RRI Tools
Fostering Responsible Research and Innovation

Training Showcase:
The UK's Engineering and Physical Sciences Research Council's Framework for Responsible Innovation

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Note	This Showcase is designed for training purposes. Thus, it cannot be a detailed history of the development of the EPSRC's Framework for Responsible Innovation. Nor does it acknowledge all of the many people who contributed to the Framework's development.

1 Introduction

Researchers funded by one of the United Kingdom's largest research councils are expected to follow a simple 'formula' to ensure that the work they carry out is socially responsive and responsible. The Engineering and Physical Sciences Research Council has adopted a Framework for Responsible Innovation that involves the 'AREA process' – Anticipate, Reflect, Engage, and Act – to help researchers consider societal issues that may be involved with, or flow from, their work (see www.epsrc.ac.uk/research/framework/area/*)*.

Professor Dave Delpy, who was the Chief Executive Officer of the Research Council at the time EPSRC's Framework for Responsible Innovation (FRI) was adopted in 2013, says: "To me RRI conveys something that any good researcher thinks of as part of the research that they are undertaking. Being a researcher means having good ideas but also thinking of the potential impact of research and the potential consequences of research. I don't see it as a separate item that is divorced from research, it is part of being a good researcher, especially if we are spending public money."

Professor Delpy's attitude was to prove crucial to the development of his research council's FRI. EPSRC's *framework* – rather than regulatory – approach has helped to get this adopted by the scientists and engineers they fund [1].

*This **showcase** summarises the processes that EPSRC went through in the development of its Framework for Responsible Innovation, and outlines how it has been applied in judging proposals in societally sensitive areas and how it is working out in practice for some projects. The numbers in [] are then referred to in Section 2.9.*

You can watch an interview with Dave Delpy at:
www.youtube.com/watch?v=YwS8IxukgVY

2 The EPSRC's Framework for Responsible Innovation

2.1 The Societal Issues Panel

In 2003, the UK had run a major public engagement exercise on the future of genetically modified (GM) crops. To the surprise (and, amongst many, the dismay) of the government and leading researchers, British citizens indicated their hostility to GM foodstuffs at town-hall meetings, deliberative debates, and in opinion polls. Other new technologies were emerging – nanotechnology with applications from medicine to public surveillance, geoengineering with the prospect of a 'technical fix' for problems such as climate change, and – later – synthetic biology, an attempt to assemble made-to-measure organisms from simple genetic parts.

EPSRC would have responsibility for some, if not all, of these. So it established a Societal Issues Panel under the chairmanship of Professor Lord Robert Winston, who was also a member of the Council of EPSRC: "What was happening was that there was an increasing concern about the misuse of science and technology." [2]. To ensure that the research community was kept on board with the Panel's work, Winston allowed issues to be discussed to come from the bottom-up rather than imposing a top-down agenda, thus allowing ordinary researchers to raise societal concerns about their own work and to become more involved with public engagement [3].

"What we would do is to see where a technology might have issues surrounding it and then get someone in to present this technology to us, and then we could have a discussion about it," Winston explains. "A report on nanotechnology was one of the things that came out of the Panel, and carbon capture too. And we spotted very early on that drones had a significant issue about them."

"All scientists have to recognise that technology will have a downside, that is unpredictable, along with the hoped for benefits," Winston says. But he does not think that unpredictability argues against responsibility. "You can have an over-watching group like the Societal Issues Panel, that look at what the prospects might be."

In the last few years, the Societal Issues Panel has been disbanded – partly as a result of budget cuts to the research council – in favour of a Strategic Advisory Network. But Winston still sits on the House of Lords Science and Technology Select Committee, a body he says does 'useful work' despite being under-resourced.

2.2 Development of the Framework for Responsible Innovation

Towards the end of the Societal Issues Panel's functioning, it began to engage with academics in the area of the social sciences to turn its issue-by-issue deliberations into a more general framework for researchers funded by EPSRC (and, potentially, other research funders, too). One of those brought into the Panel was Richard Owen, Professor of Responsible Innovation at the University of Exeter. A former chemist working on radioactive chemicals, Owen had spent four years at the Environment Agency before returning to academia. By 2010, he and others had already been looking at a number of technologies for which concerns went beyond simple risk management for some time [4].

Owen and his colleague Nicola Goldberg, the nanotechnology portfolio manager at EPSRC, had run a pilot study around nanoscience for carbon capture at power stations. They had developed a 'risk register' tool for researchers applying for funding for this specific research call.

"Although the risk register was very limited, what it did was that it opened up a conversation," Owen explains. "It was not too ambitious in its goals – we were asking the researchers to take the responsibility of thinking about the broader environmental and social impacts of their work."

Looking at the risk registers submitted by applicants for research funding showed that most researchers filled these in very conservatively. However …

> … some applicants addressed this by including investigators with expertise beyond engineering and nanosciences supporting integrated activities that included life cycle

and real-time technology assessment, which in some cases were also framed by stakeholder and/or public engagement. Proposals underpinned by a strong commitment to responsible science and innovation promoted continuous reflexivity, embedding a suite of multidisciplinary approaches around the innovation research core to support decisions modulating the trajectory of their innovation research in real-time.

Their study came up with a number of recommendations:

1. Promote continuous reflexivity, participation, and the enhancement of societal learning.
2. Embed a set of integrated, multidisciplinary approaches linked to the innovation research core, including technology assessment, risk analysis, benefit analysis, and engagement.
3. Provide a continuous feedback process that allows modulation of innovation pathways at specific decision points (e.g., funding at various points in the technology readiness level framework).
4. Ensure a clear mechanism for an on-going dialogue with policymakers as the process co-evolves.
5. Following points 1-4, embed early on the concept of responsible science and innovation for continuation across the TRL framework.

(see Owen R. and Goldberg N., 2010. *Risk Analysis* 30, 1699-1707.)

It was this work that was taken to the Societal Issues Panel and then developed – in conjunction with the UK's Economic and Social Science Research Council – to provide the discussion paper that went to the Council of EPSRC in 2012 (Appendix 1).

2.3 Taking the proposal through EPSRC Council

According to Dr Alison Wall, the Associate Director for Building Leadership, one of the key factors in getting the ideas coming from the Societal Issues Panel through the Council of EPSRC was that several of its own members were already interested in the issues raised. The

support of David Delpy, EPSRC's CEO, was also vital: Delpy had been very involved with a dialogue exercise that EPSRC had run jointly with the Biotechnology and Biological Sciences Research Council (BBSRC) 2009-10 on public attitudes to and concerns about the newly opening research area of synthetic biology, which aims to construct 'new biological parts, devices or systems' or re-design 'existing, natural biological systems for useful purposes' according to engineering principles.

EPSRC Council had already been faced with some real societal issues around geoengineering, and information and communication technology (ICT), as well as the work of the Societal Issues Panel, prior to the paper on the Framework for Responsible Innovation arriving [5]. "This meant that Council had a good idea of the approach we would take," explains Dr Wall, who had the lead responsibility for taking the framework through Council. "They could be comfortable with it, as we were not going for rules and regulations, and specific grant conditions, but producing a framework for researchers to use." [6].

It was also important to have people on Council who could take what was fundamental social science research on innovation for public needs and make that accessible to the engineering and physical sciences research community [7]. And the work from the Societal Issues Panel itself had to be adapted and some of the wording changed to create the AREA framework, according to Dr John Hand, Head of Physical Sciences at EPSRC. Note that in the paper put to EPSRC Council in October 2012, the original quartet of RRI procedures was Anticipation, Reflection, Deliberation, Responsive – the latter two were changed later to Engage and Act to make the more appealing AREA acronym (see Appendix 1). The Framework for Responsible Innovation was then published in 2013.

