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Voice from the Beehive: structuring and recording responsible innovation for novel technologies

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ABSTRACT

Societal trust in research and innovation is predicated on factors such as governance, safety, and responsible development. These are often thought of as regulatory matters, but regulation may be ill-adapted for many novel technologies. Anticipatory governance, potentially in the form of responsible innovation (RI), can help to provide this adaptivity and granularity. However, RI remains new to many fields, and can be difficult to apply. This paper analyses the literature to identify challenges for RI and lessons from other domain frameworks, synthesising this with empirical evidence to develop a Framework. The Beehive Framework is a straightforward to use, translatable scaffold, with accompanying guidance for mapping and recording RI within projects of various scales and types. Its iterative process model approach to RI contains elements of project management methodology, and captures information gathered during the processes of RI. It records these processes for further iteration, and comparison between projects.

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Introduction

Novel technologies can affect society in both positive and negative ways, as has been most recently seen with the example of machine-learning. Through the enormous growth in compute power and the increased availability of vast datasets (e.g. Wiens and Shenoy 2018), machine-learning (also known as artificial intelligence or AI) has become able to provide significant advantages in fields that handle large quantities of data and have a focus on pattern-recognition. This facility has enabled major advances in, for example, skin-cancer care, where a trained machine-learning model has proven to be adept at helping to identify cancerous lesions (Hekler et al. 2019). However, this same machine-learning technology, when used for facial recognition applications, has been shown to both entrench and amplify existing biases against people of colour (Garvie, 2019).

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It is possible or even likely that technologies such as machine-learning will soon require formal regulation, including legislation, at both national and international level – indeed the EU AI Act is already in progress and some commentators speak of a ‘race to regulation’ (Smuha 2021). However, governance does not consist only of legislation, and the process of creating legislation is slow and often difficult to accomplish (for example the Online Safety Act, which became law in 2023, was first proposed as a Green Paper in 2017). Such governance is also macro-scaled and may be difficult to operationalise at a detailed level. If possible, it is better to address challenges before they arise than to wait for harm to occur that may undermine societal trust – as in the machine-learning example above. Other forms of governance – used here in the broad sense of practices that regulate activities at all levels – include tools that provide greater degrees of granularity and operate at a smaller scale, such as industry and professional standards, or codes of conduct. However, these generally require a mature sector with established players and existing institutional infrastructure. One pre-emptive – or anticipatory – approach to minimising negative effects is Responsible Innovation (RI), which can also operate without the need for mature sectors – indeed is envisaged to operate ‘upstream’ early on in development processes. Although definitions vary, one of the most useful comes from Stilgoe, Owen, and Macnaghten 2013.

Responsible innovation means taking care of the future through collective stewardship of science and innovation in the present. (Stilgoe, Owen, and Macnaghten 2013, 1570)

RI methodologies draw together multiple threads. They incorporate inclusiveness of those who may be affected; consideration of both negative and positive outcomes; and responding to both these consultations and reflections – potentially influencing the course of a technology if deemed necessary (Stilgoe, Owen, and Macnaghten 2013). RI arose partly as a response to some of the issues involving emerging sciences of the last few decades, such as the Bovine Spongiform Encephalopathy crisis, and the complex arguments around genetically modified organisms (Burke 2004). It has now become embedded within European and UK policy frameworks (de Saille 2015), and in the UK as the AREA – Anticipate, Engage, Reflect, Act – Framework (Owen et al. 2013). It aims to try and ensure that research and innovation are carried out *for* and *with* society in order both to increase acceptance and to improve outcomes for society (Owen, Macnaghten, and Stilgoe 2012), and its principles have become adopted across a wide variety of fields – there is work on RI in nanotechnology (Pandza and Ellwood 2013), in synthetic biology (Ribeiro and Shapira 2019) and in climate engineering (Stilgoe, Owen, and Macnaghten 2013) – all complex, large-scale novel technologies. RI is not the only such anticipatory governance/ pre-emptive approach, but its incorporation in policy frameworks in the UK makes it a valuable example for scholars in terms of how anticipatory approaches to novel technologies may be embedded and utilised.

However, the practice of RI is not without its challenges – this paper’s contribution is to first examine the literature that highlights and discusses some of these challenges, and to investigate the use of frameworks found in other fields. It then draws on empirical research in multiple domains that are relevant both for the use of frameworks in general and the practice of RI in particular, and synthesises the literature with the

empirical research in order to develop and propose a novel Framework for the practice of Responsible Innovation – the Beehive Framework. This Framework aims to provide a process for RI that does not constrain the user, but that allows for documentation, tracking, and recording.

