RESPONSIBLE RESEARCH AND INNOVATION: OPTIONS FOR RESEARCH AND INNOVATION POLICY IN THE EU

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1.1. Introduction

'Research and innovation must respond to the needs and ambitions of society, reflect its values and be responsible . . . our duty as policy makers (is) to shape a governance framework that encourages responsible research and innovation'.

Marie Geoghegan-Quinn, EC Commissioner for Research, Innovation and Science May 2012

Responsible Research and Innovation is set to become an important cross cutting theme for the EC Horizon 2020 programme[1]. This report aims to provide ERIAB with a concise overview of the state of the art in terms of how RRI is being framed and how it is emerging both in policy and practice. It also presents a set of concise recommendations for ERIAB to consider in terms of immediate next steps in the context of Horizon 2020. Much of the academic discussion concerning RRI has emerged from disciplines such as Science and Technology Studies (a branch of social sciences) and humanities (e.g. philosophy), notably within the Science and Society domain at the EC. These have provided important foundations for RRI, defining broad conceptual approaches, frameworks and a philosophical underpinning. I will briefly summarise these, signposting ERIAB to further sources of information for reference. Although discussions are very much ongoing, some distinct commonalities have emerged in terms of how RRI is being framed, which I will describe. What many are now turning to consider, and indeed a few public funders of research are experimenting with, is how to move RRI from words to deeds in a meaningful and constructive manner, and what the EC might do

[1] Article 5 of the Regulation establishing Horizon 2020

to support implementation within Horizon 2020. It is also notable that engagement with RRI by those involved in the study and practice of innovation management and governance, for example in business studies and in corporate settings, has to date been somewhat limited. This is important since some well-established approaches to managing innovation in these settings, such as innovation 'stage gating' (Cooper, 1990, Asante et al, in press), offer promising avenues for embedding and implementing a RRI approach within Horizon 2020, and therefore in this report I will go on to focus on these 'doing' aspects of RRI and the contribution innovation management in business studies can make.

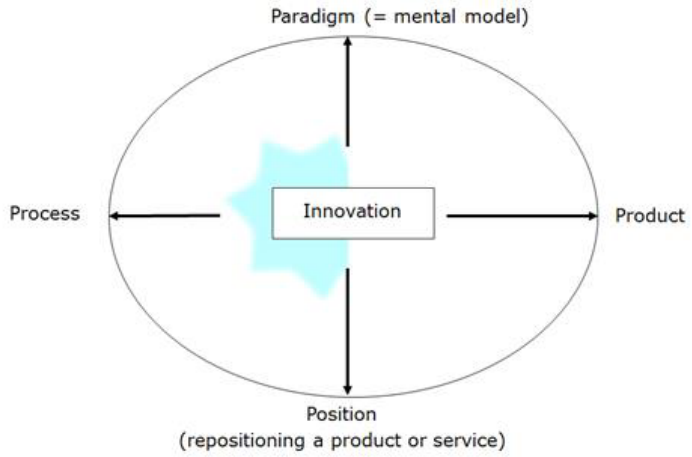
This is a rather critical moment for RRI in the context of its future within Horizon 2020 and beyond. Ultimately RRI is something that could become a meaningful and even transformational way of governing innovation responsibly in the EU, both in word and deed: ERIAB I believe has an important role to play in defining this destination.

1.2. What is RRI? Framing and definitions

Few would argue against the sentiment, or notion, of responsible research and innovation. It is rare to hear a counter view to one that innovation, and research leading to it, should be undertaken responsibly. But beyond sentiment lie quite profound questions of framing and motivation, what RRI actually means and how (if at all) it differs from what has come before. The last five or so years has been a period of sense making, during which time academics and others (including those within institutions such as Research Councils and the EC) have started to rationalise what RRI means as an innovation itself, its potential implications and underlying motivations.

In general in the discipline of innovation management we can map the innovation space according to four dimensions: product, process, position and paradigm (Figure 1):

Figure 1: Locating RRI (in blue) within the innovation space (adapted from Francis and Bessant, 2005)



RRI is first and foremost a *process innovation*, in as much as it proposes different ways of organising, funding, undertaking and engaging with innovation and research leading to this, for example within the context of the Horizon 2020 programme. RRI as a process is evolutionary in nature, building on

foundations (e.g. technology assessment, stakeholder and public engagement, anticipatory governance, socio-technical integration, open innovation) and cognates (e.g. responsible development) that have a rich history in academic thought across disciplines (see Fisher and Rip, 2013 for a recent review), a history which is also very evident throughout successive Framework Programmes (Owen et al, 2012, Rodriguez et al, 2013): it integrates many of these foundations and aims to embed them into the policies and processes of innovation. In doing so this RRI *re-positions* and reframes these antecedents. Fundamentally, by repositioning these (e.g. within Horizon 2020) it offers a new mental model for innovation policy and its delivery, a potential *paradigm* shift that may present profound opportunities for Europe.

Although the framing of RRI in this space is ongoing, some distinct, common themes have already emerged which allow its contours to be sketched. One important emergent theme is the departure point for RRI. This is not one of risks and regulation, important though these are, but rather posing, and seeking - in an inclusive, democratic way - to answer the question '*what sort of future do we collectively want innovation to create for Europe?'* (Owen et al, 2012; Owen et al 2013; Stilgoe et al, 2013; von Schomberg 2013).

'What sort of future do we want innovation to create for Europe?'
The departure point for RRI

In this regard RRI acknowledges the transformative power of innovation to create futures, that innovations are often socially and politically constituted (Winner,1980) and that they embed values (van den Hoven 2012). RRI pro-actively seeks to create spaces and processes to allow these futures, the role of innovation in creating them, and the values on which they are based, to be opened up to inclusive discussion and debate, and for such discussions to *be responded to* i.e. as a *deliberative, participatory, anticipatory and reflexive process*. It aims to empower social agency in innovation choices (Stirling, 2008), which are in turn made more publically accountable (Jasanoff, 2003). This immediately raises the important question of which values, or 'normative anchor points', should underpin innovation in an EU context (von Schomberg 2013): what are the 'right impacts' that innovation should be directed towards and how should these be arrived at? I will turn to this point shortly. It also raises tensions concerning long standing traditions of scientific autonomy (Guston, 2012), the principle of market choice as a primary mechanism to direct goods and services to their most desirable end use (Lee and Petts, 2013), the established role responsibilities of scientists and innovators (Douglas, 2003; Mitcham 2003), and the existing moral division of labour between, on one hand, the undertaking of research and innovation and, on the other, understanding of (and where necessary managing) their social, political and environmental implications.

This departure point for RRI has been evident in from a re-framing of 'Science in Society' to 'Science for Society, with Society' at the EC (Owen et al, 2012), and the directing of science and innovation towards societal 'grand challenges' Europe is facing now, and could face in the future (Lund Declaration, 2009). This departure point challenges the European Commission, and others who fund research and innovation in member states, to systematically facilitate inclusive engagement with the purposes, motivations, intended impacts and politics of innovation, for example as a key element of Horizon 2020, which is in turn responsive in its constitution, content and delivery:

Why do it? For what purpose and goals? Are these desirable? What are the motivations? Who could benefit and how? Who might not benefit?

These are precisely the sorts of questions that are posed by publics when they encounter new technologies and innovations (e,g, TNS-BRMB, 2010), and the sort of questions that history has taught us should not be ignored. They will apply to many areas of techno-visionary science, convergent technologies and innovation within the Horizon 2020 programme, from robotics to synthetic biology, and from ICT to climate engineering. They are fundamentally questions of *social desirability* and *social acceptability*. If explored and responded to such questions can allow identification of new opportunities for value creation through innovation that is in the public interest, while avoiding innovation that is not. As one example of this, in 2008 the UK Research Councils undertook a series of public dialogues which identified the relative priorities of six potential application areas in the field of nanotechnologies for healthcare: these were subsequently used to frame the subsequent call for research proposals (Jones, 2008). The dialogues showed strong support for nanotechnologies research and innovation that empowers people to take control of their health, and less support for research on approaches such as theranostics (the simultaneous combining of diagnostics and therapies), which were perceived as being disempowering: the value of personal empowerment was therefore an important emergent theme from these dialogues. This programme has been hailed as a success and is leading to a number of important new applications destined for market. A similar approach is used by the Alzheimers Society which has a research network of some 200 carers and people with dementia who help set research priorities, prioritize grant applications and sit on grant selection panels, with the understanding that such participation supports better decisions (i.e. research and innovation that is more relevant, more desirable, of more value). There are clear parallels with concepts of user-led innovation in the corporate world here. Similarly the Netherlands Responsible Innovation programme places emphasis on 'valorisation' i.e. the involvement of stakeholders on research and innovation valorisation panels to ensure that they are closely involved in the research and that results from such research can be implemented directly.

Counter examples to these include the cases of smart metering and electronic patient safety records, also in the Netherlands, where the desirability of such innovations were wrongly assumed (von Schomberg, 2013, van den Hoven, 2013) and became deeply contested. On grounds of privacy both innovations were rejected by the Dutch Senate, at a very considerable cost to the taxpayer, costs which dwarfed the costs of the public dialogues undertaken in the area of nanotechnologies healthcare. These are considerations that the company Monsanto also neglected at some cost in the field of genetic modification, and which have cast long shadows in Europe, despite the potential for GM, and now synthetic biology, to meet challenges facing society such as food and energy security.