2.4 How the framework works

EPSRC funds research in what is called 'responsive' mode as well as making its own managed calls for particular areas of science and engineering. The Framework approach means that it is possible to be sensitive to areas that are likely to have a strong requirement for societal

considerations – nanotechnology, geoengineering, synthetic biology being ready examples – whilst others closer to pure mathematics have less concerns for the public.

For the responsive mode calls, where the research community is the immediate source of the proposal, portfolio managers for the area are expected to "get out into their community," according to Hand, to ensure they are aware that there may be RRI issues for consideration. For the more targeted calls, the research council has made it clear that the proposal should "build in an approach to responsible innovation and resource it appropriately".

Both Wall and Hand see the Framework as an opportunity not a threat for researchers. "There is some concern about how to engage with the 'right people'," warns Wall, and finding collegial academics may be difficult as the social scientists are being asked to give advice to scientists and engineers rather than to undertake the more fundamental societal and critical research for which they are more usually recognised. Richard Owen is also concerned about the 'Babel effect' of scientists and engineers, on the one hand, and social scientists, on the other hand, not talking each other's language.

Hand's warning is that researchers may feel they have to have to follow the AREA code in order to avoid negative consequences; but the real strength of following the Framework is likely to be that researchers do not miss out on positive opportunities for research and its applications – opportunities that can provide for genuine co-production of research [8]. He sees 'building on (RRI) champions' as key to ensuring that the use of the Framework spreads amongst the research community [9].

2.5 The synthetic biology call and evaluating the response to RRI issues

The joint BBSRC-EPSRC public dialogue on synthetic biology involved some 160 people during 2009-10 in workshops and stakeholder interviews around UK. The report that resulted had two key conclusions for the research councils themselves, namely:

1. Research councils were seen to have a very significant role in the governance of synthetic biology.
2. One of the key issues to emerge was what was meant by funding good science. Currently, this process was generally seen as focusing on technical excellence. Participants also wanted to see a broader definition of good science – in a normative or social sense. (www.bbsrc.ac.uk/engagement/dialogue/activities/synthetic-biology/)

Delpy found the results challenging and encouraging at the same time: "The public were not against adventurous research, including really quite speculative and, we could almost say, dangerous research. But they expected the scientist to give some thought to what they were doing, and why they were doing it, and how they were doing it," he comments [10].

In 2013, BBSRC and EPSRC jointly put out a call that resulted in several research centres around the UK being funded, many of which had explicit work-packages on responsible innovation, with the direct involvement of social scientists with the relevant experience. Richard Owen was involved in assessing the grant proposals that were submitted.

"I believe we have seen a real change in how people are responding. Initially, it was 'fill in Appendix D for technology strategy', and people would fill in the form or get someone down the corridor to do it for them. This was then evaluated separately from the scientific excellence," he says. And there could be tensions between those on the assessment panel who wanted to fund 'excellent research' no matter what its response to responsible innovation issues, and those who wanted RRI to be fully accounted for in the final decisions as to whether or not to fund.

"But what I have seen in the more recent synthetic biology research proposals is a more flexible, embedded approach in response to the framework. It's much more putting together multidisciplinary teams that can develop the processes within their project as an embedded part of the project. This is resulting in really imaginative, really creative proposals that are pushing how inter-disciplinary research can be done." [11].

2.6 The SynthSys Centre for Synthetic Biology

The SynthSys Centre for Synthetic Biology at the University of Edinburgh covers many areas of this fast-growing area, including modelling, biosensors, mammalian synthetic biology, and biophysics. Additionally, it includes social scientists looking at the responsible innovation dimensions of the area along with governance and regulation. SynthSys, through some of its leading participants, has been one of the recipients of resources from the joint BBSRC / EPSRC funding streams that required a commitment to the Framework for Responsible Innovation and activity in accordance with its process requirements.

Professor Alistair Elfick, SynthSys Director, has had a long-term commitment to the principles of responsible research and innovation that predates EPSRC's formal adoption of the AREA framework. So Elfick was involved, for example, in the Synthetic Aesthetics project, imaging futures for synthetic biology – both positive and less positive, nuanced, and utterly dystopian. "My involvement in that was thinking about how to be good at doing synthetic biology as an engineer. This involves a huge amount of challenges but a huge amount of opportunities, too. A lot of the opportunities come from avoiding the mistakes that previous generations of engineers have made," Elfick explains.

Responsible innovation is now very much a part of SynthSys, as a result of Elfick's own commitment and that of the Centre's staff, and as a result of its winning EPSRC/BBSRC funding. Elfick feels that researchers, faced with a new project or problem, tend to "zoom straight into the science". The Centre now actively zooms out in order to see the bigger picture – "RRI forces us to do that," Elfick says. "I feel very upbeat about it as a way of getting researchers to think about the wider implications of their research."

Whilst SynthSys does not have what it calls 'formal methods' for carrying out RRI processes, the close working relationship between the scientific researchers and the social scientists means that they are part of the research project team. This means the Centre as a whole, and its individual members, taking responsibility for understanding the interactions between the scientific research and wider society – a moral responsibility towards society and a responsibility to how science uses the money provided by the public. That said, Elfick is keen

to develop institutional processes that will help individual researchers understand and incorporate processes that will lead to responsible innovation.

The synthetic biology community currently sees the best way for it to have an impact on society as by being open, sharing knowledge and expertise to build its community further. This way of working means that commercialisation will take place around individual products rather than around ways of working and techniques. Elfick thinks that commercial model for synthetic biology will look more like the open source software community, rather than traditional industrial biochemical firms, although their techniques will more and more underpin such industries [12].

2.7 Working with the researchers – a social science viewpoint

Professor Nik Rose heads the Department of Social Science, Health, and Medicine at King's College, London. He is involved in several research and innovation projects, such as the European Union's Human Brain Project, taking responsibility for societal and ethical issues. In May, 2012, the EPSRC announced funding for the Flowers Consortium for synthetic biology research and led by Imperial College, a project that involved some of Rose's PhD students being 'embedded' in the research laboratories. "By virtue of being in the lab, and asking people why they were doing what they were doing, that caused the young researchers to question what they were doing." Rose's team also taught on the synthetic biology masters' programme and attended the lab meetings and meetings of the principal investigators and what were known as 'all hands' meetings, where they presented their work. This ensured that there was a high-level commitment to the project's research being socially responsible.

Rose's team also ran a series of stakeholder workshops that looked at social and ethical issues around synthetic biology, which went on to produce a series of reports. "We did one on deliberate release – what social and ethical issues arise when you deliberately put something out in the environment – and the links to genetic modification." Others involve bio-security, intellectual property, and the development of biosensors. Each report involved

several months of scoping research as well as the workshops themselves, typical attended by around 25 people.

Rose considers the primary role of his team was in raising researcher awareness and asking questions to encourage them to reflect on their work [13]. A typical initial reaction from researchers was it was 'absurd' to expect them to be able to anticipate and predict all the consequences of their work. "You social scientists could not predict the consequences of the personal computer or the internet, so how can we? We are doing some very basic research and who knows what's going to happen 20 or 30 years down the line?" But Rose also finds that the younger researchers really do have a social conscience – "they would like to do good, they don't want to do harm, they would like their bugs to help cure disease and assist bio-remediation".

