Information and Communications Technology (ICT) which is now firmly embedded within all aspects of society.

From a social science perspective, agency is understood to be the independent capability or ability to act on one's will. This ability is affected by the cognitive belief structure formed through experiences and the perceptions held by the society and individuals of the structures and circumstances of the environment, and the position into which one is born.

In the context of RRI, and with particular application to ICT research, we define agency as the ability of a researcher or developer of a technology to influence how it is used, and thus to effect control as to its ultimate impact on society.

Reacting to the impact that a technology has already had on society is only one way of dealing with the broader implications of technology-enabled transformation. But it is the main method that is open to governments, regulatory bodies and other agencies that consider the effects of technology on society. The mechanisms used are often slow and unwieldy and may only be able to react a long time after the impacts have already occurred. Changes to regulatory frameworks and laws all take time. Even institutional bodies set up to examine particular issues, such as the Ada Lovelace Institute and the Centre for Data Ethics and Innovation, are responding 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 (although Facebook was fined £500,000 by the UK's Information Commissioner in October 2018 – the maximum available).

An alternative to mechanisms predicated on actual impact, are mechanisms that act on anticipated impact. There are a number of approaches to 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 RI or 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.

The UK's Research Councils, which fund much of the UK's academic research, have adopted the AREA Framework approach to RRI created by Stilgoe, Owen & 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 research and innovation process.

Reflective Exercise

Who has agency?

Using the 'who' cards, work in small groups to discuss whose opinion you think matters, and whose does not. The 'who' cards contain different groups represented in society.

Make two piles from the cards: who has agency and who does not.
Discuss your opinions and thoughts with the wider group.

Prompt questions

- Who should be given a platform to shape your research?
- Whose ideas are useful?
- Whose ideas are detrimental to the research process?
- In what circumstances could the different groups contribute?

Overview of RRI

RRI is now embedded in the structures of the major public research funders. This is based on the recognition that research has potentially significant social and ethical consequences, and that major stakeholders of the research ecosystem share some responsibility for these consequences. This is particularly important in publicly funded research where societal resources are used, and which therefore should benefit society.

RRI's aim of ensuring and promoting societal acceptability, desirability and sustainability of both the processes of doing research and its outcomes and products (von. Schomberg, 2013) tries to capture this sentiment. Some aspects of this integration of RRI are long established, such as ethics approval processes, or public engagement exercises particularly with contentious technologies.

The current drive towards RRI, as exemplified by its adoption and promotion by EPSRC, tries to go further by developing a culture across the entire research ecosystem that fosters a proactive approach to these questions. It aims to encourage all stakeholders to consider future consequences of their work, to be open and willing to question their work and to reflect on it and reach out to other stakeholders in order to better understand different perspectives. The idea behind the approach is that these activities will strengthen the connection between researchers and society, ensuring that societal concerns are taken seriously and integrated into research, so that desirability, acceptability and sustainability are considered by default.

One crucial question is what measures or criteria would allow us to assess whether a research process, method or outcome is aligned with public preferences. This is a difficult question to answer. Scientific and technical innovations often bring about dilemmas, e.g. an increase of economic efficiency may come at the price of environmental degradation, or improved services call for the collection of data may jeopardise privacy. But even if there were agreement on the criteria, it would create significant methodological challenges to assess public perceptions of particular pieces of research.

This probably explains the popularity of the United Nations Sustainable Development Goals (SDGs) as a proxy for acceptability, desirability and sustainability. The seventeen goals represent an international agreement and a call to action to end all forms of poverty, fight inequality and tackle climate change.

Sustainable Development Goals

Arising from a long and inclusive UN-led process, they can be read as a world consensus on moral questions. This does not imply that they are perfect, or applicable to all aspects of research and innovation. But they are a good starting point to navigate the question of what research and innovation should achieve.

The purpose of RRI is to align science, research and innovation with society's needs and preferences. If RRI is to ensure that the processes and products of research are desirable, acceptable and sustainable, we have to ask how we can know whether these aims are achieved.

The SDGs play an important role in the RRI discourse because they provide a substantive answer to what counts as acceptable, desirable and (morally) good.

For RRI this means that they can be interpreted as targets, counting as evidence of successful RRI. Moving towards the SDGs is therefore broadly recognised as a hallmark of RRI, and it can help researchers adjust the aims of their research. RRI is an initiative that aims to promote a culture of anticipation, reflection and engagement in the hope that this will ensure a close alignment between research and society. Although this is a worthwhile aim, it cannot be seen as being a panacea.

ORBIT's interpretation of RRI is that individuals involved in research and innovation need to understand, agree and adopt the principles of RRI. They will then benefit from using existing tools and techniques for putting RRI into practice.