History has also taught us that the purposes, promises and politics of innovation will often be ambiguous and interpretively flexible, and that views and perceptions concerning these will be plural, contested and dynamic. Innovation under umbrella terms such as 'synthetic biology' or 'sustainability', or societal challenges such as 'secure, green and efficient energy' will belie a host of goals, motivations and intentions (Owen, 2013), which can never be assumed. The future unintended interactions and impacts of innovation will also always be the subject of considerable uncertainty, and often ignorance. Innovation reflects a complex weaving of 'knowledge spaghetti', involving multiple actors, sometimes at global scales, in which innovations can be re-purposed and where their interactions and impacts are often unpredictable. Irresponsibility is usually an emergent consequence of the innovation ecosystem (what Beck described as 'organised irresponsibility') rather than the lone actions of an individual, reflecting what Johnson (2001) described as "the problem of many hands" i.e. the organizational reliance on a division of labour where most activities are split up between numerous different individuals. Interactions and implications may only become clearer when

the *context of use* is understood, particularly since adaption and re-purposing by users can change innovation trajectories in entirely unpredictable ways. Good intentions may therefore paradoxically result in bad outcomes. One example was the innovation of mortgage-backed, collateralised debt obligations which, as 'toxic sub—prime', wreaked havoc in financial systems across the globe: an innovation whose roots can in part be traced back through the 1990's to political aspirations in the U.S. for affordable housing, particularly for low income and minority borrowers.

'How can we proceed under conditions of uncertainty, ignorance and ambiguity?'
The second key question for RRI

The unpredictability of innovation is something RRI acknowledges cannot be ignored in governance terms. Innovation presents a well-known dilemma of control (Collingridge, 1980) i.e. the case for control (e.g. through regulation) is often weak during the earlier phases of innovation as evidence of impacts is poor, but by the time evidence of such impacts has become clearer, the innovation may be 'locked –in', and /or subject to the influence of powerful vested interests, or associated with disproportionately high control costs. Significant impacts that are undesirable for society may have occurred.

Anticipation
Reflexivity
Deliberation
Responsiveness
Transparency
Dimensions of RRI

Regulation will always have an important role to play in any formulation of RRI, but as a governance approach it is limited: myopic or even blind to things it has not encountered before, or which lie at its margins. The second key question for RRI is therefore 'how can we proceed under conditions of uncertainty, ignorance and ambiguity?' In addressing both this, and the first question, RRI as a process seeks to embed a *collective capacity* to be more *anticipatory*, more *reflexive* and more *deliberative* within the research and innovation process (Appendix 1), which in turn is more *responsive* in terms of its goals, directions and trajectories. These form key dimensions which, as a *flexible*, *integrated* and *iterative* learning approach are emerging cornerstones of a RRI framework. Other dimensions such as *transparency* and *precaution* are also important, the latter particularly when this is considered in an EC context. Others have described an RRI approach using slightly different words (e.g. the Dutch Research Council describes an approach to RRI as embedding *valorisation* by stakeholders, fostering *interdisciplinarity* amongst scientists, social scientists and humanities scholars, and being *proactive* so that ethical and societal aspects are incorporated into the design process from the start, Appendix 2). While discussions are ongoing, these are consistent themes emerging from debates and the literature on RRI. Individually, these dimensions of RRI have a rich history in academic thought. Integrated approaches such as constructive and real time technology assessment (Schot and Rip, 1996; Guston and Sarewitz, 2002) and 'midstream modulation' (Fisher et al, 2006) also present important foundations for RRI (Fisher and Rip, 2013). It is perhaps the dimension of *responsiveness*, particularly at institutional levels that is critical, and which in turn is catalyzing reflection by institutions (e.g. Research Councils) in terms of their own role responsibilities, noting the collective nature of responsibility, which must be assigned across the innovation ecosystem, and where innovators, funders, stakeholders and publics all have an important role to play. This collective nature of responsibility is a key feature or RRI, but one which may present considerable challenges for implementation.

Von Schomberg (2013) has usefully drawn together the thinking into a working definition:

‘Responsible Research and Innovation is a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view to the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products‘

This is a process which should be undertaken with normative and substantive motivations, i.e. it is the right thing to do for reasons of democracy, equity and justice and that it makes for better decision making in ways that accommodate social knowledge and values (Sykes and Macnaghten, 2013; Stirling 2008).

1.3. RRI in European Research Policy: insights for Horizon 2020

Many of the tools and practical approaches to support the dimensions of RRI described above are well-established and have a strong history in the EU: from programmes of technology assessment in Norway, Germany and the Netherlands, through the undertaking of ‘grenelles’ in France and other well known methods of public engagement such as consensus conferences and citizen’s juries in Denmark. A few Research Councils and other public funders of research and innovation in EU member states have also begun to make formal policy commitments to RRI, and / or they have developed formal RRI programmes, or have embedded explicit RRI elements within broader programmes of emerging technologies and innovation. These provide useful insights and signposts for the possible development and evolution of RRI within the EC, and specifically Horizon 2020.

The Engineering and Physical Sciences Research Council (EPSRC), one of the largest public funders of innovation – driven research in the UK, made a formal commitment to a framework for responsible innovation in October 2013 (EPSRC, 2013). EPSRC frames RRI around the dimensions described above, as a ‘process that seeks to promote creativity and opportunities for science and innovation that are socially desirable and undertaken in the public interest’. It ‘acknowledges that innovation can raise questions and dilemmas and is often ambiguous in terms of purposes and motivations and unpredictable in terms of impacts, beneficial or otherwise’ going on to state that RRI ‘creates spaces and processes to explore these aspects of innovation in an open, inclusive and timely way’. It stresses that ‘this is a collective responsibility…which goes beyond considerations of risk and regulation’. What is important about this policy statement is that it makes clear that EPSRC itself has important responsibilities as a funder to ‘promote reflection, understanding, and training... welcome funding proposals that seek to explore aspects of RRI as an integral part of the research endeavour, be vigilant to emerging social, environmental, ethical and regulatory challenges which may arise from new research (including the alerting of policy makers in Government to emerging issues and opportunities as these become apparent), with a role to broaden debate at an early stage. It makes a commitment to ensure RRI is prominent in EPSRC’s strategic thinking and funding plans, including proposal assessment.

The EPSRC statement describes that in some cases RRI will be an approach where detailed consideration is premature or even unwarranted, but that in other cases it may be recommended, or even required. As such, all should be familiar with and be committed to RRI, reflecting an overarching commitment by EPSRC’s *across all its investments,* whilst acknowledging that it should be *flexible* in terms of implementation. In doing so EPSRC states that it (and others it works with such as universities) will need to actively *promote partnerships* across disciplines and spheres of expertise, and support programmes of training, integrated approaches and collaborative research to enable a meaningful commitment to RRI to be taken forward. Importantly, EPSRC recognises that RRI must itself be a deliberative and responsive process in its own development, shaped by the research

community and stakeholder base. Ultimately, while these are only words, they represent an important and necessary statement of commitment, and present a broad framework under which EPSRC will ask its community to respond and within which it frames its expectations. This type of commitment and overarching framework could be an important first step for taking RRI forward within Horizon 2020.

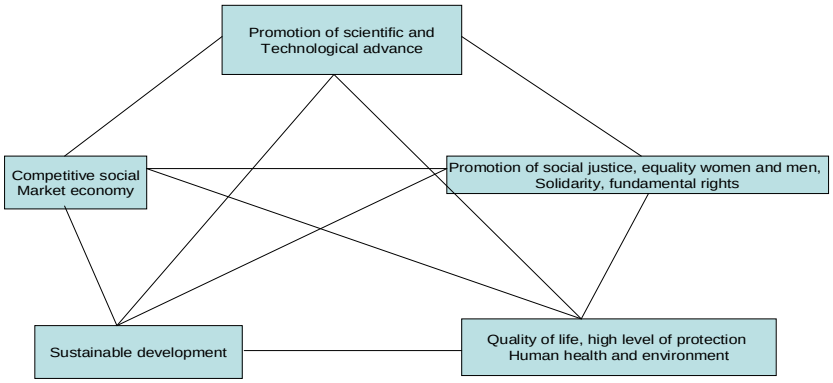
A stated commitment to a clearly articulated EU framework for RRI
The first step

The framework I and colleagues have developed and which EPSRC adopted is not a normative framework, in the sense that it has defined a process but not the values upon which this should rest i.e. the 'right impacts' that innovation should strive to realise, for example in a European context. The rationale for this was that it was designed as a generic framework that acknowledges that values will differ according to the context in which the framework is applied, and will be culturally – sensitive. Any EU framework for RRI will therefore require a *normative basis* upon which a RRI process should act, in order to allow the departure point for RRI above to be addressed and the 'right impacts' for innovation to be identified, and subsequently explored via Horizon 2020. Von Schomberg (2013) has argued that these 'right impacts' should be based on the 'normative anchor points' described in the Treaty of the European Union (Figure 2). This suggests that, at least *at a high level*, innovation, science and technological advance should be promoted with the aim of a 'harmonious, balanced and sustainable development of economic activities, a high level of employment and of social protection, equality between men and women, sustainable and non-inflationary growth, a high degree of competitiveness and convergence of economic performance, a high level of protection and improvement of the quality of the environment, the raising of the standard of living and quality of life, and economic and social cohesion and solidarity among Member States'.