"So we tell them if you do want to develop something that promises do some good, it may be a good idea to talk to the end users really early on. If you're developing a bio-sensor for arsenic in the water in Nepal, it might be a good idea to go out to Nepal to see how they manage their water supplies, to talk to them about what might be and might not be practical, and perhaps even to work out a way so that it could be manufactured at low-cost in the country where it is going to be used. And then the intellectual capacity as well as the manufacturing capacity is something you can build up as the project goes along."

2.8 The Wearable Assistive Materials project

On its responsible innovation website, it is clear that: "EPSRC does not wish to be prescriptive about how responsible innovation is embedded in the research and innovation process. We recognise that some researchers are already well engaged with this agenda. We also recognise that different approaches might be required for different research areas." (www.epsrc.ac.uk/research/framework/)

One researcher who has been following his own 'framework' for responsible innovation for some time is Professor Nick Tyler, of University College London's Department of Civil

Engineering. His research into various questions around mobility – public transport and personal mobility – has made considerable use of public engagement processes. His Wearable Assistive Materials www.cege.ucl.ac.uk/arg/WAM/Pages/WAM.aspx project was funded in 2012 around the time that EPSRC was adopting *its* Framework.

"WAM is a project which started from asking a question about what would make a transformational difference to someone who is experiencing difficulties in walking. The answer was to be able to walk without visible (or audible) assistance," Tyler explains. The question that Tyler's team was set came itself out of EPSRC's 'creativity training' programme for its own researchers, and then by having a series of public conversations with older and less mobile people as to how did they do ordinary, everyday things. How, for example, do you try on clothes in a shop if you're in a wheelchair? What about the length of time it takes on busy shopping days?

Tyler says that WAM, has the long-term goal of creating synthetic materials that can be worn and that will assist (some) wheelchair-bound people to become genuinely bipedal again, is a mixture of chemistry and physics – the bread-and-butter of mainline EPSRC-funded research – and on-going public engagement (see www.youtube.com/watch?v=Ew6Y0cDpdek). He estimates that 15% or more of the project time goes into engagement. But it is worth it!

Discussions with their user focus group have raised issues around the friction and possible skin chafing that flexible but supportive synthetic materials may cause, and the way in which wearers of these materials may start to overheat. So WAM is refining the materials with a view to making them more comfortable and building temperature sensors into the clothing it is proposing to make.

Engagement with user groups has also brought to light other conditions that could benefit from WAM materials, such as rheumatoid arthritis, where whole limbs may not be affected but where, for example, a wearable wrist support that could be switched on and off as required could make a real difference. This is something the project had not originally

considered, but now feel they could deliver on a much shorter timescale than the 10-20 years probably needed for a full, comfortable, wearable 'exo-skeleton' [14].

2.9 The role of industry

WAM's original proposal had an industrial partner named that has yet to be fully involved, although Tyler says now may be a good time for them to be brought back into the project [15]. And even at this stage, Airbus is interested in whether or not materials WAM is developing could be used for deformable plane wings – getting rid of the need for hydraulically-operated flaps – and conformable seats that would make flying much more comfortable.

Another project that Nick Rose is involved with is the SynbiCITE, an EPSRC 'launchpad' that is focussed on the link between training and support from Imperial College and many industrial partners, using or hoping to use synthetic biology in commercial products (www.synbicite.com). This Centre has explicitly adopted responsible innovation – www.synbicite.com/synthetic-biology/responsible-innovation/ - as part of its way of working. Its 'Innovation and Knowledge Centre' has three main aims:

1. To act as an industrial translation engine, which translates university and industry based research in synthetic biology into industrial process and products.
2. To be an effective vehicle for the support of small to medium sized UK companies including Start-ups in synthetic biology.
3. To actively engage in open dialogue with the public and other stakeholders focusing on the risks and benefits of synthetic biology technologies.

Rose explains: "The lab environment is a closed environment of people who are used to being regulated by codes of conduct etc. But when you have anywhere between 20 and 50 companies, ranging from small start-ups to large enterprises, the small ones have no capacity to take anything else on, because they are on the margins of profitability, and the large ones say you should talk to our corporate social responsibility guys, and may look on responsible innovation as just a bit of public relations."

So Rose's team have been holding a series of workshops with commercial leaders involved with synthetic biology explaining just why RRI is important. In SynbiCITE, organisations that get funding have to show that they are really taking these principles on board, and not just treating it as a tick-box exercise. One way of convincing partners of the importance of RRI is to show examples of where not adhering to responsible innovation principles leads to commercial problems.

More generally, EPSRC partners with the UK Government's Innovate UK, in particular its responsible business awards (www.gov.uk/government/news/responsible-business-awards-a-win-for-innovate-uk-funded-project.) Alison Wall feels, however, that the research council does need to do more to follow up with its industrial partners to ensure that their part of the research and innovation process follows the responsible framework that the more academic research element is working with. "I would be quite optimistic that companies would be pretty open to this sort of approach, pretty much in the same we as we found a lot of researchers, and Council members, and people were very open to the approach. I think the tricky thing is making sure companies are really engaging and not just using it as a nice paragraph in their CSR report," Alison Wall says [16].

2.10 EPSRC Centres for Doctoral Training

One of the key routes for developing RRI within the EPSRC community is through its Centres for Doctoral Training that have responsibility for ensuring young researchers have a broad range of skills relevant to their work. The more recently funded now involve the Framework for Responsible Innovation, and have been explicitly asked to ensure that RRI issues feature in their programmes. The work of these centres means that there is now a new cohort of young researchers who have had RRI concepts built into their training programmes, says John Hand [12].

Whilst some centres are more narrowly focussed on the research and innovation skills themselves, the Oxford University's Centre explains: "The training will be based on a varied and innovative programme that will range from classes and seminars to student-led group

projects and exploratory and PhD research projects at the forefront of the development of synthetic biology. Ethical, Legal, and Social considerations, public engagement, and the needs of industrial, academic, and potential end users of synthetic biology will be integrated into the training programme from the start. We will engender within the cohort a sophisticated, multi-faceted appreciation of the opportunities and potential hazards of synthetic biology that is essential to responsible innovation."

Similarly, the Centre for Doctoral Training through Sustainable Chemical Technologies, promises: "All students will receive foundation training to supplement their undergraduate knowledge, in addition training in Sustainable Chemical Technologies. Broader training and practice in public engagement and creativity will encourage responsible innovation and attention to ethical, societal, and business aspects of research."

2.11 Conclusion: some issues raised by this showcase

The EPSRC and its AREA set of processes is clearly widely applicable, and has the *potential* to be important for all of the agendas, outcomes, and processes envisaged as leading to RRI, set out in this project's Policy Brief. But the Framework is a *process*-orientated strategy. It does not set out to define societal challenges that need addressing, nor many of the learning and RRI outcomes. Nor does it address all the agendas RRI Tools has been confronted with. In particular, whilst issues around engagement and training, governance, and ethics are fairly well included, Open Access is not.

Nor are gender issues explicitly tackled. Dave Delpy himself acknowledges this to be a particular problem for EPSRC: "The reality is that in the engineering and physical sciences we have an appalling gender misbalance – far too many men and far too few female researchers," he explains. "On the other hand, the general public that we interacted with were at least 50/50 and I suspect probably slightly more biased in terms of female engagement. And the approach that the researchers took in presenting their research I think was certainly adapted as the community – especially the women in the audience – asked

questions from a slightly different view point, one that I suspect that many researchers had not even thought of when they were originally preparing their speech."