However, this does not imply that RRI is a static and simple method leading to fixed or predictable outcomes. The methods discussed here are tools to help you approach specific questions. But whatever their results, they need to be critically questioned and analysed. The core of RRI is an individual mindset which is replicated collectively in a research culture. It is not an algorithm that can be employed with guaranteed results.

Moreover, RRI does not come for free. There is a need for resources at various levels. First, resources must be allocated for training and to develop awareness. RRI may then require additional time and effort throughout the research, for example in project governance structures that promote reflexivity, or through engagement activities with the public. While anticipation of likely outcomes is at the heart of RRI, there is no guarantee that they will capture the key problems of tomorrow.

Despite all this, RRI is worth embracing and integrating into research. One way of approaching RRI is to think about how we think about research and innovation. Research strongly relies on first order reflexivity. Researchers needs to think about why they want to do the research, which methods they want to use for data collection and analysis, on what basis they draw conclusions and on how they disseminate their insights. Second order reflexivity is taking a step back from this, thinking about how we think about research, and is an important part of successful research.

AREA 4P Framework

The AREA Framework

Developed specifically for the EPSRC (Owen & Goldberg, 2010; Owen 2014) in response to perceived problems of dealing with societal concerns (Macnaghten & Owen, 2011), the AREA Framework is a way of conceptualising and implementing RRI, and was adopted as part of EPSRC's strategy:

ANTICIPATE	Describing and analysing the impacts – intended or otherwise (e.g. economic, social, environmental) – that might arise. This does not seek to predict but rather to support an exploration of possible impacts and implications that may otherwise remain uncovered and little discussed.
REFLECT	Reflecting on the purposes of, motivations for and potential implications of the research, and the associated uncertainties, areas of ignorance, assumptions, framings, questions, dilemmas and social transformations these may bring.
ENGAGE	Exploring and validating such visions, impacts and questioning to broaden deliberation, dialogue, engagement and debate in an inclusive way. Inter and transdisciplinary exploration to identify potential synergies and emergent properties.
ACT	Using these processes to influence the direction and trajectory of the research and innovation process itself. Acting to inform society of the potential impact of innovations on their way of life, to permit preparation and participation of all.

From 2011 onward, EPSRC commissioned a research project on a 'Framework for RRI in ICT' (FRRIICT) – the predecessor of ORBIT – which aimed to make the AREA concepts more accessible and applicable.

The Four Ps

FRRIICT extended the AREA (Anticipate, Reflect, Engage, Act) Framework to include 4Ps (Product, Process, People, Purpose) creating the AREA 4P Framework. By mapping the AREA principles against the four P components of RRI (below), this framework creates the space to think about how RRI can be made relevant to ICT.

PROCESS	Process refers to the processes undertaken in research and innovation. These cover all activities in preparing research, undertaking data collection and analysis, storage and presentation of data and interaction with respondents.
PRODUCT	Product RRI is specifically interested in the outcomes of research and innovation activities. This can refer to products or services. It includes the consequences of use as well as misuse of research products and the impact that research has on the natural and social environment.
PURPOSE	Critical scrutiny in RRI extends beyond the conduct (process) and outcome (product) of research and covers the question why research is undertaken at all. The purpose of research is a crucial factor influencing acceptability and desirability, and thus is open to scrutiny.
PEOPLE	Research and innovation are undertaken by and for people and have intended and unintended consequences for them. People are at the heart of RRI; they need to be explicitly considered.

The ideas behind RRI and the AREA Framework may be easy enough to understand, but they raise significant conceptual and practical questions. Fundamental problems include the fact that research and innovation do not follow linear and predictable patterns. Bunching together research and innovation blurs important boundaries and hides significant differences. Pluralistic democracies usually do not have a substantive consensus on what counts as acceptable and desirable. Stakeholder engagement can be misused for specific aims. The idea of RRI itself contains specific values and implementing it may engender power struggles.

These concerns pose significant challenges to RRI in ICT that may go beyond those in other fields. ORBIT therefore developed the 4 Ps (product, process, people and purpose) as well as other concepts and approaches (to be explained in the following pages), to develop a framework for RRI which is specific to ICT.

Framework for Responsible

AREA-4P can be represented as a 4 x 4 matrix and the idea of the AREA-4P Framework is to develop a set