Normative anchor points for a European Framework for RRI
High level values within the EU Treaty

Of course, as has already been noted, many of these anchor points will belie a range of motivations and create tensions, or even be in conflict with one another. One possible example is the tension between 'a high degree of competitiveness and convergence of economic performance' and 'a high level of protection and improvement of the quality of the environment'. This suggests that while at a high level such normative anchor points provide *a legitimate starting point* for a conversation concerning the goals for innovation that Europeans aspire to, and for what purposes and motivations, this must only be seen as a starting point. This conversation, which will surface tensions, dilemmas and, ultimately, opportunities, will inevitably vary according to the country, even region within a country, in which it is undertaken. The example quoted above concerning nanotechnologies and healthcare shows that while few would argue that at a high level the goal of innovation for health is desirable, beneath this there are specific areas of health innovation that are more desirable than others, and some that are in fact undesirable, reflecting the tensions caused by conflicting values: this may result in what has been described as 'moral overload' (see van den Hoven 2013). While there can never be any guarantee of resolution for this, inclusive deliberation presents the best chance of ensuring innovation is reflexive, responsive and ultimately both acceptable and desirable in this context. Of course one cannot advocate or feasibly implement an EU - wide phase of public engagement with every detailed element of Horizon 2020, but at least at a programmatic level, for example associated with the content and targets for the societal challenges themes within Horizon 2020, or the Future Emerging Technologies theme, this will be important.

Figure 2. Normative anchor points derived from the Treaty on the European Union



RRI: from normative anchor points in the EU Treaty to the work programmes within Horizon 2020

The Dutch Responsible Innovation progamme (MVI)[2],funded by NWO (the Dutch Research Council), offers some useful insights in terms of the transcription of high level values within the EU Treaty into programmes of work in Horizon 2020. Established in 2009, MVI 'encourages research that considers the ethical and social aspects of new technology from the design phase onwards'. Researchers in the fields of science, humanities and social sciences are encouraged to *come together* to proactively explore the ethical and societal issues surrounding innovation, in close consultation with relevant stakeholders: it is therefore both *inter* and *trans disciplinary* in nature. NWO developed its Responsible Innovation programme in partnership with six Dutch ministries, which contributed to the research programming and to the funding. After a successful first phase in diverse areas of innovation, the second phase is now focussing on the Dutch 'Top Sectors'[3]: In January 2013, ten projects in four separate top sectors (Energy; Agriculture, Food and Horticulture; Life Sciences and Health; Propagation Materials) were launched in the Responsible Innovation programme, addressing subjects put forward by the Top Sectors themselves. These include projects addressing issues such as the desirability and ethical / societal dimensions of shale gas extraction, smart grids and offshore wind turbines (Top Sector Energy, the latter with a focus on design) and confidence in and ethical issues concerning telecare and telemonitoring (Top Sector Health).

The approach taken by the Dutch RRI programme provides some useful insights for RRI within the Horizon 2020 programme. The societal challenges identified within Horizon 2020 (Appendix 3) might for example also adopt a similar strategy taken by the NWO in terms of embedding an RRI approach within the 'Top Sectors' in the Netherlands, and this could offer one immediate, concrete pathway for implementing RRI at an EC level beneath a common EU RRI framework that sets out the

[1] http://www.nwo.nl/en/research-and-results/programmes/responsible+innovation

[3] http://www.government.nl/issues/entrepreneurship-and-innovation/investing-in-top-sectors

framing, conceptualisation and expectations (see above). The Horizon 2020 Societal Challenges programme is already committed to a 'challenge-based approach that will bring together resources and knowledge across different fields, technologies and disciplines, including social sciences and the humanities' and therefore offers an excellent opportunity for taking a RRI framework forward in a meaningful and substantive way. The 'Secure, Clean and Efficient Energy' challenge for example already contains a public engagement key objective. This challenge will focus on energy efficiency, low carbon technologies and smart cities /communities in the first work programme, and much like the Dutch Top Sectors approach could benefit immediately from the embedding of a RRI approach.

Other Research Councils that have been considering RRI in the context of their operational activities also offer useful insights for the EC in terms of implementation within Horizon 2020. The Norwegian Research Council (NFR) has for example undertaken some experiments in RRI which provide intelligence in terms of both framing and implementation. Norway is facing a future in which there may well be a need for transition from a historically resource – extraction focused economy, based for example on oil, fishing, mariculture and forestry, to a different (or perhaps even new) economic model, while maintaining Norwegian values that include the desire for economic resilience, environmental sustainability, a robust welfare state and strong regional identity (e.g. within its coastal communities). This presents an important opportunity for a balanced and inclusive discussion about the role of innovation in securing Norway's future and how the NFR and others it works with (e.g. Innovation Norway which works primarily with businesses) should proceed: NFR, like many public funders of research and innovation across Europe, is therefore considering how the innovation space should be best exploited in a changing and uncertain world and in line with its values. As with many other countries in the EU, Norway has many of the ingredients to support a strong and meaningful RRI initiative: there is for example long standing experience in technology assessment, stakeholder engagement and associated specific methodologies within the Norwegian Technology Board, a well-established tradition of research ethics (including well –established national research ethics committees) and a small but globally - recognised and internationally well-networked ELSA (Ethical, Legal and Societal Aspects) academic community, funded by NFR through dedicated programmes since 2002. Indeed the current NFR ELSA work programme[4] already advocates key elements of a RRI philosophy, with an emphasis on the need for reflexivity, as the 'capacity of actors (researchers, institutions) to question their own taken-for-granted assumptions and routines and limitations of knowledge'…where 'reflexive learning means insight into the assumptions which tacitly shape our own understanding and interactions'. The work programme describes the importance of moving away from 'aspirations of prediction and control, towards a richer public deliberation about visions, ends and purposes of science and technology' and 'interactive models of knowledge production'.

Member states may already have some or even many critical elements for a co-ordinated RRI approach

NFR began to formally consider RRI in 2010, and subsequently included an embedded RRI component in its Nanotek 2021 programme and associated call for proposals in 2012, which received submissions from both academic and private research and innovation institutions. NFR requested ELSA/HSE (health, safety and environment) approaches *within the project proposals* and the RRI elements were formally, and independently evaluated. However, reflecting the absence of a clear, overarching framework and ambiguity in terms of NFR's expectations, submissions were found to be

[4] http://www.forskningsradet.no/prognett-elsa/Home_page/1224698247023

extremely mixed in terms of how applicants responded. In a few cases there were dedicated work packages which considered ELSA and HSE, with some incorporating stakeholder and public engagement and some proposing life cycle assessment approaches: in isolated instances these were imaginative and well-formulated. In other instances the submissions were cursory in nature and in at least one case the RRI dimensions of the call were effectively ignored. Few applicants had attempted to reach across to experts with competencies related to RRI, for example in Norwegian universities and beyond. Some on the assessment panel argued that while the need for a RRI approach was never in dispute, they had concerns about any significant diversion of financial resources from the core science and innovation activities.

This Norwegian experience replicated a similar experience in the UK two years earlier, where the EPSRC had also attempted to embed RRI within research proposal evaluations in the third of its nanotechologies 'Grand Challenges'. This was aimed at investigating the potential contribution of nano for carbon capture from the atmosphere (Owen and Goldberg, 2010). The framing of RRI within this call was narrow: applicants were required to submit a risk register (an example of which is given in Appendix 4) identifying any environmental, health or societal impacts both within the research itself or envisaged application(s), qualitatively provide an appraisal of risk for each identified impact, and an estimate of uncertainty, and identify who in the project team would be accountable for managing any risks identified. The responses to this call were, perhaps unsurprisingly, both conservative and, by and large, equally narrow. There were no reflections on the purposes or motivations for the proposed research. It demonstrated the limits of an RRI approach that is based solely on risk assessment and the importance of framing RRI and the associated expectations of funding bodies in research calls. However it did, for the first time, prompt both EPSRC and its community to reflect on the broader impacts and implications of the proposed research, and this proved to be a useful and manageable entry point. In a few cases, as with the Norwegian experience, the proposals also went beyond risk assessment to include mechanisms of public engagement, life cycle analysis and technology assessment, with collaborations involving experts from across disciplines through an integrated approach.

These experiments in RRI implementation, as well as the findings of research into perceptions of RRI (e.g. a forthcoming report on perceptions in the ICT community (Eden et al, in prep)) have highlighted several important lessons which may be of value as the EC considers RRI within Horizon 2020:

- for many researchers framings of role responsibility tend to focus on *established norms* of best scientific practice, research integrity, laboratory health, safety, hazard and risk management, ethical compliance (e.g. data protection and privacy, informed consent where necessary) and regulation where this applies (see also Douglas, 2003). Researchers may struggle with, and will *certainly require support* for, the establishing of a more broadly-configured role that considers the societal context of the research and innovation (Mitcham, 2003; Douglas, 2003), even in areas such as ICT where researchers appreciate that the uncertainties are often more social than scientific. Broader moral and social responsibilities may in this regard be assigned by them to others, such as public or private institutions. Even in some contentious areas of research and innovation (e.g. on climate engineering) projects may be framed as purely technical ones, with the primary goal of objectively producing data in a robust way on which others can act, and with little consideration of the broader political symbolism or societal context (Owen et al, in press), see below.