Comparing the EPSRC Framework for Responsible Innovation, it can be seen that – whilst it is comprehensive – it is not quite as explicit as that of RRI Tools itself. It can be a useful exercise to compare the two, along with the ideas set down by the European Commission itself – e.g. its report on strengthening RRI in Europe: ec.europa.eu/research/science-society/document_library/pdf_06/options-for-strengthening_en.pdf

Finally, throughout the text of the showcase, numbers in [] have been inserted. So some of the key points of relevance for RRI that are being made (usually by the various interviewees) include:

1. The role of leadership – referred to often in text, as well as highlighted point.
2. A problem that needed solutions – several examples relevant to UK are given. Users of this showcase from other countries and communities may have similar examples of their own.
3. A 'bottom-up' approach – allows for stakeholder input, and is referred to by several others in this showcase.
4. Scientists and engineers engaging with relevant academics – e.g. *social* scientists – to extend their expertise and collaborations, and fill in key gaps.
5. A Research Council leadership already sensitised to possible problems was part of the background to the Framework development.
6. Keeping leadership updated and 'comfortable'.
7. 'Translation' from social science speak into more approachable language – Owen warns of 'Babel effect' – is important.
8. Positive opportunities should not be missed – others also stress the positives, as does RRI Tools D2.2 report.
9. The need to build on 'champions' – good researchers who are adopting RRI – seeing how its done is always helpful.

10. The public can accept speculative – and even dangerous – research, but expects scientists to do this responsibly.
11. An RRI framework can lead to imaginative solutions.
12. Openness in a research community can lead to successful commercial models.
13. Raising researcher awareness by asking questions as a method of training (in addition to workshops).
14. Engagement with the public leads to positive applications of research not originally foreseen.
15. The timing of industry engagement can be critical.
16. It is important to ensure the commercial sector really is engaged with RRI and not just 'using' it for corporate ends.
17. Embedding RRI in the next generation of researchers is key to its on-going success.

NOTE: this is not meant to be a comprehensive list, and there are many other issues that can be drawn out of a detailed examination of this Showcase.

3 The EPSRC Framework for Responsible Innovation from an RRI perspective

3.1 Reflection on the process criteria

The EPSRC's AREA Framework for Responsible Innovation (Anticipate, Reflect, Engage, Act) is not really a research or innovation project in itself, and as such it does not particularly incorporate the processes identified by the RRI Tools project as leading to responsible research and innovation. Rather, it is a 'meta-project' insofar as it enables other projects and programmes to reflect and incorporate elements of RRI. Nonetheless, it is worth looking at the various RRI Tools process criteria – some of which derive from the AREA framework – to see how the overall initiative of EPSRC does fit with them.

Diversity and inclusion

The aspect of the AREA framework that most closely corresponds to this pair of process criteria is 'Engage'. On the EPSRC website, it is explicitly stated that this means "opening up such [research] visions, impacts, and questioning to broader deliberation, dialogue, engagement, and debate in an inclusive way". The RRI Tools understanding of 'inclusion' is that this 'inclusion' very strongly includes the gender dimensions of research and innovation, and of the institutions responsible for this activity. Although not mentioned explicitly in the AREA framework, the EPSRC website makes clear elsewhere that they understand 'inclusion' to mean 'harnessing all the available talent', and are aiming towards 50% women on their leading bodies by 2020. They also have policies covering 'Citizenship, ethnicity, and nationality', 'Maternity, paternity, and adoption leave', and allowances for disabled students – see www.epsrc.ac.uk/funding/equalitydiversity/. Thus there is an expectation of diversity and inclusion amongst those funded, as well as within EPSRC as an organisation.

In terms of the processes and developments that led to the Framework for Responsible Innovation, it is clear that one of the key programmes was that of public consultation over the possibilities and challenges of synthetic biology. Taken together with the inclusion, particularly by the Social Issues Panel, of research from social scientists outside of the 'usual' EPSRC community of engineers and physical scientists, concerns following public

engagement – including the earlier (2003) GM Nation debates – acted as a spur to action for the research council.

Anticipation and reflection

This pair of RRI Tools process requirements is clearly taken from the first two components of the AREA framework. The AREA website states:

> A responsible innovation approach should be one that continuously seeks to:
>
> **Anticipate** – describing and analysing the impacts, intended or otherwise, (for example 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.

The SynthSys Centre in Edinburgh, which follows a lot of the AREA framework, sees 'zooming out' to be essential to understanding the wider context and the wider implications of the research projects they are undertaking.

Openness and transparency

Here the AREA framework is not at all explicit, the RRI Tools project having including these processes in part in response to the Open Access agenda of the EU. That said, within the UK there has been a 'presumption of openness' where decision-making around scientific issues is concerned ever since the 2000 House of Lords *Science and Society* report. Being 'arm's-length' government agencies, the UK's research councils are bound by that ethos. For projects that have responded to the AREA framework, it is clear that openness is seen as part of wider community building, rather than as a threat to the area becoming commercially successful.

Responsiveness and adaptive change

The EPSRC AREA framework urges its researchers to '**Act** – using these processes [the proceeding three components of the AREA framework] to influence the direction and trajectory of the research and innovation process itself' as its final injunction. Here

responsiveness and adaptive change are clearly included in what EPSRC has in mind for its responsible researchers and innovators.

Overall, one can see that, whilst the terminology is sometimes different, EPSRC's Framework for Responsible Innovation did come up with much of what RRI Tools now considers essential RRI. AREA is a neat, compact, formulation of the essence of RRI. The accompanying interviews and projects that have foreshadowed or flowed from EPSRC's commitment to responsible research and innovation help to explain how this has worked out in practice.

3.2 Using this showcase

Although this showcase has been envisaged as being used in a workshop scenario, it may also be possible to use it as part of a more academically formal programme, delivered either face-to-face, or online. The exact usage of this showcase will clearly affect how any RRI training is delivered. In Section 4, a workshop scenario is outlined.

3.3 Learning Outcomes from this showcase

The RRI Tools project has developed an ambitious set of learning outcomes that it would like to see addressed by those training stakeholders in the principles and practice of RRI. These are set out in the RRI Tools *Learning Outcomes* document, and made explicit in Section 2 of that document. They are divided into outcomes for all stakeholders and stakeholder specific outcomes. Trainers should be familiar with this document, and be prepared to amend and augment it as they deliver their training and deal with particular situations.

Under the All Stakeholders set of learning outcomes, this showcase clearly addresses Outcome 1 "Be able to explain the concept of RRI …" outcome. It also explicitly addresses Outcomes 2 "Be able to identify the opportunities …" and 3 "Be able to identify the possible obstacles …". Depending on how training using this showcase is delivered, it is quite probable that many of the other Outcomes will be addressed, although some of the specific agendas that RRI encompasses are not explicitly addressed, especially Gender and Open Access. In terms of stakeholder specific outcomes, insofar as EPSRC is itself part of the

policy-making machinery for research (and innovation, to a lesser extent) governance, all of the five understandings are covered in this showcase. Additional exercises are included to strengthen this, and to develop further RRI understanding amongst the other stakeholder groups.

3.4 Adapting this showcase

One of the reasons for developing the story of the EPSRC Framework for Responsible Innovation into an RRI Tools Showcase was that it was felt to have some generally useful lessons for the community across the European Union. However, there are some features of UK research councils that may not be replicated in other countries; most notable of these is something called the Haldane Principle in which the UK Government sets the overall budget for publically funded research, but devolves to the research councils themselves how that money should be divided between various areas of science, engineering, and medicine. The individual research councils then set their own disciplinary priorities. So there may be features of this showcase that are simply not applicable. Trainers making use of it should adapt as their local or regional requirements dictate.