	Process Speed of innovation and diffusion	**Product** Ubiquity and pervasiveness Applied and fundamental research
Anticipate (Opportunities)	**Is the planned research methodology acceptable?** Lab health & safety Ethical approval/Informed consent Risk assessment Methodology Data management plan	**Will the products be socially desirable?** Foresight Vision assessment Scenarios **How sustainable are the outcomes?** Materials Green ICT Energy
Reflect (Considerations)	**Which mechanisms are used to reflect on process?** Advisory board Internal workshop 'Stage-gating' 'Midstream modulation' Sociotechnical integration Backcasting / Hindsight **Alternatives:** How could you do it differently?	**How do you know what the consequences will be?** Systematic evaluation of technologies in situ **What might be the potential use?** Intended and unintended Misuse cases **What don't we know about?** Blind spots Ethical prototyping **How can we ensure societal desirability?** Privacy by design Ethics by design **Alternatives:** How could you do it differently?
Engage (Alternatives)	**How to engage a wide group of stakeholders?** Identify stakeholders Participatory processes Process evaluation	**What are viewpoints of a wide group of stakeholders?** Public engagement mechanisms Prototype / demonstrator evaluation (public)
Act (Capacities)	**How can your research structure become flexible?** Agile project management Document emerging perspective, views and norms Recalibrating the vision of the project **What training is required?** Research integrity Research management Skills and methods in public engagement Data management **What infrastructure is required?** Departmental ethics committee capable of addressing ICT concerns Funding for engagement activities Tools to support the ICT community Database of project 'lessons-learned'	**What needs to be done to ensure social desirability?** Create incentives for thinking about research outputs Encourage appropriate development approaches **What training is required?** Understanding of regulation **What infrastructure is required?** Accessible participatory tools and methods Open access to data and publications

Research and Innovation in ICT

of scaffolding questions and indicative answers that allow users to reflect on various aspects of their work.

	Purpose Logical malleability	**People** Problem of many hands
	Why should this research be undertaken? Addressing grand challenges Economic growth Social need Scientific curiosity Extended impact statement	**Have we included the right stakeholders?** Principles of stakeholder engagement (Sciencewise, British Science Association)
	Is the research controversial? Ethical Social Political **Alternatives:** How could you do it differently?	**Who is affected?** Who might care? Who benefits? Who is in control? Who will decide? Who will take responsibility if things go wrong? What is the gender balance in the project? **Alternatives:** How could you do it differently?
	Is the research agenda acceptable? Public engagement mechanisms	**Who prioritises research?** Public engagement mechanisms **For whom is the research done?** Public engagement mechanisms
	How do we ensure that the implied future is desirable? Consider implied future state at project/programme inception **What training is required?** Understanding of ELSI Understanding current debates and controversies **What infrastructure is required?** Reflection on purpose part of funding mechanisms Reflection on purpose part of project evaluation criteria	**Who matters?** Stakeholder participation **What training is required?** Contextualise projects as sociotechnical **What infrastructure is required?** Community building Leadership council Champions / Advocates Science education to allow the public to engage intelligently

RRI and the EU: The Six Keys

Although the EPSRC commissioned the AREA Framework, it is widely recognised and used as a basis for RRI approaches across a range of funders and projects.

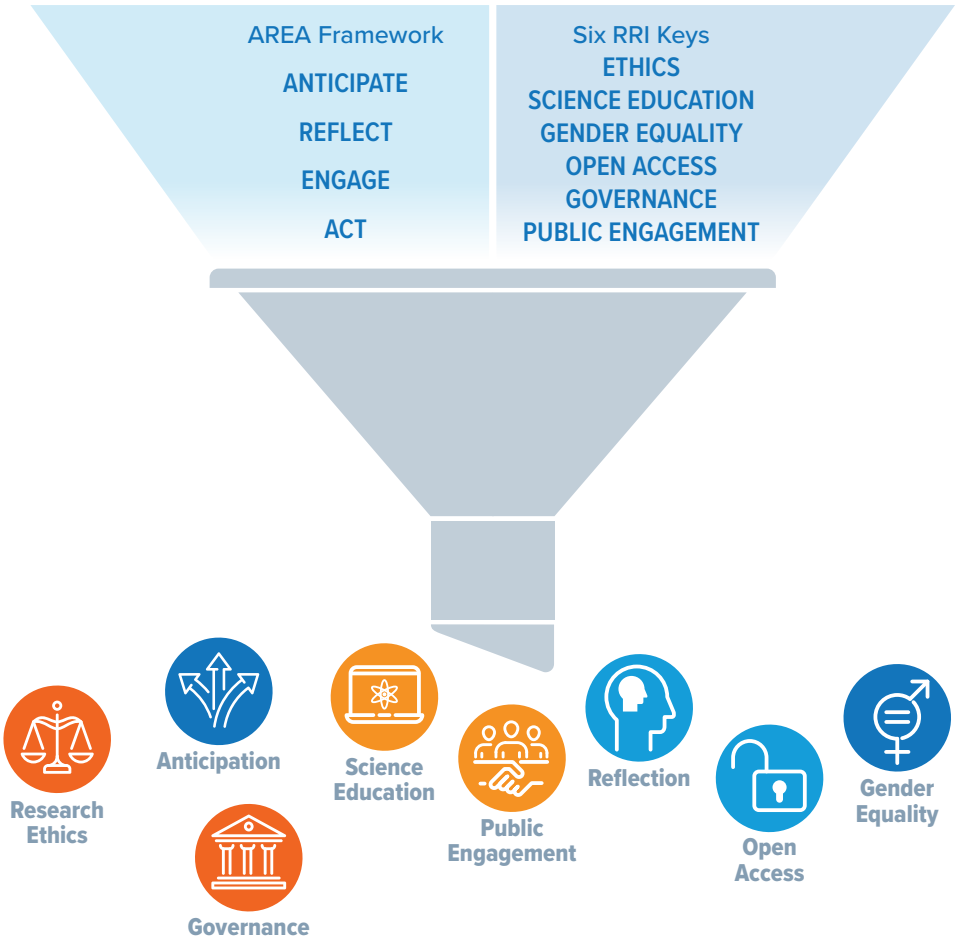
The European Commission has also covered and promoted RRI in its Research Framework Programmes. The EU perspective builds on a different organisational history and has a different emphasis. But it provides a complementary perspective on RRI here.