- a broadly – configured and clearly articulated framework for RRI established for Horizon 2020 is necessary to guide applicants making research proposals and to ensure expectations are clear to all: this will be for many may be new territory since many may have *never explicitly been asked* to consider these broader questions. Conversely, the absence of guidance may result in a patchy, poor or poorly- conceived response.

- the level of detail that such a framework contains is critical: if this too general, unclear, or ambiguous the response may be variable, inappropriate or insufficient. Conversely if it is too prescriptive it will not allow sufficient flexibility for applicants to respond in imaginative and creative ways that are appropriate for the innovation context in which they work – a 'deficit' model of engagement may create a 'closing down' framing and be perceived as heavy-handed or a burden rather than an mechanism to promote working with others which creates opportunities for innovation in the public interest.

- to achieve the necessary inter and trans-disciplinarity applicants will need to be signposted to resources and tools that can support them and be facilitated to work across and beyond disciplines *prior to proposal submission* . They will need to budget for the necessary competencies within their proposals, which are allowed for and encouraged in the call documents themselves.

- integrated and embedded approaches where RRI is *designed in* from the outset are preferable ('RRI by design')[5]. Funding bodies have a particular role to play in this regard, within their programme and funding initiative such as Horizon 2020.

- the EC should resist the temptation for RRI to become a bureaucratic tick box, or add-on, no matter how easy and practical this may seem. RRI will require a longer term culture change, including *the work of the Commission itself*, which ultimately will be of greater value.

> *RRI: a culture change, not a bureaucratic tick box exercise*

In the Netherlands and Norway this more broadly configured approach is under serious consideration. As an example, the newly formed NFR Biotek 2021 programme[6] in Norway has learned from previous experiences. Its work programme contains a specific objective to 'ensure the responsible development of technology that addresses global social challenges in the areas of health, sustainable food and industrial production'. Its International Advisory Group has formally recommended that the programme be underpinned by a framework for responsible innovation, from design through delivery, which is developed at *a more generic* NFR level but for which the Biotek 2021 programme acts as an exemplar. An initial period of significant and meaningful stakeholder and public engagement (with academics, end users, industry, clinical groups, civil society groups, and the public, using a variety of approaches (e.g. focus groups, stakeholder workshops)) was recommended, to refine the scope and goals of the programme, and specifically target programmatic research in challenge areas and beyond through a substantive process in which such engagement supports the programmes's strategic direction and alignment of project to areas of national importance for Norway.

[5] See http://www.joseph-murphy.org/synthetic-biology-and-responsible-innovation.html for an example.

[6] http://www.forskningsradet.no/prognett-biotek2021/Home_page/1253970728140

2. RRI: Insights from Strategic Innovation Management in Business Studies and corporate settings

So far this report has considered RRI from a conceptual and emerging research and innovation policy perspective in Europe. What insights can be gained from the corporate world, and in particular innovation management? Innovation is an activity that is frequently managed within corporate and sometimes public organisations. Indeed there is an entire discipline of strategic innovation management in Business Studies devoted to research, identifying best practice and optimising the innovation process for value creation.

One of the most well- known and empirically validated models of innovation management is one developed by Tidd et al (2009), for which associated audit tools[7] have also been developed (Figure 3)

Figure 3: Innovation Management Model (after Tidd et al, 2009)

This model defines distinct elements of a successful innovation management process. These are:

a) *search*, or the development of effective mechanisms for identifying innovation opportunities: ideas that can be both *radical* and *incremental*. How this is done can vary considerably between organisations, but it has a long history, e.g. through the employment of focus groups and formal or informal processes of horizon scanning (Palomino et al, 2012).In the area of ICT for example there is a long tradition of the use of techniques that facilitate public participation such as workshops, focus groups, prototyping and co-design activities. In recent decades, and in particular since the advent of the internet, there has been a progressive move towards more participatory models of user- defined and open innovation (Chesbrough, 2006), reflected in the innovation strategies of multi-national companies such as Procter and Gamble and its 'Connect and Develop' approach[8]. In this regard processes of deliberation and stakeholder engagement proposed in emergent RRI frameworks are not

[7] http://www.managing-innovation.com/tools/How%20Well%20Do%20We%20Manage%20Innovation.pdf
[8] http://www.managing-innovation.com/ar_chapter6_roy_sandbach.php

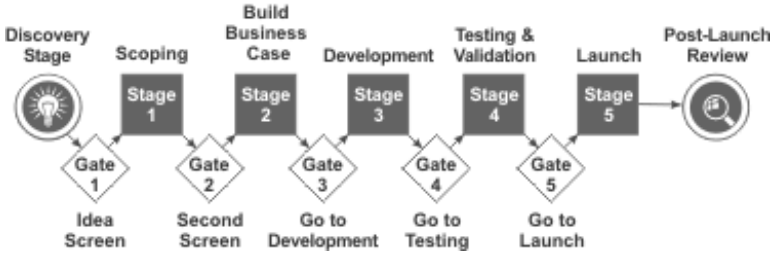
uncommon, although the motivations, purposes and intended outcomes of such deliberative approaches i.e. *how this is framed and its normative basis*, are key.

b) *selection*, where the organization makes decisions concerning which innovation pathways to support in the context of the organisations' values, mission and / or business strategy; the value proposition (to customers, shareholders, stakeholders, community); the knowledge base (either internal or external) that will be required, how accessible this will be and the resources required; risks and 'fit' with the business. This is a phase where the reflection and anticipation dimensions of RRI are often evident, but again the framing and its normative basis can vary, extending from a value proposition that is aimed at maximising a single bottom line and shareholder return, through triple bottom line and concepts of shared value (Porter, 2011) to innovations that are entirely aimed at social goals, and where profit is not a primary motivation (e.g. Gupta 2012). The framing of such reflection and anticipation may be quite narrowly focussed within the context of the organisations' mission, values and culture, and will depend on whether the innovation is likely to be incremental or disruptive (Asante et al, in press).

c) *implementation*, a process that gradually pulls together different pieces of knowledge and weaves them into an innovation with the aim of acquiring knowledge; executing the project; and launching and sustaining the innovation.

Companies may employ such tools as *stage gating* (Cooper, 1990) to guide decision making during the search, selection and implementation phases of innovation management (Figure 4)[9], whereby investment of resources is phased (i.e. the 'stage'), with each phase being subject to formal or informal approval at a decision 'gate'. Typically the inputs to a decision gate will include considerations of technical feasibility, market potential and risk.

Figure 4: Simplified stage gating process (after Cooper 1990)



d) *learning* (also related to this is the concept of benefits and value capture), where the organization develops mechanisms to learn and capture value from the innovation, including commercial success, increased market share or knowledge, aimed at refining and improving subsequent cycles of innovation. Learning is however a more holistic feature of the innovation management model as a whole, reflecting the observation that innovation management is a learned capability, where the idea of learning through trial and error to build effective routines can help improve the chances of successful innovation. The model stresses the importance of proactive development of *linkages* (e.g. with universities) which support an organization to cross boundaries and connect to external

[9] http://www.managing-innovation.com/tools/Stage%20Gate%20Models.pdf

knowledge sources (users, suppliers, customers etc…), an innovative culture (*organisation*) and (particularly for larger organisations), the need for a formal innovation *strategy* as important elements of a successful innovation approach.

In summary, innovation management approaches in corporate (and indeed some public service) organisations highlight:

a) that there are well- established processes that incorporate anticipation (and foresight[10]), reflection, deliberation and responsiveness: these are not unfamiliar words in a business context, and indeed are often a requirement (to varying degrees) for securing venture capitalist funds for small and medium size companies, where questions such as 'what value will be created?' and 'what are the risks?' are important elements of any investment proposition and business case. It is how these processes are framed, and their normative basis that is key. It is for this reason that any framework for RRI developed through Horizon 2020 must have both process and normative dimensions, in which the normative framing is itself opened up to broad deliberation in terms of how programmes are scoped, their goals and motivations i.e. *the value propositions within Horizon 2020 itself.*

b) that practical tools in innovation management which are commonly used in businesses (e.g. in new product development departments) have a strong potential role to play in how RRI could be *implemented*, for example in the Horizon 2020 Societal Challenges, the Future Emerging Technologies programme and Enabling and Industrial Technologies programme.