RI in practice

The application of RI presents some theoretical and methodological challenges. RI's flexibility is demonstrated by the breadth of discussion in the literature around definitions of terms, such as the exact meaning of 'responsibility', and by the number of indicators of possible 'good' RI practice (eg Strand et al. 2015). These discussions also demonstrate how much the processes of RI – anticipate, reflect, engage and act – overlap and interact with each other. In terms of its description as a 'framework', it may perhaps be best understood as a set of 'frames' in the social science sense, rather than a model, or scaffold, in the software engineering sense. Ribeiro, Smith, and Millar (2017) describe it as an 'umbrella' term, suggesting that RI can be adapted to a variety of different situations without discarding any key elements. 'Its greatest potential may be in its ability to unify and provide political momentum to a wide range of long-articulated ethical and policy issues' (Ribeiro, Smith, and Millar 2017, 81). This pragmatic approach seeks to leapfrog precision of meaning in pursuit of practical workability.

However, many commentators are less positive about the flexibility of RI. Some criticise the degree to which it has become common in the innovation discourse without being adequately defined – Delgado and Åm (2018) argue that the indeterminacy around its definition is problematic not just in terms of defining RI but around conceptualisations of 'public good'. da Silva et al. (2019) claim that RI has 'stalled' after its adoption as a process of normative governance, and – particularly relevant for this paper – lacks sufficient guidance as to how it is to be done in practice.

Others point to the difficulty of acquiring the additional skillsets that may be required. Conley et al. (2017) argue that for RI to be successful, innovators will need to be experts in not just their field of innovation, but also in how to innovate responsibly – this is known as 'T-shaped' expertise (Guest 1991). There are criticisms of the use of RI as an 'add-on', or the potential for it to become a tick-box exercise (e.g. interviewees for Pansera and Owen 2018 and Ten Holter, Stahl, and Jirotko 2022).

Even proponents of RI acknowledge its challenges in practice. Per Jirotko et al. (2017), these challenges can include

- research and innovation are by their nature highly unpredictable
- the bundling-together of research and innovation hides their differences
- pluralistic democracies do not usually have social consensus
- stakeholder engagement can be misused
- RI is predicated upon particular values, around which there may be disagreement

The pragmatic approach described above does not materially assist with these difficulties of implementing RI in practice. The remainder of this section outlines some of the knottier challenges.

Challenges for anticipation

Carrying out anticipatory work in practice presents challenges on many fronts. As von Schomberg points out, ‘negative consequences are often neither foreseeable nor intentional’ (von Schomberg 2013, 59). Epistemologically the future can’t be known, so some commentators ask whether we can subject it to governance processes that run the risk of completely missing the mark (Mittelstadt, Stahl, and Fairweather 2015). Mittelstadt, Stahl, and Fairweather (2015) are among the many commentators that also point to normative challenges – by attempting to steer a technology in one direction or another, choices are being made about what ‘ought’ to be the case.

Some have argued that because it isn’t possible to know with certainty what outcomes any action will have, ‘responsible’ and ‘irresponsible’ innovation are indistinguishable from each other during the innovation process and that this therefore cannot be action-guiding (van de Poel and Sand 2018). Von Schomberg would disagree, listing behaviours such as ‘technology push, neglect of fundamental ethical principles, policy pull, and lack of precautionary measures and technology foresight’ as specifically ‘irresponsible’ innovation (von Schomberg 2013, 60).

Nordmann (2014)’s work on anticipation suggests that even if we were to have ‘perfect knowledge’ of what will happen, this would be insufficient to allow us to react to the future – underlining the distinction between ‘prediction’ and the way *anticipation* is framed in RI. Likewise, at the other end of the scale from such ‘perfect’ knowledge are entirely unknowable ‘black swans’ – events so unpredictable that it is unlikely that they could have been foreseen in any of their specifics, meaning that the ‘preparedness’ that RI supports is key. Nordmann also questions the degree to which we owe a duty of care to the future – what obligations can be ascribed towards our future selves or others’?

There are responses to these challenges for ‘anticipation’, however, often including exercises such as envisioning, and focus groups – both methods for trying to draw on collective ideas of what lies in store by looking at what might be emerging in the present, and extrapolating (eg Macnaghten 2020). The emphasis here is on ‘preparation’ for the future (Reeves 2012) and thus some mitigation of uncertainty. van Oost et al. (2016) also discuss the value of scenario analysis for exploring possibilities, while other approaches recognise that people will use their moral imagination to decide what they think *ought* to happen (Lehoux, Miller, and Williams-Jones 2020). Analogies have also proved useful here for facilitating extrapolatory thought, whereby an understanding of a known phenomenon can be extended to a new phenomenon with which it shares characteristics (Schwarz-Plaschg 2018).