The European Commission uses the term RRI to denote a number of policy activities it has pursued. These were combined under the headings of 'Science and Society' (FP6), 'Science in Society' (FP7) and 'Science with and for Society' (Horizon 2020).

The six keys under these headings constitute responsible research and innovation practices according to the EU. These six keys are: Ethics, Science Education, Gender Equality, Open Access, Governance and Public Engagement.

One way of interpreting the relationship between the AREA Framework and the six keys is that AREA answers the question of 'how' to do RRI, whereas the six keys focus on the 'what', i.e. the RRI content.

Below, the four AREA elements and the six keys are described together in more detail in order to provide a basic explanation of RRI that can be used for projects funded either by the UK or the EU.



Anticipation

Thinking about the possible consequences of research and innovation is a key component of RRI. Concern over the role of science and technology in traumatic developments such as the industrialised mass killings in modern warfare and the potential annihilation of humanity through nuclear weapons led to new ways of reflecting on science and technology research and innovation. Chernobyl and Bhopal had become synonymous with industrial accidents made possible by scientific and technical progress.

It is not only catastrophic one-off events that need to be considered. Current discussions of the social consequences of social media use, for example, focus on the way in which novel technologies have cumulative effects that were unforeseen and unplanned when these technologies were developed.

This points to a key challenge of anticipation: the future is unknown. How can an individual researcher, research institute or funder be expected to know what all the future consequences of their work will be? Although not all the consequences can be known, we may have strong reasons to believe that some aspects of the future can be successfully anticipated. Past experience can to some degree be extrapolated to expectations of the future. In addition, researchers have expectations about the outcomes of their work. In the UK funding environment, most proposals have to be accompanied by a description of expected 'pathways to impact'. Anticipation in the RRI sense of the word can be more or less formal and elaborated. The key to anticipation for RRI is to ensure that consequences of undertaking the research and of possible findings are considered and that these considerations are reflected in the research design.

Further reading

Doteveryone's consequence scanning:
https://doteveryone.org.uk/project/consequence-scanning/

Georghiou, L., Harper, J.C., Keenan, M., Miles, I., Popper, R., 2008. The Handbook of Technology Foresight: Concepts and Practice. Edward Elgar Publishing Ltd.

UNIDO, 2005. UNIDO Technology Foresight Manual – volume 1: Organization and Methods. United Nations; Volume 2: Technology Foresight in Action. United Nations.

Reflection

Reflection is at the heart of RRI. Researchers always reflect on the research question they ask, the type of data they collect, the way they analyse the data and the implications of findings. Reflection in the RRI sense goes further to examine the research or innovation activities more broadly. This means asking fundamental questions such as *"Is this research required at all?" "Will the (foreseeable) negative consequences of this work be proportional to the (intended) consequences?" or "Could the research question / problem be addressed in a completely different way?"*

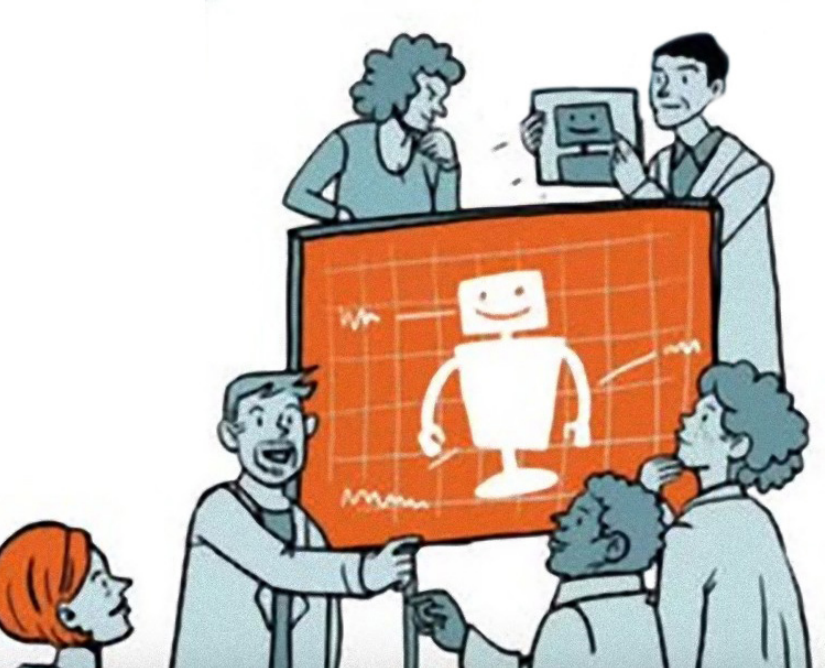
One way of describing reflection in RRI is to see it as an example of second order reflexivity, i.e. of a reflection on the processes of reflection that underpin and guide research. This means that the axioms and basic assumptions need to be questioned with a view to ensuring that the research is aligned with societal needs and requirements.