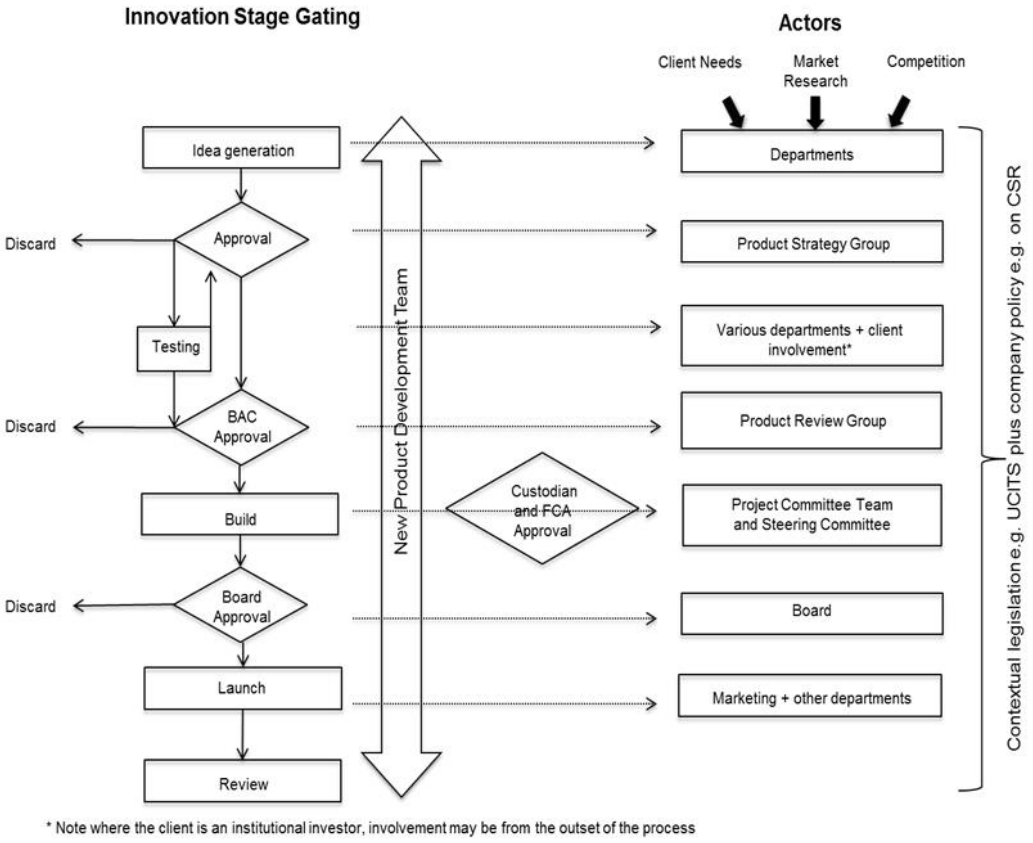
Figure 5 shows an example of such an innovation stage gating approach which is used in a large, global asset management company and that we have researched in some detail. This shows that innovation of new products (here new funds and other financial products) is carefully managed, with a central co-ordinating function provided by a small Product Development team who co-ordinate innovation – related activities of a large number of internal and external actors, from ideation through Business Acceptance Case (BAC) development, product testing and launch: it is far from *a laissez faire* approach. The innovation process is phased and governed, with clear decision gates where formal approval for continued resourcing is made by accountable individuals within the company. This is framed by EU legislation and involves specific prospectus approval by, in this case, the UK Financial Conduct Authority. It is also framed by the company's existing policies on Corporate Social Responsibility, bribery, corruption and ethical investment.

Our research in this company (Asante et al, in press) showed that while there was strong evidence of anticipation, reflection and deliberation (including the involvement of retail and institutional (e.g. pension fund) clients in product design and testing) these were quite *narrowly framed*, for example on understanding operational, legal, regulatory and reputational risks (echoing earlier findings described in section 1.3 above). Creating value through innovation by meeting client needs was found to be an acceptable definition of what responsible financial innovation meant to staff. The context for this was an inherently cautious corporate culture, where innovation was largely incremental and the probability of bringing something destructive to market perceived as being low. This resulted in what has been described as 'iterative agency' (Pandza and Ellwood, 2013) in which there is routine, habitual and selective reactivation of past behaviour patterns which become institutionally stabilized. In these

[10] http://www.shell.com/global/future-energy/scenarios.html

instances issues of responsibility are perceived as being largely uncomplicated. This can be at the expense of other forms of agency (e.g. projective agency which involves imaginative projection of possible future trajectories of actions) and evaluative agency (where judgements are made among alternative possibilities in response to emerging demands, dilemmas and ambiguities).

Figure 5: Stage gating model of innovation management at Fidelity Worldwide Investments (from Asante et al, in press).



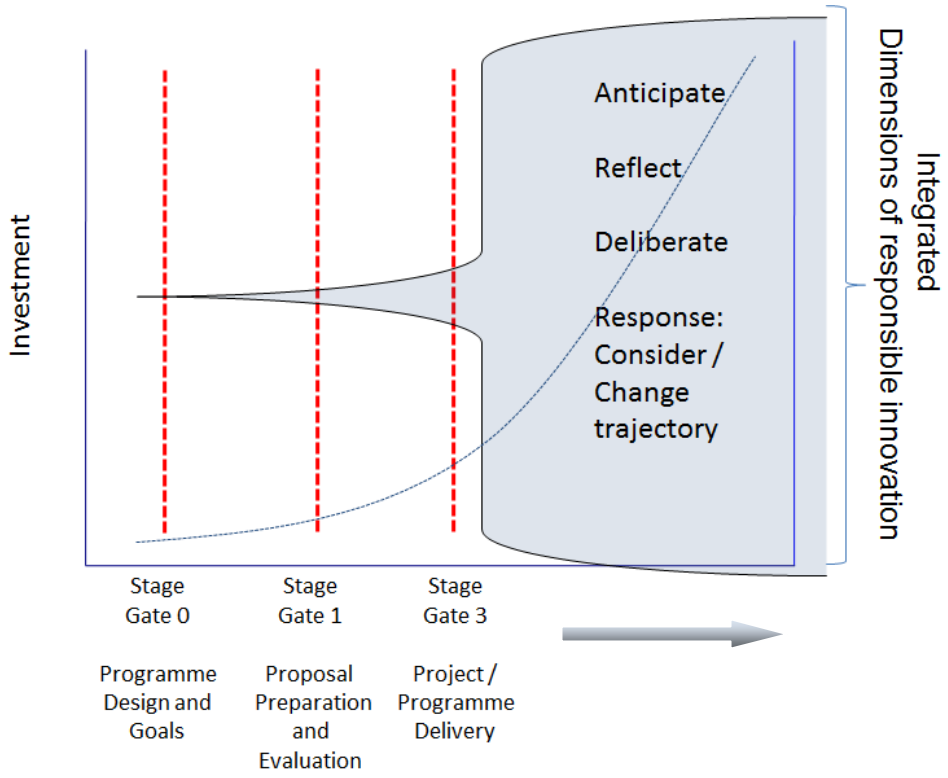
Established innovation management approaches offer opportunities for RRI implementation

Arguably, where innovation is incremental and tightly regulated such as in this case, existing approaches to innovation management such as this may be sufficient, although this can never be guaranteed. In other contexts, particularly where innovation is disruptive and falls into a regulatory gap or void, the embedding of a more broadly-configured RRI approach that facilitates projective and imaginative agency may be recommended, or should even be required by the EC. It is inevitable that the Horizon 2020 programme will present something of a continuum from the incremental to the transformative, radical and disruptive. As such, a generic RRI framework is necessary, even if there will be instances where, *at least initially, detailed* consideration may not be required.

This stage gating model of innovation management, if this is broadened to include the dimensions of RRI described above, from the design or ideation phase onwards, offers one potentially useful

approach to implementing RRI within Horizon 2020 thematic elements such as the Societal Challenges and Future Emerging Technologies themes, under a generic framework adopted at a high level (Figure 6).

Figure 6. Embedding RRI within a flexible stage gating model of innovation governance (adapted from Owen et al, 2013)



Initial experiments in to how such stage gating approaches might be broadened have already been undertaken in a contentious, political and disruptive field of 'techno-science in the making', solar radiation management (SRM) – a form of climate engineering technology. (Macnaghten and Owen, 2011; Owen et al, 2013; Stilgoe et al, 2013; Owen in press). In 2010 several of the UK Research Councils funded a project called SPICE (Stratospheric Particle Injection for Climate Engineering). The SPICE project aimed to investigate whether it might be feasible to design a system that allows injection of gigatonnes of sulphate particles into the Earth's stratosphere via a 20km high hose attached to a large tethered balloon. By undertaking such stratospheric particle injection it was proposed that it might be possible to mimic the transient, global temperature-reducing effects witnessed during volcanic eruptions, through a reduction in incoming solar radiation. The project would not undertake SRM itself, but aimed to investigate a) what types of particles could be injected into the stratosphere for the purposes of SRM; b) how these particles could be deployed stratospherically and c) what impacts might be associated with deployment. The second objective included a proposed field trial in which a hose would be tethered to a balloon at 1km altitude, through which small quantities of water would be pumped: the aim was to understand the dynamics and behaviour of the tethered balloon configuration in order to inform the design of the 20km high deployment system (Appendix 5).