Nordmann (2014) argues further from his ‘perfect knowledge’ point that we don’t need to *know* the future, as long as we can be *ready* for it – this requires agility, keeping options open and not closing down alternative paths (this links clearly to Collingridge 1980). This is an area where the commercial world has significant experience – the use of ‘foresight’ in industry has been commonplace for many years. Gordon et al. (2020) provide a useful historical analysis of the business literature, showing how business forecasting first used foresight strategies to improve their planning, eventually moving away from ‘prediction’ and towards ‘preparation’ (Bjorklund 1988; Gordon et al. 2020; Rohrbeck and Schwarz 2013). The business management literature has therefore

created a plethora of tools with which to ‘anticipate’ – these include relatively well-known approaches such as PESTLE analysis (as generally adapted from Aguilar 1967) for analysing the macro-business context, or Five Forces diagrams to examine a company’s relationship with their competition (Porter 1979). It is very possible that some of these tools could be compatible with RI-type approaches.

Challenges for engagement

Although frequently discussed as though it is a relatively simple exercise, ‘engagement’ can take many forms, from simple inclusion through to full co-design, and can present many difficulties in practice (Schubotz 2019). In particular, the timing of inclusive approaches may be crucial. Bearing in mind the need to retain flexibility early on in the process of technological innovation, much RI work calls for ‘upstream’ engagement (e.g. Banks 2016; Gerber 2018; Krabbenborg and Mulder 2015) – meaning at an early phase of the development process – with da Silva et al. (2019) agreeing that ‘late’ inclusion leads to poor anticipation, because paths are already locked in. ‘Early’ and ‘late’ are relative terms and give no guidance about precisely when intervention is ideal. It is possible to argue, however, that developers should err on the side of earlier, rather than later intervention and engagement.

Inclusivity can also be challenging for other reasons – Davies and Selin (2012) point out that inclusive deliberative processes may appear simple on paper, but in practice are often ‘messy’. This messiness may result in no clear ‘answer’ from a stakeholder engagement exercise, potentially allowing it to be sidelined altogether (Smallman 2018). It may be for reasons such as this that Smallman also finds instances of public engagement exercises actually influencing policy, for example, are so rare as to be almost undocumented. da Silva et al. (2019) adopt a combative position in the face of this messiness, discussing what they term ‘excessive’ inclusion and suggesting that this may lead to lack of resolution, or no clear decision. However, this may be missing the point of inclusion, which is not necessarily to come to a conclusion or achieve consensus but rather to discuss alternatives and possibilities in a collective way.

Finally, the politics of inclusion cannot be ignored. Forsberg et al. (2015) argue that a realignment of science as part of and co-created by society creates a need for societal input not just into the *how* of innovation, but also into the *why* and the *for whom* and the *what*. This requires decisions to be made about what and who is included or excluded – and these are political decisions, per van Oudheusden (2011). As Nowotny (2003) puts it, ‘The question of whose knowledge is to be recognised, translated and incorporated into action has been exacerbated under the pressure for democratisation’ (Nowotny 2003, 152, emphasis mine). Blue and Dale (2016) agree, arguing that the question of *who* is consulted may be even more exclusionary in areas where technical understanding may be required. Drawing lessons from Participatory Design approaches may provide a deeper understanding of the ways in which politics is necessarily a central concern in responsible innovation (Ten Holter 2022). Wesselink and Hoppe (2011) point out that deciding to consult publics in the first place is already a political decision, while others are clear that the way questions are framed also has political significance (Blue and Dale 2016; Pereira and Saltelli 2017).

Additional challenges for RI

As well as the specific challenges around anticipation and engagement described briefly above, the practice of RI may face difficulties in its application in the innovation lifecycle in general, whether in research or industry. There may also be disagreement around the meaning of ‘societal alignment’; challenges of repeatability; difficulty of making comparisons between projects; questions of normativity implicit in these approaches; and issues with self-regulation.

The latter challenge may be particularly problematic. RI, because of its forward-looking, harm-prevention modality, operates as a granular, self-regulatory form of governance – meaning that it requires individuals, groups and companies to act pre-emptively. This would appear to place the onus on innovators and designers to be the instigators of this type of anticipatory governance. Asking innovators to act in two different modes – as both designer and regulator – may create tensions when their different modes have different requirements (such as the *Challenger* shuttle crash where during the decision-making process an engineer was asked to put on his ‘management hat’ (Feynman 1988), which resulted in a different – fatal – decision). It is therefore legitimate to question whether self-regulation can be sufficient in fields where a variety of motivations and drivers will be experienced by innovators, of which ‘responsible innovation’ may be only one. One possible response to this challenge comes from commentators who stress ‘collective’ reflexivity and responsibility (Grimpe, Hartswood, and Jirotka 2014), potentially distributing the onus of self-regulation throughout the institution.