Reflection can be an individual activity, with the individual innovator thinking about their work. However, in many cases this will not lead to relevant insights, as it is difficult for most people to clearly understand their own biases and preconceptions. Reflexivity is therefore often best undertaken collectively. It typically forms part of engagement activities. There are also many ways of forcing reflection through organisational processes and structures, e.g. in the form of a project advisory board, stage gating processes, review and quality assurance steps and many others. The key is to ensure that there is space in the research activities to take a step back and look at the work from different perspectives

Further reading

An example of building reflexivity into a project structure through dialogic processes:
Stahl, B.C., Akintoye, S., Fothergill, B.T., Guerrero, M., Knight, W., Ulnicane, I., 2019.

Beyond Research Ethics: Dialogues in Neuro-ICT Research. Front. Hum. Neurosci. 13.
https://doi.org/10.3389/fnhum.2019.00105



Ethics

Research ethics are relevant not only to researchers and research institutions but also to funders, policy makers and industries as they are all involved in the research and innovation process. There are three key components:

Research integrity, which refers to the appropriate conduct of researchers to prevent misconduct or negligence. As a researcher you are not only responsible for the research that you carry out, but also for your behaviour.

Applying fundamental ethical principles to research such as General Data Protection Regulation (GDPR) compliance, data privacy, consent.

Taking into account society's needs to ensure societal relevance of research and align research to social values. This also includes reflecting on people's concerns about research and innovation and including societal actors in the discourse.

Further reading

The European Textbook on Ethics in Research: www.bit.ly/2BrfV3w

RRI Tools contains a list of resources on Research Ethics: www.rri-tools.eu/ethics

Science Education

Engaging with schoolteachers and students can be very effective in reaching a broad cross-section of society and inspiring the next generation of researchers. Some of the latest research about attitudes to Science, Technology, Engineering and Maths (STEM) subjects shows that students find science interesting and relevant at school, but do not see themselves as scientists. This is often connected to their level of 'science capital' – a measure of a person's engagement or relationship with science, how much they value it and whether they feel it is 'for them' and connected to their life.

Visits from working scientists or researchers can help break down the barriers for students with low science capital. Having a face-to-face meeting with a role model can make a big difference to whether a student thinks they could do science in the future.

If you are new to working with schools, there are many existing programmes you could join in with to get started. There is a UK-wide STEM Ambassadors scheme which provides basic training and the required Disclosure and Barring Service (DBS) certificate to clear you for working in schools. In addition, there are regular events that schools want help with, including British Science Week, CREST awards (science projects done by school students), after-school science or coding clubs and regional and national events like Big Bang Fairs.

When you are talking to school students, include information about your career path and be honest about your ability and struggles. Talk about your personality traits (not just what you do), values and what it is like to work in a team. Some educational research suggests that hearing about the type of people that work in science, rather than just what they do, may help inspire more girls in particular to consider STEM careers.

Further reading

STEM Ambassadors Scheme www.stem.org.uk/stem-ambassadors

CREST Award scheme (STEM projects in Schools) www.crestawards.org

People Like Me resources (WISE downloadable workshops to run in schools) http://bit.ly/2W1oYBM

Computer Science 4 fun – ideas on how to link research to engaging topics for school students www.cs4fn.org

Computer science activities you can do without a computer www.csunplugged.org/en

British Science Week www.britishscienceweek.org

Research on evidence of under-represented groups in STEM www.wisecampaign.org.uk/wp-content/uploads/2018/06/not_for_people_like_me-full-report.pdf

Gender Equality

There are many reasons why you should be thinking about gender equality within your RRI analysis and in your research work in general. Society is 50% female, yet the physical sciences, ICT and engineering are still majority male, especially at the higher levels. Without intention this could affect the research questions you ask or the models that you build.

In her book 'Invisible Women: data bias in a world designed by men', Caroline Criado Perez highlights many technology solutions that do not take gender differences into account, such as drugs trials, car seatbelt design and voice recognition technology.