The project raised a number of difficult ethical, political and risk-related questions. However it had been conceived as a purely technical project assessing feasibility and impacts (e.g. on precipitation patterns), reflecting the moral division of labour described earlier: its broader moral, social and political dimensions were not considered, and it passed the standard ethical approval processes within the universities with little or no comment. The project's politically symbolism (Stilgoe et al, 2013) and associated questions concerning governance, moral hazard, our relationship with nature, uncertainty and its political constitution (Szersynski et al, 2013) had not been considered in the project design in any way, despite the fact that these issues would prove to be critical to the public and stakeholders (Macnaghten and Szersynski, 2013; Stilgoe et al, 2013).

Embedding an RRI approach into a stage gating architecture allowed us to explore these questions in a balanced and structured way, based upon the RRI dimensions described above. These were translated into a set of criteria and simple questions which the project team were asked to respond to at an independent 'stage gate panel' (Appendix 5) i.e. a decision gate, which was convened by the Research Councils (Macnaghten and Owen, 2011; Stilgoe et al, 2013). Release of funds for the field trial was contingent on the outcomes of this decision gate: as such the process was responsive in terms of whether, and if so how, the research should proceed. Two of these criteria (on proximal risks and regulatory compliance associated with the test bed itself) were passed with little comment. However the remaining three criteria - which asked for broad reflection and anticipation concerning possible impacts, social, political and environmental implications and to undertake deliberation with stakeholders and publics - were not passed and as a result the test bed was delayed until such activities has been undertaken and evaluated independently by the stage gate panel again. Ultimately this prompted a useful period of public and stakeholder engagement (Pidgeon et al, 2013; Stilgoe et al, 2013) which has been an important contribution to the debate on the social desirability and acceptability of SRM (Owen, in press). It also prompted more detailed reflection and questioning by the SPICE team itself, which surfaced the existence of a prior patent application for the proposed system which had not been known to the project team, raising questions of motivation and disclosure and which eventually resulted in the field trial being cancelled.

RRI will need to be 'designed in', adequately resourced and supported by programmes of training and education

There were some important lessons learned from this experiment in RRI implementation. Firstly, the RRI approach was introduced after the project had been funded – it was effectively retro-fitted within the project rather than being designed- in. One of the principle issues with this, which became very clear during the subsequent stakeholder engagement, was whether the project should have been funded at all without due consideration of its broader political, social and moral dimensions. The Research Councils, stakeholders, scientists and ourselves recognised this as a distinct limitation (Macnaghten and Owen, 2011). There was an absence of an overarching framework which could be applied during the programme scoping (by the Research Councils) and project proposal development and evaluation. Secondly, and resulting from this, the necessary competencies to allow an RRI approach to be taken forward were not embedded and resourced within the project itself, which was problematic for the project team: ultimately the engagement work had to be commissioned as additional work to expert practitioners in public engagement (Pidgeon et al, 2013). Although the SPICE team attempted valiantly to respond to RRI, they lacked the skills, experience and training to do this. The implications of this for successful implementation of RRI at a Horizon 2020 level are twofold:

a) for RRI to be successful it must be designed in and adequately resourced within projects and programmes from the outset.

b) this in turn will require both the facilitation of multi and interdisciplinary partnerships and more systematic programmes of training and education at a doctoral (even undergraduate) level.

The lessons learned in this case study were strongly echoed in another experiment in RRI, one conducted with businesses but in an entirely different field of research and innovation: synthetic biology. In 2012 the UK Technology Strategy Board, building on the recommendations of Roadmap for Synthetic Biology[11], made several significant investments in synthetic biology in which RRI was a prominent feature. The first of these was an industrial feasibility competition, which was business – led and required applicants from companies to make a RRI submission (so called 'Appendix D') as part of their proposals, in accordance with a responsible innovation framework[12] : these were assessed by an independent panel. RRI was framed by the TSB as 'consideration of ethical, societal and regulatory issues and appropriate response during the process of carrying out the R&D, and the commercial use of the findings' where there was a requirement to 'anticipate and give responsible consideration to the intended and potential unintended impacts of the commercial development and use of the technology, including the potential for misuse, before the work begins….and to propose appropriate action to prevent or mitigate adverse impacts'. The framework they used drew on a number of inputs, including my work described above and processes used in ethical investment and ethical finance: it is a rather complex document divided into two parts: a) *ethical and social* and b) *regulatory*.

In terms of ethical and social considerations it asked applicants to ensure basic human rights are respected, that there should be a net environmental benefit and no exacerbation of environmental degradation, that products be developed in accordance with trade principles that are fair and that recognise the rights of people to just reward (including labour rights and intellectual property rights) and that costs and benefits are equitably distributed. The framework had normative elements, with defined 'positive drivers' that included the need for innovation to:

a) benefit society and/or human wellbeing (education, arts and culture, housing and employment or life-saving and life-enhancing products such as medicines, medical devices and safety equipment) – a number of the project proposals submitted were therefore in the area of healthcare and specifically disease control;

b) enhance and support the environment (green transport, waste minimisation, improving efficiency of water use and resilience of water systems, minimal use of non-renewable resources, increased use of renewable resources). Projects were asked to take a life cycle approach and indicate any environmentally beneficial impacts – a large number of the projects submitted were therefore for the engineering of microbes to enable recovery from waste streams to produce fuels or high value chemicals and chemical intermediates, with less reliance on volatile, carbon intensive petrochemical feedstocks.

[11] http://www.rcuk.ac.uk/documents/publications/SyntheticBiologyRoadmap.pdf

[12] http://webarchive.nationalarchives.gov.uk/20130221185318/www.innovateuk.org/_assets/responsible_innovation.pdf

c) companies that exhibit good governance, sound practices in terms of employment ethics, health and safety etc.

'Negative drivers' included end uses leading to social damage (e.g. disadvantaging communities economically or socially or bearing disproportionate risk on them); environmental damage; absence of clear policies on bribery and corruption; inappropriate use of animal products; not following best practice in terms of testing on animals; production and sale of weapons outside relevant treaties or for non-defence purposes; and addictive substances and behaviours.

In terms of the regulatory aspects of the framework applicants were asked to demonstrate familiarity and compliance with applicable regulations (e.g. to genetically modified organisms, biological and toxin weapons, and regulations on medicines for human use), while committing to making regular reassessments of regulatory requirements as the project develops.

The RRI submissions were assessed by the panel as being disappointing overall. By and large the health and safety and regulatory aspects were adequately addressed, and the proposals arguably met the 'positive drivers' for the call (i.e. being directed towards health and sustainable manufacturing approaches). However there was little evidence of meaningful reflection, anticipation or deliberation, with most proposals relying on standard dissemination practices. There were concerns that beyond the *de minimus* requirements companies had not seriously engaged with the call requirements (which was also perceived by some as being unclear or ambiguous) (Appendix 6). The TSB, in part recognising the need to further support the companies on the RRI aspects of the call, established two RRI 'Mentors' with considerable experience in business who subsequently visited the companies, evaluated their RRI activities and provided help and support. At a subsequent workshop in November 2013 convened by TSB and which included all the companies and the mentors it was notable that very few details about specific activities being undertaken by companies were presented or discussed Feedback from the companies may in part explain this, and is important learning in terms of how RRI might be implemented in the context of Horizon 2020.

RRI in a commercial environment: the need to demonstrate added value

Most of the companies were aware of, and appreciated the need for, responsible innovation and even some of the principles behind it, and that RRI ultimately makes good business sense. However, most of the companies were small and medium enterprises and it was clear that for them RRI incurs a potential financial cost for which the added value would need to be demonstrated, particularly to investors (e.g. venture capitalists). Some companies had very little capital and for them the priority was that they were commercially viable in the coming year: many wanted to know what the return on an RRI investment would be given the hard commercial realities they faced. There was therefore a need to *articulate the benefits and added value* from a commercial perspective. Many seemed to understand that these were short term constraints, and that in the long term, and in particular for the sustainability of their businesses and synthetic biology as a whole, RRI was important, even critical. They appreciated that if one company failed to implement RRI properly or meaningfully, or did not do it at all there could be consequences for all and the future of the technology.

Case studies of good practice of RRI and *signposting to resources and sources of expertise* were perceived as useful to make the case for their investors. *Leveraging networks* such as knowledge transfer networks were recommended as an important vehicle to provide resources and expertise and the funding of RRI activities in and across companies, acting in the interest of the sector as a whole.