3.5 Further use of this showcase

After any workshop use of this showcase and at an appropriate point in any online training course, Sections 1 and 2 should be made available to the workshop participants and online trainees, along with the additional materials outlined in Section 5 and the appendices.

3.6 Limitations of this showcase

The EPSRC Framework for Responsible Innovation Showcase is intended only to illuminate some aspects of developing a climate for responsible research and innovation, and is not a complete solution to how to do this. It needs to be used in conjunction with the RRI Tools *Policy Brief*, with (parts of) the *Quality Criteria*, the *Catalogue of Good RRI practices*, the *report on the analysis of opportunities, obstacles and needs*, and relevant items in the comprehensive Toolkit produced by the project. This showcase, by itself, does not lead to familiarity with the RRI Tools Toolkit, but this is provided for in the final exercise.

4 Workshop training exercises

Based on the EPSRC Framework for Responsible Innovation outlined in Section 2 (above), this section now sets out how this might be used in a training workshop involving all of the stakeholder groups RRI Tools addresses. This involves an introductory plenary session, a stakeholder specific group session (stakeholder groups meeting in parallel), a multi-stakeholder group session (with two or more groups, depending on participant numbers), and a final plenary session.

These come with suggested timings: depending on the knowledge levels of participants, this showcase could be used for a half-day or whole-day event. Ideally there would be 20-30 participants and two or three trainers. Model PowerPoint presentations are under construction and will be available by the end of January 2016.

Depending on how conversant the workshop participants are already with RRI, and how conversant the trainer(s) want them to be, prior to the workshop participants can be asked to visit the EPSRC Framework for Responsible Innovation website – www.epsrc.ac.uk/research/framework/ – and asked to read the RRI Tools *Policy Brief.* **Neither of these should be accessed during the workshop itself, however.**

4.1 Plenary briefing

30 minutes to one hour

This plenary session of the workshop should be used to briefly (re-)familiarise trainees with some of the main issues that RRI is trying to address based on the RRI Tools Policy Brief. In terms of making use of this showcase, it should make use of Sections 1, 2.1, and 2.2, but – given the sessions that follow – not give too much away as to what the eventual outcome of EPSRC's deliberations were. Given that the EPSRC showcase does not explicitly address (all of) the agendas covered by RRI or the expected outcomes, some indication of these can be given.

Learning Outcomes: This session starts to address the All Stakeholders "Understand where RRI has come from …" learning outcome, and bullet points 1 and 2. The next sessions will help to address some of the individual stakeholders' and some of the other All Stakeholders' learning outcomes.

4.2 Meeting 1: Stakeholder Groups

30mins - I hour – 4 to 6 per stakeholder group

A meeting has been called by (one of) the country's leading research funding bodies to discuss making research and innovation more responsive to societal needs and concerns, more open to being influenced at an early stage by citizens and civil society organisations, more inclusive and open generally, and more able to address global challenges to which the government has made strong commitments. It is clear that a long-term strategy is being sought such that the education of future researchers, innovators, and entrepreneurs will be an issue.

The stakeholder groups will be:

1. Policy makers from the research council concerned and the relevant government department(s).
2. Representatives of companies that are developing leading edge technology and have a record of working closely with the research community to bring (potentially) transformative new products to market.
3. The research community based mainly – but not exclusively – in university departments and institutes.
4. Pressure and special interest groups – e.g. environmental activists, patient groups, labour organisations etc. – who feel the need to be more closely involved with ensuring research caters for their needs and concerns.
5. Educators trying to ensure that young researchers and innovators are aware of societal issues as they set out on their careers, and that young citizens generally are aware of what research and innovation may or may not be able to achieve.

The aim of the research council in convening this meeting is to agree a simple framework that can guide the scientists, medics, and engineers it is funding for the research stage, as well as leading to a societally responsible relationship with its industrial and commercial partners.

Your group is meeting a few days *ahead* of the research council's meeting, to which you have been invited to send representatives. Your tasks are:

1. Decide on two key *positive* inputs can your stakeholder group make towards this goal.
2. Agree on one key 'sticking point' that your group feels would be a deal-breaker, making it impossible to reach the agreement the research council is hoping to achieve. NOTE: this sticking point is to be kept private to the stakeholder group, and may need to be argued during the course of the second meeting.

Learning Outcomes: This session starts to address the individual stakeholders' learning outcomes. For Policymakers, it is likely that their Outcomes 2 and 3 should become clearer. Researchers should particularly start to understand their Outcome 1. The next sessions will help to address some of the other All Stakeholders' learning outcomes as well as those of the individual stakeholder groups.

4.3 Meeting 2: The Research Council's stakeholder meeting

1 - 1.5 hours – 2 to 3 per stakeholder group in each of two or three meetings as required

This is the meeting called by the research council to discuss its proposal for a simple research and innovation framework. It will be chaired by a leading member of the research council itself, even if a representative of government is available.

Prepared by the discussions held in their own stakeholder group – even if these did not lead to complete agreement – representatives bring their group's positive ideas to the meeting for discussion. Without revealing the details of their 'deal-breaker' representatives will argue

to ensure that this is taken into consideration. They may amend their stance as the meeting progresses in the light of arguments from other groups.

The aim of the research council's meeting is to come up with a list of no more than 10 *key* features that its framework for responsible research and innovation should contain. As far as possible these should be written down in abbreviated form.

Note – it may well be the case that this list includes items that were not included in the set of 'positive inputs' brought to the meeting from the stakeholder groups.

Only at the end of the meeting should stakeholder representatives reveal what their (potential) sticking point was. This will be discussed further in the plenary session.

Learning Outcomes: This session builds on the understanding of the All Stakeholders' learning outcomes generated in the first plenary session. It should enable workshop participants themselves to start to address Outcomes 2-5. For the individual stakeholders' learning outcomes, all stakeholder groups should be building on their understanding of their own learning outcomes.

For Policymakers, as well a strengthening their understanding of their bullet points 2 and 3, their role in advocating RRI (Outcome 1) should be much clearer.

Researchers should particularly get to grips with their Outcomes 4 (reflect on values), 3 (inclusive and diverse), and 5 (influence innovations).

Industry learning outcomes should be to start to understand how to identify potential contradictions (2), and to understand their own and other viewpoints (4).

Educators should understand the importance of educating the next generations of researchers, innovators, and entrepreneurs in the principles encompassed in RRI (their

Outcome 1), and to have ideas on delivering an understanding of science that is more reflexive (2).

Civil society organisation representatives should have a good grasp of how their insight can assist in bringing RRI to life (their Outcome 1), and begin to formulate ideas for becoming involved in research and innovation (2 and 3).

4.4 Plenary report back meeting

1 – 1.5 hours

This session is designed to get groups to report back from both the stakeholder group meetings and research council convened meetings. It should start with each of the two or three research council convened groups showing their list of key features, before the chair of each meeting presents their report.

The main questions to be answered are:

1. How easy or difficult was it to reach agreement on these key features for the RRI framework?
2. Did any of the stakeholder representatives feel that their deal-breaker had been so poorly addressed that they could not sign up to the framework the meeting came up with?
3. If so, why?
4. Who else, other than the stakeholder representatives, might usefully have been present at the meeting?

This should be followed with a report from each of the five stakeholder groups about the meeting they held prior to the research council's meeting(s). The main questions to be answered are:

1. How easy or difficult was it for them to come up with their two positive inputs and their sticking point?
2. Were those prior discussions useful in preparing them for the research council's meeting?
3. Did they feel that their input(s) were incorporated, and their potential sticking points dealt with fairly?
4. Did they feel that one 'stakeholder group' actually covered the various facets of their members?