Many research funders ask for evidence of your action plan on equality, diversity and inclusion in order to apply for funding; quality mark schemes such as Athena-SWAN (HE) and Project Juno (Institute of Physics) aim to assess action taken to ensure no barriers remain for women who want to progress in their careers of choice.

In recent years, it has become a legal requirement to publish pay data from both public and private sectors to encourage organisations to address the gender pay gap. This has begun to make changes to embedded cultural issues that were often hidden in industry and academia.

There are both ethical and economic reasons for implementing gender equality: research conducted by Harvard Business School/McKinsey shows that gender diverse boards generate better profits than those that are not.

Further reading

Research on how diverse companies are more profitable: https://mck.co/33LSjCT

Invisible Women: Exposing Data Bias in a World Designed for Men by Caroline Criado Perez. Chatto & Windus

Practical tips for action from the Women in Science, Technology and Engineering (WISE) Campaign www.wisecampaign.org.uk

Invisible Women: Four ways the world is built for men

Heart attacks

Women are

60%

more likely

to be misdiagnosed

Car accidents

Women are

47% **more likely**

to be seriously injured

(seat belts tested on men)

Voice technology

70%

more likely

to recognise a male voice

Office temperature

5°C

too cold

for women

Source: Invisible Women: exposing data bias in a world designed for men. Caroline Criado Perez. Chatto and Windus. 2019

Open Access

Making research free to access and publicly available to everyone is the thinking behind Open Access – or Open Science.

There is growing evidence that Open Science can benefit research and society by reducing wasteful duplication, increasing transparency and reproducibility of results. There is also a strong moral argument for publicly funded research to be widely accessible to the public.

Open Science has been considered to be a core activity for the EU and has been included in the Horizon 2020 work programme, making it mandatory for all H2020 funded projects. On top of this, in 2018 Science Europe launched Plan S, an initiative that requires researchers that are funded by public money to publish their work in open repositories and open journals by 2021.

Further reading

FOSTER is an e-learning platform that hosts a collection of best training resources for those who want to learn more or implement OS practices in the daily workflow.
https://www.fosteropenscience.eu/

The DOAJ is the Directory for Open Access Journals (It provides a catalogue and access to high-quality, peer-reviewed, open access journals.
https://doaj.org/

Open Science Access:
https://ec.europa.eu/programmes/horizon2020/en/h2020-section/open-science-open-access

Governance

Governance refers to practices that an organisation has in place in order to foster and promote responsible research and innovation. For instance, this could be:

- having transparent and reflective internal procedures
- promoting participatory governance
- fostering stakeholder engagement exercises
- encouraging future-oriented governance
- valuing responsiveness

These approaches highlight the importance of including stakeholders in policy research, and the importance of the active role of researchers in reflecting on and shaping the direction of their research. Not only should this reflection be directed at the effects of the research being carried out, but also on the governance principles and rules that determine the behaviour of an institution.

Further reading

European research projects that look at the best research governance practices:

CONSIDER (Civil Society Organisations in Designing Research Governance):
http://www.consider-project.eu

GREAT (Governance for Responsible Innovation):
www.great-project.eu

RES-AGORA (Responsible Research and Innovation in a Distributed Anticipatory Governance Frame. A Constructive Socio-normative Approach):
https://cordis.europa.eu/project rcn/108668/reporting/en

Public Engagement

Before you start any public engagement activity you should think about your motivation and the most suitable audience for your message.

Your public engagement activity may meet a number of motivations; for example working with school students can inspire the next generation of STEM professionals (democracy), be rewarding for you (personal) and have economic impact (research shows strong links between a country's economy and its provisions for STEM graduates).

You may feel that improving scientific literacy is of great importance and this may direct you towards a certain audience to raise their level of knowledge about a subject. By improving scientific literacy, you may also help people become better-informed in their decision making. Most forms of engagement will fit one or more of these motivations and it can be very useful to be clear with yourself which ones are important in your research and to you as a citizen as part of your planning.

Further reading

RRI Tools has a useful summary of what types of engagement may benefit your research www.rri-tools.eu/public-engagement

The Action Catalogue – an interactive tool that suggests formats and case studies based on your intended audience and aims. www.actioncatalogue.eu/search

Research on relationships between graduates and economic growth across countries: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/229492/bis-13-858-relationship-between-graduates-and-economic-growth-across-countries.pdf

The ORBIT Self Assessment Tool

How aligned is your research to the principles and practices of RRI? Use the Self Assessment tool to find out:

1. Find the Self Assessment tool on the ORBIT website: www. orbit-rri.org
2. Complete the Self Assessment Tool questionnaire. It will give you a radar graph as a result.
3. Copy your radar graph on to this page.

The Self Assessment Tool gives a snapshot perspective of your research project at the moment.

Where do you need to improve?
What actions can you take to realise these improvements?