3. Options for taking RRI forward within the EC Horizon 2020 programme and beyond

The EC's Science in Society programme has framed RRI as: a process that 'fosters the creativity and innovativeness of European societies. In general terms, it implies anticipating and assessing potential implications and societal expectations with regard to research and innovation. In practice, RRI consists of designing and implementing R&I policy that will a) engage society more broadly in its research and innovation activities, b) increase the access to scientific results, c) ensure gender equality in both the research process and research content, d) take account of the ethics dimension, and e) promote formal and informal science education'' (Science in Society Work Programme, Horizon 2020). Building on a set of projects (Appendix 6) funded in the last two phases of FP7, the first Science in Society work programme of Horizon 2020 contains a number of elements which are aimed at the further building and strengthening of RRI across Europe.
The experiences in RRI that I have described provide some useful insights for how these existing and new RRI elements funded by the EC might contribute to a holistic RRI approach within Horizon 2020:

a) As I have stressed several times, an important first step is the articulation of, and commitment to, a clearly worded and unambiguous RRI *policy framework* for Horizon 2020 *that helps guide all stakeholders and clearly sets out expectations*[13]. A number of EU RRI projects that have recently begun (Appendix 7) can provide helpful inputs to this, but ultimately this is something that has to be undertaken at a Commission level as *an overarching and central element of Horizon 2020*: currently most of the funding and RRI activities lie within the Science in Society programme. As I have mentioned before the framing, normative basis and level of detail contained in such a framework are important considerations. The EC has already made a general commitment to RRI in Horizon 2020, what is now needed is a guiding framework to support delivery across Horizon 2020 investments. ERIAB could be an important location for the articulation of such a framework, working with other stakeholders, and play a leadership role in this regard. The development of an EC Framework for RRI could be achieved in a relatively short space of time, with a key goal to support and underpin the scoping and publication of the *second work programme for Horizon 2020* in 2015-2016.

b) Beneath this EU RRI Framework there is a need to identify particular thematic elements of the Horizon 2020 programme within which an RRI approach is specifically recommended, or even required, and which can subsequently serve as exemplars for RRI implementation[14]. An initial scoping exercise could productively result in a Horizon 2020 RRI Roadmap which guides the second and subsequent work programmes. Clear candidates include the *Societal Challenges programme, Future Emerging Technologies programme, Enabling and Industrial Technologies programme and Leadership in Enabling and Industrial Technologies programme,* and associated challenge driven programmes such as the *European Innovation Partnerships.* Funded project(s) within the current Horizon 2020 Science in Society work programme can provide inputs into this e.g. the current call for 'developing governance for

[13] This concurs with a key recommendation made in an expert group's report to the EC on Options for Strengthening RRI in Europe which states that 'the key objective of EU action should be to develop a coherent approach among the EU Member States that defines processes, instruments and criteria for RRI'. http://ec.europa.eu/research/science-society/document_library/pdf_06/options-for-strengthening_en.pdf
[14] This aligns to a degree with *Option 2* in the Expert Report on Options for Strengthening RRI in Europe

the advancement of Responsible Research and Innovation' which aims to foster RRI uptake in current research and innovations systems (including in industrial contexts)

c) Embedding of RRI into thematic elements of the Horizon 2020 programme and beyond will require 'RRI by Design' in terms of both how the work programmes are scoped and how they are subsequently delivered. A *stage gating architecture* may be useful in terms of how this is achieved, over which a EC RRI framework serves to describe the EC's expectations both in terms of activities within the 'stages' (signposting to specific tools and supporting techniques) and in terms of the configuration and activities of decision' gates', which must be both multi and trans- disciplinary in nature to ensure a substantive and responsive process is embedded into innovation trajectories. Embedding such integrated, multi and trans –disciplinary approaches into Horizon 2020 will require consideration of how programmes and projects are resourced, structured, delivered and – ultimately – governed.

d) The need for education and training in RRI is already well recognised by the Commission within the first Horizon 2020 Science in Society Work programme. Calls exist for projects that aim to design, produce and disseminate RRI educational material and curricula for use by Higher Education Institutions and other higher education establishments, and incorporate these into educational programmes for science and engineering studies. This 'embedding of RRI in curricula will help Higher Education Institutions to shape more responsible and responsive researchers, able to better frame their research in a societal context, necessary for tackling societal challenges more effectively and in a more transdisciplinary manner'. These projects, and existing investments under FP7 such as the RRI Tools project, along with future investments aimed at supporting structural change in research organisations to promote RRI, will be important and should provide helpful and consistent guidance for RRI implementation.

5. Key Recommendations (Appendix 8)

Clearly RRI is a long term ambition which will necessarily evolve over the lifetime of Horizon 2020 and beyond. My recommendations are therefore short term and aimed at making RRI more systematic, embedded and integral to Horizon 2020 as a whole:

Recommendation 1: For the EC to develop, commit to and adopt a common RRI Framework as a guiding framework to embed RRI across all Horizon 2020 investments in which expectations are clear.

Recommendation 2: To develop a Horizon 2020 RRI roadmap which identifies specific programmes in which RRI should serve as an underpinning approach, with the aim of making such programmes 'RRI by Design. This should also consider the use of commonly-used innovation management approaches such as stage gating to facilitate delivery.

Primary candidates in terms of Horizon 2020 themes include the Societal Challenges, Future Emerging Technologies, Enabling and Industrial Technologies and Leadership in Enabling and Industrial Technologies programmes. Associated programmes such as the European Innovation Partnerships programme also offer important opportunities. The aim would be to support the development and implementation of the second work programme of Horizon 2020, in particular for the societal challenges theme.

Recommendation 3: Building on investments currently being made in the Science in Society programme, develop and systematically embed programmes of RRI education and training across Horizon 2020. There is quite probably a case for funding a multi – and trans - disciplinary European centre for RRI to provide expertise, guidance, training and to undertake associated research. There is certainly a case for more engagement with the Business Studies community, and in particular Management discipline which to date has not made a significant contribution to debates concerning RRI formulation and implementation.

Appendix 1: Dimensions of RRI[15]

RRI involves a collective and continuous commitment to be:

a) ***Anticipatory*** – describing and analysing those intended and potentially unintended impacts that might arise, be these economic, social, environmental or otherwise.
Supported by methodologies that include those of foresight, technology assessment and scenario development, these not only serve to articulate promissory narratives of expectation but to explore other pathways to other impacts, to prompt scientists and innovators to ask 'what if…' and 'what else might it do?' questions. Tempered by the need for plausibility, such methods do not aim to predict, but are useful as a space to surface issues and explore possible impacts and implications that may otherwise remain uncovered and little discussed. They serve as a useful entry point for reflection on the purposes, promises and possible impacts of innovation. Guston (this volume) provides further discussion on this dimension.

b) ***Reflective*** – reflecting on underlying purposes, motivations and potential impacts, what is known (including those areas of regulation, ethical review or other forms of governance that may exist – and what is not known; associated uncertainties, risks, areas of ignorance, assumptions, questions and dilemmas.

c) ***Deliberative*** – inclusively *opening up* visions, purposes, questions and dilemmas to broad, collective deliberation through processes of dialogue, engagement and debate, inviting and listening to wider perspectives from publics and diverse stakeholders. This allows the introduction of a broad range of perspectives to reframe issues and the identification of areas of potential contestation. Sykes and Macnaghten 2013 describe a number of specific methods that can be employed, emphasising the goals of such deliberation should be normative (i.e. that dialogue is the right thing to do for reasons of democracy, equity and justice), and substantive (i.e. that choices concerning the nature and trajectory of innovation can be co-produced with publics in ways that authentically embody diverse sources of social knowledge, values and meanings

d) ***Responsive*** – using this collective process of reflexivity to both set the direction and influence the subsequent trajectory and pace of innovation, through effective mechanisms of participatory and anticipatory governance. This should be an iterative, inclusive and open process of adaptive learning, with dynamic capability.

[15] (Owen et al, 2013)

Appendix 2: Approach within the Dutch Research Council Responsible Innovation Programme (MVI)

- **valorisation:** stakeholders are represented in valorisation panels to ensure that they are closely involved in the research and that results can be implemented directly
- **interdisciplinary:** researchers in the fields of science, humanities and social sciences work in close partnership to develop Responsible Innovation projects
- **proactive:** ethical and societal aspects are incorporated into the design process from the start
- **international: t**he research has an international focus and takes the global context into consideration
- **relevance and knowledge utilisation:** research proposals will be considered in terms of relevance and the practicality of their results

Appendix 3: EC Horizon 2020 Societal Challenges Programme

Funding will focus on the following challenges:

- Health, demographic change and wellbeing;
- Food security, sustainable agriculture and forestry, marine and maritime and inland water research, and the bioeconomy;
- Secure, clean and efficient energy;
- Smart, green and integrated transport;
- Climate action, environment, resource efficiency and raw materials;
- Europe in a changing world - inclusive, innovative and reflective societies;
- Secure societies - protecting freedom and security of Europe and its citizens.