Since there will probably have been more than one research council convened meeting, a variety of responses to these questions may be given.

At this stage, it may be useful to say more about the EPSRC's own Framework for Responsible Innovation, particularly to compare it with the 'key features' that have arisen from the scenario meetings. There should also be a comparison between the 'key features' that the groups came up with and the elements of RRI contained in the Policy Brief. And finally, it may be worth reflecting on whether the groups identified – explicitly or implicitly – the 15-point 'lessons' of the EPSRC showcase for RRI (Section 2.9).

Note – the RRI Tools Policy Brief actually contains 13 multi-faceted items: 3 Outcomes, 4 Process pairs, and 6 Policy Agendas. So it will be interesting to observe whether or not there is a tendency for particular 'items' from the Policy Brief not to be included or touched upon by the group 'key features'.

Learning Outcomes: This session enables the participants to consolidate their grasp of the All Stakeholders general understandings, in particular to understand what RRI means as an overall concept (7). Discussion of the 'sticking points' generated in Meeting 1 (stakeholder groups) should also help to tackle learning Outcome 3 (obstacles), whilst reflection on Meeting 2 (Research Council's stakeholder meeting) should result in a good grasp of working with partners (5), and perhaps flag up some opportunities (2).

4.5 An alternative workshop delivery

1 hour

If time is relatively short for the session, it may be better to 'tell the EPSRC story' and then encourage discussion around the topic 'the EPSRC Framework for Responsible Innovation from an RRI perspective', as set out in Section 3.1. This does, of course, assume that the participants have familiarity with RRI – in particular with the Project Brief.

4.6 Possible follow up exercises

Following the workshop, further training could be effected using simple follow up exercises based on having read the RRI Tools *Policy Brief* and the EPSRC showcase. These can also be appropriate if this scenario is being used for distance (e.g. MOOC) training. If feedback is to be given, then training resources will be required. Some possible exercises might include:

All Stakeholders: This workshop scenario module envisages participants drawing heavily on their own experience and knowledge, but being kept somewhat 'in the dark' as to the direction of travel that the EPSRC had followed. No explicit reference to the RRI Tools Toolkit has been made, therefore.

Depending on how this module is situated in an overall workshop, however, it may be useful to have mixed stakeholder groups access the RRI Tools Toolkit to see what resources (if any) they can find that may have been of help to them in their deliberations. Note: if, during the course of the module individual participants or stakeholder groups did try to access the Toolkit, this should not be discouraged.

Policymakers: The EPSRC Framework for Responsible Innovation does not explicitly cover the RRI agendas of Gender and Open Access, although it is clear that 'Engage' activities should be inclusive. Without losing (too much of) its appealing simplicity, how could one or both of these agendas be more clearly included in the Framework? How might the AREA process be modified, expanded, or developed to produce a memorable *aide memoir* for researchers?

Researchers: You are putting together a proposal for funding. Write a short work package to ensure that the principles of RRI are foregrounded in your proposal. How will you ensure that RRI is not simply an 'add-on' to your work, but is genuinely embedded in it?

Industry: You are thinking of working with academic partners on commercialising research that has been carried out with a strong (even, binding) commitment to RRI. Write a short paper to your company board outlining the advantages of continuing this commitment into the commercial innovation phase, whilst flagging up what you see as the main difficulties.

Civil society organisations: academics and industrialists are working on products that have some bearing (for good or, perhaps, not so good) on the areas that your organisation exists to advance and/or protect. Write a short letter to them, proposing that your organisation becomes involved in their work, bringing with you your insights, expertises, and memberships, and suggesting at what stage(s) they might find this useful.

Educators: RRI is clearly raising important issues for research and innovation, and it is important that young people and ordinary citizens are aware of these. Write a short paper for your staff meeting explaining how RRI principles can be incorporated into your curricula and your exhibitions.

5 Useful resources

(1) Model PowerPoint presentation

(2) Appendix 1: Paper to EPSRC Council, 16/17 October 2012

(3) RRI Tools reports referred to in Showcase

(4) References and weblinks listed in Showcase

(5) Video interview with Professor Dave Delpy, former Chief Executive Officer of EPSRC – available on www.youtube.com/watch?v=YwS8IxukgVY

Appendix 1: Paper to EPSRC Council – EPSRC 42-12 – 16/17 October 2012

ENGINEERING AND PHYSICAL SCIENCES RESEARCH COUNCIL

RESPONSIBLE INNOVATION

Alison Wall, Associate Director, Impact

INTRODUCTION

1. Responsible innovation is about encouraging researchers to think imaginatively and reflect on the potential applications and societal and ethical impacts of their research. This should be over the whole life cycle of research and innovation. A responsible innovation approach will help to inform policy and regulation discussions at an early stage. EPSRC's 2010 Delivery Plan contains an undertaking in the Delivery Plan to 'promote responsible innovation'.

2. EPSRC has been piloting aspects of responsible innovation over a number of years albeit through stand alone and independent activities. Some examples of these are identified in Annex 1. The outcome of, and learning obtained from, these activities have been valuable in helping to shape our thinking about the different routes that responsible innovation might take.

3. The purpose of this paper is to set out the background to the more recent work that has been carried out to begin to develop a coherent approach to responsible innovation that can be embedded in a day to day operational context but in a way that is acceptable, practical, and proportionate. The paper concludes by setting out how we propose to proceed with this.

CONTEXT

4. Science and innovation not only produce understanding, knowledge, and value, but result in unintended positive or negative impacts, questions, ethical dilemmas, and, at times, transformations in social life. In addition, experience has also shown that regulatory frameworks are sometimes slow to deal with emerging technologies. Substantial time delays between the development of novel emergent technologies (e.g. nanotechnologies and synthetic biology), understanding of their wider impacts and subsequent regulatory response has led to repeated calls for more anticipatory approaches. This was something highlighted by the Royal Commission on Environmental pollution which identified "a *clear need for an adaptable and spontaneous governance approach that that allows for*

the early identification and response to the wider impacts of innovation".

5. Through discussions and activities initiated by the former Societal Issues Panel (SIP), chaired by Robert Winston, it became increasingly evident that our stakeholders rightly expect to be able to trust funders to ensure that scientists think about the potential impacts of their research and act responsibly, and that government puts in place appropriate and timely regulatory processes. Indeed, for those areas where a licence to proceed is required as a community we need to nurture greater trust in how research is commissioned and conducted. This is even more important today, given that innovation is a key focus in the government's economic growth policy.

RISKS

6. As has been seen in the past (e.g. with Genetically Modified Organisms) if these issues are not satisfactorily addressed through a responsible approach to innovation then there could well be a reaction against emerging technologies limiting our ability to realise the potential benefits. This is more evident today for EPSRC given the emergence of novel and exciting but potentially controversial technologies within the research portfolio (nanotechnology, synthetic biology, digital economy, and robotics).

7. It was these earlier deliberations through the Societal Issues Panel that prompted EPSRC to provide an undertaking in the last Delivery Plan to promote 'responsible innovation'.

IMPLICATIONS

8. This paper will bring Council up to date with developments to introduce responsible innovation. No decisions are required at this point.

DEVELOPING EPSRC'S RESPONSIBLE INNOVATION APPROACH

9. As a first step and in conjunction with ESRC we commissioned a 9-month study in 2011 to provide the basis for a more detailed and informed discussion about how such an approach might be developed.

10. The study was conducted by SAN members Professor Richard Owen and Professor Phil Macnaghten. The report concludes by making some specific recommendations about how EPSRC might take forward its Delivery Plan commitment to promote responsible innovation. These recommendations were discussed in some detail at a meeting of a

sub-group of the SAN on 11 May which was also attended by Robert Winston.