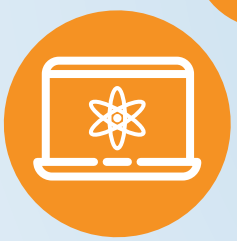
The key to anticipation is to ensure that you consider any consequences of undertaking research and possible findings into your research design from the outset.

Research ethics are as relevant to researchers and institutions as to funders, policy makers and industries. They are all involved in the research and innovation process.

3 key components of research ethics:

- Research integrity
- Applying fundamental ethical principles
- Taking account of society's needs

see pg 20



Engaging with school teachers and students can be very effective in reaching a broad cross-section of society and inspiring the next generation of researchers.

On pages 16 - 23, the four AREA elements and the six keys of RRI are described together in more detail. These pages provide a basic explanation of RRI that can be used for projects funded either by the UK or the EU.

Further reading examples are given in each area to guide you in improving the level of each of these areas in your own projects.

Meeting role models can raise students' confidence in science.

Reflection is at the heart of RRI

Reflection is the process of questioning the basic assumptions of your project to ensure that your research is aligned with societal needs and values.

Common motivations for public engagement include: personal, economic, cultural, literacy, democracy, duty, influence.

Before starting any public engagement, think about your motivations and the most suitable audiences for your message.

see pg 17

see pg 19

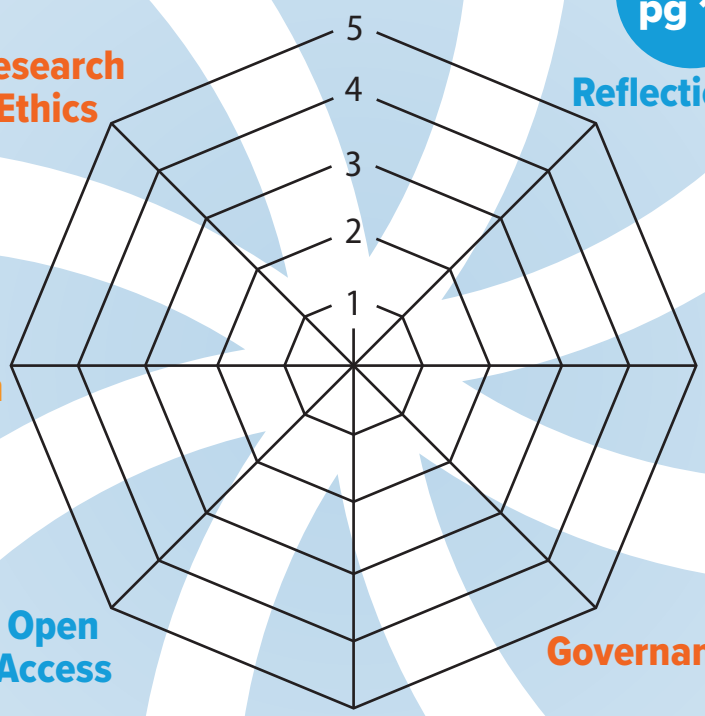
see pg 18

see pg 23

see pg 22

see pg 22

see pg 21



Governance refers to an organisation's practices which foster and promote RRI

Making research free to access and publicly available to everyone can benefit both research and society.

The physical sciences, ICT and engineering are still majority male, especially at the higher levels. This impacts the research questions we ask.

Research has found that diverse companies are more profitable

https://mck.co/33LSjCT

Responsible practices in your organisation

In order to be successful, RRI needs to be implemented in an environment that is conducive to doing the (morally) right things for the right reasons. The baseline standards of socially acceptable behaviour are usually legally defined, and the assumption is that an organisation trying to integrate RRI follows these minimum standards. It is therefore assumed that companies have processes in place that guarantee compliance with legal requirements in areas such as: data protection and privacy (GDPR compliance), equality, diversity and inclusion, health and safety and combatting modern slavery, to name some of the more prominent ones.

In addition, organisations need to have in place standards or procedures that help them deal with issues that arise from research. This means that there are research ethics processes that can help them deal with the issues identified through RRI and that there are measures in place to ensure research integrity etc.

Organisations that take RRI seriously can adopt social responsibility standards and practices, such as ISO26000 and the UN Global Compact. They can also sign up to be certified as a B-Corp and undertake sustainability reporting. The importance of these steps is to ensure that a minimum baseline of acceptable corporate behaviour is guaranteed. They also demonstrate that there are many ways for an organisation to go beyond the minimum and aspire to contribute to a liveable society.

Further reading

For research integrity: UK Research Integrity Office:
https://ukrio.org/

ISO 26000 Social Responsibility:
https://www.iso.org/iso-26000-social-responsibility.html

UN Global Compact:
https://www.unglobalcompact.org/

B-Corp:
https://bcorporation.net/

RRI Intensity Level

When designing the RRI aspects of a project, researchers must ask themselves not only which RRI activities are necessary, but which quantitative and qualitative measures make them sufficient. In other words, how do these necessary and sufficiency tests vary for different project or technology types?