Appendix 4: Example of Risk Register submitted in response to EPSRC funding call on nanosciences for carbon capture[16]

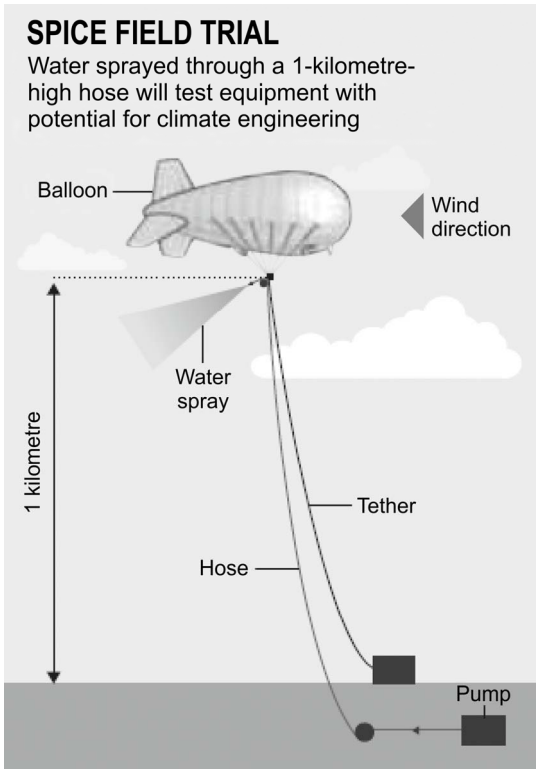
APPENDIX: SAMPLE RISK REGISTER RECEIVED TO NANOTECHNOLOGIES FUNDING CALL

Risk Register

Project Activity/ Outcome	Potential Impact	Risk	Uncertainty	Intended Actions/Measures in Place	Who
Synthesis of nanoparticles on RAMSI, lab-scale CHFS.	Health concerns of nanoparticles getting into the air or the environment.	Low	Low	Will follow BSI guidelines for specific disposal plans for nanomaterials, which are based on both U.S. Department of Energy (DOE 2007) and U.K. Environmental Agency Guidance (HWROI) existing documents in all activities herein.	JAD
	CHFS and RAMSI operator exposure.	Low	Low		
Synthesis of iron–sulfur clusters.	Use volatile and smelly thiols.	Low	Low	All reactions will be carried out in well-ventilated fumehoods.	GH
Electrochemical testing of nanoparticle catalysts.	Health concerns of use of nanoparticles for production of electrode array.	Low	Low	Reduce dust hazards for breathing in nanoparticles by handling in well-ventilated fumehoods and use of any protective clothing or measures as recommended by the above guidelines.	KH
Fabrication of electrochemical demonstrator CO_2 treatment.	Health concerns of use of nanoparticles for device fabrication.	Low	Low	Reduce dust hazards for breathing in nanoparticles (these will be dry and highly agglomerated as a result) by handling in well-ventilated fumehoods.	JAD
Synthesis of nanoparticles on the mini-pilot plant.	Health concerns of nanoparticles getting into the air.	Low	Low	See first activity for intended measures: effluent streams will be heavily diluted and we will also use particle traces (ion exchange) to capture particles and as per the above-mentioned BSI guidelines. Any nanowaste will be separated and disposed of separately from regular waste. As per the DOE guidelines, we will evaluate surface contamination or decontaminate equipment used to manufacture or handle nanoparticles before disposing of or reusing it and we will treat wastes (cleaning solutions, etc.) resulting from decontamination as nanomaterial-bearing waste.	JAD
Synthesis of nanoparticles on the mini-pilot plant.	Mini-pilot plant operator safety and exposure, and the environmental impact of the process compared to other routes.	Low	Low	Inherently the process offers low risk. There are, of course, pressure and temperature hazards for supercritical water usage. However, the volume of the pilot plant is much less than a comparable	JAD
		Low	Low	batch scale-up process (ca by 100 times). The pilot plant is also remotely operated and hence safer for operators. The process is also kinder to the environment than many competitor technologies as it uses water as a solvent with the avoidance of toxic organic solvents and offers high product yield, so the process is very atom efficient.	

[16] (reproduced from Owen and Goldberg, 2010)

Appendix 5: SPICE SRM proposed field trial, stage gate criteria and associated RRI dimensions[17]



	Criteria	RRI Dimensions
1.	The test-bed deployment is safe, the principal risks have been identified and managed, and are deemed acceptable	Reflexivity
2.	The test-bed deployment is compliant with relevant regulations	Reflexivity
3.	The framing of the project (nature, purpose) for external communication is clear and advice regarding this has been obtained	Reflexivity, Inclusive deliberation
4.	Future potential application(s) and associated impact(s) have been described and mechanisms put in place to review these as significant information emerges	Anticipation, Reflexivity
5.	Mechanisms have been identified to understand wider public and stakeholder views regarding these envisaged applications and impacts	Inclusive deliberation, Reflexivity

[17] Macnaghten and Owen, 2011; Stilgoe et al, 2013; Owen in press

Appendix 6: News article concerning RRI within the Technology Strategy Board's Synthetic Biology Industrial Feasibility programme

news

Take responsible innovation seriously, says TSB

Businesses applying to the Technology Strategy Board's latest competition in synthetic biology have been warned to stop playing down the importance of responsible innovation or risk losing their funding.

The warning comes after a disappointing set of appraisals on responsible innovation in last year's Advancing the Industrial Application of Synthetic Biology competition. The appraisals, requested by the TSB, are intended to show that applicants have understood the regulatory considerations and ethical and social implications of their proposed projects.

A briefing about the latest competition, Tools and Services for Synthetic Biology, was held in London on 26 November. Belinda Clarke, a TSB specialist in the area, told attendees that there had been no "perfect" appraisals in the first competition. Many applicants did not take the exercise seriously, with some trying to outsource it and others submitting global corporate social responsibility statements that did not relate directly to their project.

As in the first competition, however, applicants will be given a chance to revise unsuccessful statements with the help of assigned mentors. "That is not to say that it is OK to do a bit of a rough job," Clarke warns. "We can stop the project if the mentor has ongoing concerns."

by Catie Lichten clnews@ResearchResearch.com

Jack Stilgoe, a lecturer in science policy at University College London, praises the TSB for embarking on something "genuinely new" and taking companies out of their comfort zone. He says that making responsible innovation a requirement for funding would be "entirely healthy" as the TSB is a public funder.

Ted Fjällman, development director at the vaccine development company Prokarium, which has won a TSB synthetic-biology feasibility grant, welcomes the debate on responsible innovation. "Everybody agrees it's important, including the investors," he says. "They know the debacle that Monsanto has in Europe and that things could happen with synthetic biology." Applicants could, however, use a bit more practical advice and guidance in the area, he says.

Another issue that Clarke cited as a problem was a lack of engagement with social scientists. Richard Owen, chair of responsible innovation at the University of Exeter's business school, stresses that responsible innovation is a collective responsibility. "It's not just a question of social scientists playing handmaidens to technology," he says.

Appendix 7: Current EC RRI projects funded under FP7

GREAT – http://www.great-project.eu

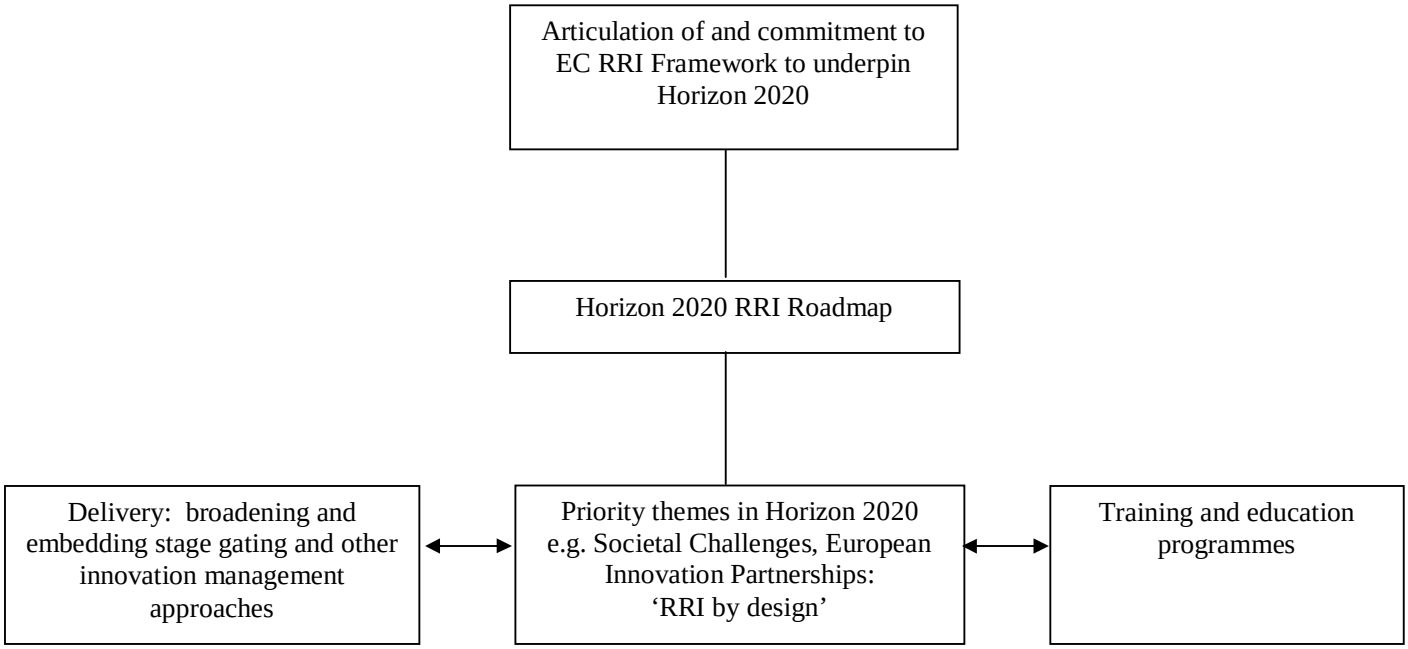
RESPONSIBILITY – http://www.responsibility-rri.eu

Res Agora – http://www.res-agora.eu

PROGRESS – http://www.progressproject.eu

RRI Tools – starts February 2014

Appendix 8: Key recommendations



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