11. This group provided some specific advice about how EPSRC might respond to the report and its recommendations. This advice is reflected in the proposed approach set out below.

AIMS OF RESPONSIBLE INNOVATION

12. Based on the work that has been done, we consider responsible innovation to be about creating the opportunity and embedding processes to allow reflection within the whole life cycle of research and innovation. As research funders we need to be mindful of the potential impacts of the areas that we sponsor and that we should also encourage researchers to think imaginatively about the potential applications and impacts of their science.

13. Responsible innovation needs to be framed sensitively and the expectations placed on scientists in terms of responsibility needs to be realistic. Responsibility in this sense therefore is not about making researchers accountable for the downstream implications of their work but about engendering a duty of care to think about implications and be responsive to new developments as they proceed.

14. To implement a responsible innovation approach there are processes that can be used to reflect, to open up and deliberate, to anticipate, and to use this to support how we act and respond, as sponsors, as innovators, as researchers. Some of the key dimensions of a responsible innovation process are:

    a) **Anticipation** – describing and analysing those intended and potentially unintended impacts (economic, social, environmental or otherwise) that might arise.

    b) **Reflection** – ethically reflecting on the purposes of, motivations for and potential impacts of the research, and the associated uncertainties, areas of ignorance, assumptions, questions, dilemmas, and social transformations these will bring.

    c) **Deliberation** – opening up such visions, impacts, and questioning to broader deliberation dialogue, engagement, and debate.

    d) **Responsive** – using these processes to influence the direction and pace of the research process itself.

15. However, care is needed to ensure a responsible innovation approach is not about halting areas of research in response to potential risk and uncertainty. The aim is to identify how to proceed responsibly and pragmatically and we need to ensure that such processes do not

encourage a risk adverse attitude to commissioning or conducting research.

16. The concepts of responsible innovation would be made available to all research areas. Ideally EPSRC's role should be to encourage, promote, and facilitate approaches to responsible innovation where we consider it is appropriate. However, we will reserve the right to mandate a responsible innovation approach in certain areas as we did in the case of geoengineering and the SPICE project.

NEXT STEPS

17. Building on the commitment in the Delivery Plan, our aim is to ensure that responsible innovation is prominent in EPSRC's strategic thinking and that we encourage our research community to think about the wider societal and ethical impacts of their research.

18. The following describes how we plan to take this forward.

Guidance:

19. In order to meet our objectives with responsible innovation, we need to build the capacity that enables the community to embrace the approach for themselves. As a start we propose to lead on the development of a guidance document for responsible innovation and to include some direction on when and how this approach might be used. Such a document needs to provide a toolbox which is both practical and helpful without being prescriptive. It should encourage researchers to be imaginative about how responsible innovation might be applied. We will commission a short project to get this underway quickly and we will engage our Strategic Advisory Network to have oversight of this. The multidisciplinary nature of responsible innovation suggests that this could be a collaborative venture including other research councils.

Strategic Advisory Teams:

20. We also propose to work with our Strategic Advisory Teams (SATs), to promote the concepts of responsible innovation and to identify some areas within the research portfolio which can serve as 'real-time' exemplars for developing approaches to responsible innovation, building on the work that has taken place in synthetic biology, nanotechnology, robotics, and the digital economy.

21. It will also be important to develop some high profile champions who might help lead on promoting responsible innovation within particular key research communities. We will therefore work with our Theme

Leaders and their Strategic Advisory Teams (SATs) to identity appropriate individuals.

Training:

22. Responsible innovation should be less about rules and more about promoting awareness through engagement and training. Responsibility is a learned behaviour and we believe that a scientist's sense of responsibility should be nurtured and should be a fundamental part of a rounded postgraduate education.

23. As a research sponsor, our aim is to build capacity within our research community to discuss and consider social and ethical questions. A key element in building awareness and capacity therefore will be through appropriate multidisciplinary training. However, it will be important not to be prescriptive about such training but rather students and other researchers should be allowed to be imaginative and develop and discuss what is appropriate within a broad framework which might also encompass ethics.

24. We shall look for opportunities to promote and encourage training in aspects of responsible innovation within our research training portfolio. EPSRC's Centres for Doctoral Training (CDTs) provide an ideal environment for responsible innovation training, because they aim for well-rounded graduate education and they train cohorts of students. The next call for Centres for Doctoral Training Centres early in 2013 therefore provides an opportunity to promote and encourage training within the curricula around the concepts of responsible innovation based around the broad guidance we propose to develop.

25. We also propose to promote and develop understanding and awareness of responsible innovation amongst our own staff, and building on the guidance material, we will hold a series of in-house workshops next year covering the practice of responsible innovation. This will focus on how aspects of responsible innovation might be factored into how they facilitate decisions about research priorities, how they set up, commission, and manage programmes and how they oversee particular projects.

Working with other Research Councils and HEIs

26. EPSRC is one stakeholder in the wider research environment. We have therefore begun to discuss our approach to responsible innovation with colleagues in other research councils and the Technology Strategy Board. Responsible Innovation is included in our work with BBSRC and TSB on synthetic biology. In particular we have provided input into a responsible innovation framework that that will be used in a forthcoming call for funding by TSB for synthetic biology.

27. Part of our approach will be to encourage more HEIs to take an active approach to ethics embracing the principles of responsible innovation. We will convene a series of workshops with our framework and strategic universities to discuss and promote responsible innovation.

28. The learned societies also have a valuable role to play in promoting responsible innovation amongst their research communities. We propose to explore this with them as part of our regular interactions.

29. To make progress next year, we propose to fund a short term (2 year) senior fellowship to work with EPSRC in this endeavour.

ACTION

30. Council is invited to **note** the contents of this paper.

FURTHER INFORMATION

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EXAMPLES OF RESPONSIBLE INNOVATION

Responsible Innovation Case study: The SPICE stage-gate: climate engineering

1. The SPICE project is one of the UK's first major geoengineering research projects. Funded by EPSRC, NERC, and STFC, it is researching candidate particles and the feasibility of using them for Solar Radiation Management (SRM), e.g. by injecting them 20km high into the stratosphere where they could reflect away incoming solar radiation and thereby reduce mean global air temperature.

2. In order to assess and evaluate this possible approach the project included a trial of the delivery system, whereby water is pumped through a 1km high balloon-tethered hose, informing the design of any 20km high delivery approach. This is not climate engineering *per se*, but is highly symbolic in nature as one of the first visible, outdoor experiments in this highly controversial new research area.

3. Decades of scientific controversies and mishaps have taught us the lesson of early societal engagement as an important element in steering radical new technologies wisely. Solar Radiation Management provides a timely reminder of this. Variously seen as important and essential, providing options for global temperature reduction should this become necessary, 'atmospheric liposuction', a 'climate fix', 'unhelpful provocation', likely to undermine international negotiations and a 'moral hazard' in which action could be deflected away from reducing green house gas emissions.

4. SPICE was always seen as a project that would require particular care. Prudently, as a condition of funding, the research councils decided to put in place a novel governance process using a framework of responsible innovation based on the following dimensions:

   - the need to understand and articulate the purposes and envisaged impacts of the project (and the motivations for these);
   - the need to understand wider impacts and risk uncertainties associated with the test-bed itself and what the research could lead to (acknowledging the inherent uncertainty and even ignorance associated with such projections of early stage research);
   - the need for strong governance and oversight (including consideration of any regulations that apply);
   - and finally the need to open these dimensions up to dialogue and debate with stakeholders and the public.