To answer this question, ORBIT created the RRI Intensity Level (RIL). This novel method can be used as a guideline for scientists to identify and select which types, and how much RRI activity is appropriate and effective. The RRI Intensity Level is based on two measures: the Technology Readiness Level (TRL) and the Innovation Potential.

TECHNOLOGY READINESS LEVEL

The TRL is a scale, which is commonly used in industry and in academia, to define the stage of development of a technology. Originally developed by NASA, the scale is now widely used to assess the maturity of a technology. Within the RRI Intensity Level contact, the TRL is adopted to assess the readiness of a project.

INNOVATION POTENTIAL

Whereas the readiness of a technology is measured by the TRL, the scale does not address the impact that technology will have on society. For instance, a technology may have a high TRL but have little or no social impact and as such require little RRI effort. There is therefore a need for a scale that can measure how technology might affect society. ORBIT suggests using the Sustainable Development Goals as a metric.

Innovation Potential is calculated based on the impact of a technology on the SDGs. The type of impact needs to be classified as either quantified or unquantified. The table below can be used as a guideline to evaluate the relevant Innovation Potential score.

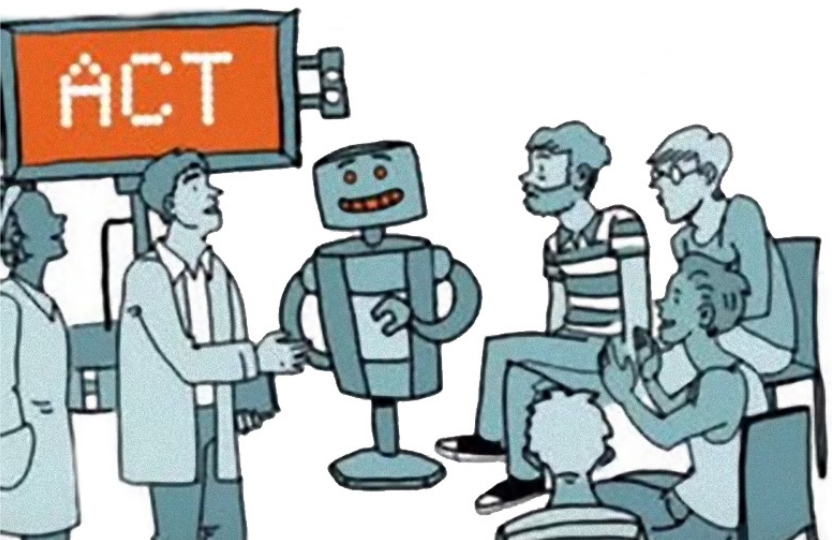
Number of SDGs affected by the technology	Type of impact		
	No impact	Quantified	Unquantified
1	Innovation Potential 1	Innovation Potential 2	Innovation Potential 4
2 or more	Innovation Potential 1	Innovation Potential 3	Innovation Potential 5

FROM TRL AND INNOVATION POTENTIAL TO RRI INTENSITY LEVEL

Once the TRL and the Innovation Potential of a technology have been assessed, the relevant RRI Intensity Level can be calculated as for the table below

RRI Intensity Level vs Innovation Potential	IP5	IP4	IP3	IP2	IP1
TRL 1	RIL 5	RIL 2	RIL 2	RIL 1	RIL 1
TRL 2	RIL 5	RIL 2	RIL 2	RIL 1	RIL 1
TRL 3	RIL 5	RIL 3	RIL 3	RIL 2	RIL 2
TRL 4	RIL 5	RIL 3	RIL 3	RIL 2	RIL 2
TRL 5	RIL 5	RIL 4	RIL 4	RIL 3	RIL 2
TRL 6	RIL 5	RIL 4	RIL 4	RIL 3	RIL 2
TRL 7	RIL 5	RIL 4	RIL 4	RIL 4	RIL 2
TRL 8	RIL 5	RIL 4	RIL 4	RIL 4	RIL 2
TRL 9	RIL 5	RIL 5	RIL 5	RIL 4	RIL 3

Each RRI Intensity Level (RIL) is associated with a list of suggested activities for each stage of the AREA 4P Framework. The intention of the RIL is to guide researchers to choose the most suitable RRI activities for their research project, and to provide them with a set of tools with which to do this.



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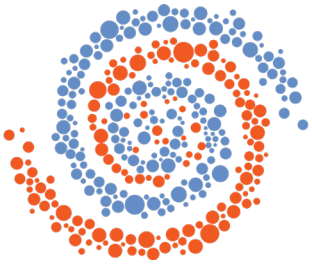
Notes

Next Steps

Write your notes here on what three things you could do to follow on from this course



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