Responsible innovation as a ‘framework’

A framework can take many forms, and indeed conceptually is fundamentally different in different disciplines. For social scientists the key idea is of a ‘frame’ that can comprise a set of concepts and theoretical perspectives, and with its ‘frames’ of anticipation, reflection and so on, this is the form that RI takes. In software engineering, by contrast, a framework is a much more concrete building-block – almost a template – that is used as a basis from which to build out a new software development, while in management literature and process engineering, a framework might take the form of a graphical model that describe processes, elements, and their relationships to each other. Elsewhere it can be a decision-making tool, a form of checklist, a matrix, or a process. In most cases, however, the common thread is that it forms a type of scaffold, which has been designed to assist with guiding thinking and structuring a way forward for a given procedure. The objectives will vary, but may prioritise consistency between different instances of the procedure, whatever it may be, or aim to focus attention on any gaps that may thus be perceived. It is in some ways a mental model – a simulation that allows users to think and reason in a particular way. As Forrester (1971) points out, such mental models are useful for identifying weaknesses or lacunae that can then be addressed, strengthening the overall procedure. Additionally, he suggests that use of such models can force assumptions to be examined, and any internal contradictions to be surfaced for either acceptance or resolution. Some of the more common types of framework from different disciplines, as well as their possible value for constructing a new type of framework for responsible innovation, are discussed below.

Process models

One of the challenges for RI mentioned above is that the ‘frames’ of RI do not automatically bring with them a ‘process’ – this is one of the characteristics that can make RI difficult to carry out. Indeed, there is not necessarily a logical ‘order’ in which to tackle the various frames, and anticipation, inclusion and reflection may all occur simultaneously. Given this lack of structure in RI processes, it was considered that an investigation of ‘process models’ and the potential for their use in RI might provide a useful pathway for analysis, or help to resolve elements of some of the critiques of RI.

Process models are diagrammatic representations that ‘convey tasks, sequencing, decisions, participation, and information’ (Long 2014, 1). The diagrams are accompanied by explanatory text but it is the diagrams themselves – following carefully worked out representations of tasks, decision points and so on – that are the key element. As with other types of framework, they provide structure and create a representation that can then be analysed for gaps or refined, depending on the requirements. Shaping the process in this way can provide elements of formality and repeatability. However, like all models, they are useful but limited: they cannot take account of the context in which the process is used, or the external interfaces; they also cannot represent what may be regarded as the ‘human’ elements (the importance of acknowledging this was seen in the policy field study, where the human factors frequently override the linear processes that are nominally in place). With due regard to these limitations, elements of process modelling may offer useful support in the development of a framework to support RI processes.

Frameworks in industry

Commercial organisations and the management literature are familiar with, and have produced, a wide range of tools and models which are frequently employed in industry and consultancy. Their purposes can be extremely diverse, reflecting the number and variety of concerns on which a commercial organisation may need to impose some structure in order to achieve some degree of certainty. Tools such as marketplace modelling through Porter’s Five Forces (Porter 1979), and horizon-scanning using PESTLE (Day, 1990) are strongly aligned with the type of anticipatory work seen in RI, and indeed sometimes cross over into research (Nandonde, 2019). Consultancy firms and professional advisers use tools and frameworks like these to focus and structure their own thinking and that of their clients, as well as to surface implicit knowledge, assumptions, and understandings.

Many of these tools will also be familiar to those in policy and academia, but it is particularly valuable to compare some of them to responsible innovation-type frameworks. As argued persuasively by van de Poel et al. (2020), translation of models such as RI can often fail to recognise anticipatory, participatory work that is already taking place in commercial companies – it may not be the case that businesses are unwilling to carry out these activities, but rather that the communication of potential benefits is insufficiently persuasive, or that there is a failure to recognise and build on work that is already taking place. One key valuable element of industry frameworks is that deliberations are documented – a PESTLE or SWOT process, for example, will be created as a live document and shared, to be updated or revised as necessary. There have previously been calls for documentation to form part of RI processes (Ten Holter 2022), as this can

provide accountability, comparability, and support reflective processes. Documentation can also support the iterative nature of RI by providing a structure to build upon.