5. This framework was set up to ensure the project progresses in a safe, open, and responsible manner that is responsive to the wider views of stakeholders and the public. Within this, approval by EPSRC and its fellow funders that the SPICE test-bed could progress was conditional upon the SPICE project team meeting five criteria, which were drawn up in January 2011 following an expert workshop held in October 2010. The response to these criteria by the SPICE team was assessed by an independent 'stage-gate' panel convened on June 2011. This panel drew on expertise from the atmospheric science, engineering, and social science disciplines and included an advisor to a major environmental NGO. The five responsible innovation criteria assessed by the stage-gate panel, which related both to the research and development within the project itself (i.e. the proposed test-bed), and the longer term goal of Solar Radiation Management in the future were as follows:

   - The test-bed deployment is safe, the principal risks have been identified and managed, and are deemed acceptable.

- The test-bed deployment is compliant with relevant regulations.
- The nature and purpose of the project for external communication is clear.
- Future potential application(s) and associated impact(s) have been described and mechanisms put in place to review these as significant information emerges.
- Mechanisms have been identified to understand wider public and stakeholder views regarding these envisaged applications and impacts.

6. On the basis of information submitted on 15 June by the SPICE team the Panel assessed that the first two criteria were passed. It however advised the research councils and the SPICE team that further work on stakeholder engagement and the social and ethical implications was required. In addition, EPSRC, acting on advice from the panel, decided to delay the planned test-bed experiment which would have used a tethered balloon and hose to disperse water at a height of 1km, until this further stakeholder engagement had been undertaken.

7. EPSRC has subsequently provided additional funding for expert researchers to carry out this work on stakeholder engagement which includes discussion of issues around the commercialisation of geoengineering research; this is in progress and will continue.

8. As a result of the stage-gate and the responsible innovation approach, the SPICE team was also encouraged to explore issues connected to the potential future use of geoengineering technologies. Intellectual property and need for governance in the field of geoengineering became, and continue to be, matters that concern them. Given these issues and the existence of a patent application for an invention to deliver particles via a tethered balloon system, the SPICE team has decided not to conduct the 1km test-bed experiment. We received formal confirmation of this from the team on 22 May 2012. This decision is accepted by EPSRC, NERC, and STFC.

9. This had provided a steep and at times difficult learning curve for the scientists and the research councils. Taking time to reflect on the wider impacts, implications, and dilemmas surrounding this area of research may be seen by some as unnecessary at this stage, particularly given the great uncertainties and ignorance that attend it. Others may see it as essential, and there will be a great deal of nuanced views between these two positions. Deciding how to proceed was not easy. There may be few unequivocally right or wrong answers to the many questions that will be asked about this research, however the governance structure that we adopted based around a responsible innovation approach provided the space and flexibility to

allow these questions to be asked, to hear the responses, and to act on them and to guide decisions.

Responsible Innovation Case study – Nanotechnology for the environment

10. Nanotechnology has been the subject of intense debate, sustained public engagement, and regulatory attention, but research is diffuse and hard to define. In particular nanotechnology promises great things for improving carbon capture technologies, but uncertainties remain about the unintended consequences of such innovations.

11. Productive discussions have however taken place in the context of EPSRC's Grand Challenges. For the environmental grand challenge in 2010, EPSRC decided to introduce a responsible innovation element. When would-be researchers applied for funds, they were asked to submit a risk register and describe where responsibility would lie for understanding and managing these risks. As well as identifying any known or likely hazards, researchers were asked to consider whether there might be other societal or ethical concerns arising from their research in the future.

12. Feedback from the subsequent telephone interviews suggested that the risk register was considered a useful tool that provoked awareness of wider impacts and a good approach for managing known potential impacts and associated risks i.e. those that could be identified with an element of certainty. These tended to be impacts associated with laboratory activities in the short to medium term. The risk register alone was considered to be of less value for identifying unknown impacts further along the innovation process (e.g. once the device had been developed, scaled up and commercialised), unless other methods that helped identify emerging impacts continuously were interfaced with the risk analysis tool.

13. A number of applicants realised the limitations of the risk register in this regard and proposed work-packages or tasks in their proposals that drew on wider disciplines outside the engineering and physical sciences to help with identification of impacts as these emerged. Technology assessment approaches (e.g. real-time technology assessment) and/or life cycle assessment (LCA) were variously proposed as ways of identifying and understanding impacts on the environment and society for the developing technology and its application. A number of applicants went further to include engagement approaches (stakeholder, public) to understand public and stakeholder attitudes and responses to the emerging innovation.

14. In a number of cases where such wider approaches were included, applicants drew on expertise and strengths in departments outside of

chemistry, physics, and engineering in their University. One application from Nottingham for example included co-PIs pioneering the embedding of social science, ethical reflection and real-time technology assessment, another from UCL (which has been subsequently funded) included a Co-investigator from the University's Science and Technology Studies department. Others went outside their own University (e.g. an application from Queen Mary University of London included a social scientist as a Co-investigator from Cranfield with experience in stakeholder and community engagement, requesting budget support for such activities within the project, the application from UCL proposed work in collaboration with the UCL Public Engagement Unit). These proposals were characterised by strong multi-disciplinarity which was praised by peer reviewers and the Panel.

15. Feedback from the principal investigators and co-applicants regarding the process was by and large positive. All expressed their support and considered it a worthwhile activity to undertake. Many embraced the philosophy that as scientists they should reflect on the wider implications of their proposed research, a view echoed by the peer reviewers and panellists.

16. In summary, proposals that were underpinned by a strong commitment to responsible innovation were characterised by strong multidisciplinarity and deployed a suite of complementary approaches that included iterative technology assessment coupled to qualitative risk analysis and engagement.

Responsible Innovation Case Study: Public dialogue around the purposes of science

17. A ground breaking public engagement activity to contribute to the choice of a subject area for a nanotechnology call for research proposals in the general area of medicine and healthcare was conducted during 2008.

18. This provided an opportunity to directly link public engagement with a real decision. Tying it to the healthcare grand challenge made it possible to focus the discussion and to say 'this is what some scientists are proposing to do what you think?' Most people can relate to this topic as healthcare touches everyone.

19. One of the main aspirations highlighted by the dialogue was that of empowerment. People warmed to technologies that let them take control of their own lives but had more concerns about devices that reduced human interaction. There was a positive reaction to technologies that gave people greater control of their health by allowing early diagnosis of disease and for drug delivery devices that

promised to reduce side-effects. But areas such as Theranostics – in vivo devices that both diagnose and administer treatment – led to misgivings because they were perceived as potentially removing power from the individual.

20. The final input about the scope for this call was made by the Nanotechnology Strategic Advisory Team (SAT). The discussion at the SAT was usefully informed by the insights from the public engagement exercise, which significantly influenced the SAT's final recommendation for the scope of the call. Indeed, the final call for full proposals focussed on just two areas both of which were those given highest priority by the public.

21. The concerns and views expressed by the public as part of this dialogue process were captured. Those researchers who were asked to submit full proposals to the call were asked to explicitly address these in their submissions, both in terms of how the technology they propose to develop would address these, and in the way their research would be conducted. The extent to which these concerns had been addressed was subject to review and part of the funding criteria.

22. Whilst the excellence of the science prevailed as the main criteria for funding the externally commissioned evaluation of the process concluded that the societal input had significantly influenced those who had taken part. The exercise had also clearly demonstrated the sophistication of public thinking around a complex topic and that this had greatly enriched the whole process.

Training Showcase: the UK's Engineering and Physical Sciences Research Council's Framework for Responsible Innovation