Academic frameworks

The relative specialisation and variety of academic fields makes it less likely that any given tool enjoys wide acceptance or understanding (as, for example, the PESTLE model could be said to do in the commercial context). However, the principles of creating and using a framework in academia are somewhat similar to those used in industry – academia has long recognised the value for shaping thinking that frameworks and models provide. For example the version of RI used in the UK is based around the AREA Framework, but there are also additional or alternative frameworks such as the 4P set of indicators (Stahl et al. 2017), and numerous RI or Responsible Research and Innovation (RRI) tools. Some of these have their foundations in European projects, and may include physical prompts such as ideation cards to spur debate and facilitate discussion (Portillo et al. 2023).

The Double Diamond

The British Design Council’s Double Diamond model (illustrated in [Figure 1](#)) has become one of the most well-known and widely-adapted frameworks in design over the last two decades (Ball 2019). Its versatility has meant that its principles and processes are utilised in numerous countries and across widely diverse fields including healthcare in Australia (Banbury et al. 2021); management and business analysis in the European Union (Molendowski and Źmuda 2013); and economic and environmental sustainability in the UK and Germany (Andrews et al. 2021). It is shaped around the partnered mechanisms of *diverging* and *converging* – within the model these processes of opening up and then closing down again are repeated, to try and ensure both that a multiplicity of voices are incorporated, but also that movement forward does not become ‘frozen’ in a morass of competing requirements. It thus implicitly recognises that trade-offs play a necessary role in any decision-making process. There are therefore clear parallels with the AREA framework for RI and some of the other frameworks from industry and policy discussed above. These processes of ‘opening up’ and then ‘closing down’: taking on board new ideas, information, and viewpoints, then absorbing, reflecting on, and moving forward with improved understanding and responsiveness – then iterating – provide a useful

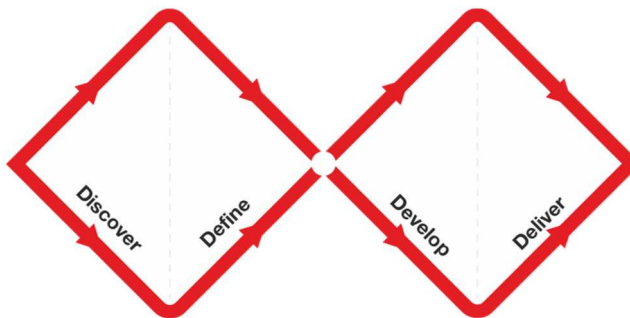


Figure 1. The design council’s double diamond (CC-BY).

method for scaffolding the anticipatory governance mechanisms that RI frameworks seek to build in.

This Double Diamond approach is therefore a useful model because it provides a means to allow for tensions, meanings, assumptions, multiple inputs and stakeholder nuance to be gathered, while also recognising that not all of these inputs can be instrumental in the final response. Drawing on the Double Diamond also builds on the work of RI scholars (for example Pavie and Carthy 2015) who have called for design thinking – a creative mode of thought that develops solutions to ill-defined or unknown problems – to be recognised as a strong contributor to RI methods.

However, it is also important to *retain* and *revisit* even the elements that could not be incorporated into the first iteration of the process model and to continue to allow them to influence the outputs. This is a factor that the Double Diamond model lacks, and will need to be developed for a responsible innovation framework.

Method

The challenges for a novel RI Framework identified through the literature and outlined above, were synthesised with research fieldwork in different domains, described below. Each domain study contributed particular shaping elements for a Framework, reflecting the priorities and context of its environment. The research domains corresponded with the triple-helix characterisation of research and innovation, focusing on industry, academia, and policy (Etzkowitz and Leydesdorff 1998).

61 semi-structured interviews were carried out with experts working in numerous fields across industry, academia and policy. Participants were drawn from extremely wide-ranging fields, in order to ensure the broadest range of views – for example the interviews with industry participants included those from knowledge transfer teams, venture capitalists, and recruiters, as well as those involved in running companies. A full list of interviewee roles is provided at Appendix A.

Interviews were transcribed, redacted, and then coded in NVivo. Analysis was carried out inductively, without any pre-existing guiding framework (Braun and Clarke 2006; Charmaz 2014). This is a method ‘consisting of flexible, successive analytic strategies to construct inductive theories from the data’ (Charmaz and Henwood 2017, 238). For this study developing the Framework, codes were selected that focused on challenges of governance, and acting responsibly or ethically.

Findings

Although many themes emerged from the interviews, this paper focuses on those that had direct relevance to the practice of responsible innovation, its challenges, and the possible uses for a novel Framework.

Respecting stakeholder input

One of the challenges with stakeholder engagement, as noted in 2.2 above, is the politically-relevant question of the degree of influence that stakeholders have in the trajectory and processes of innovation and development. Smallman (2020), for example, noted how

frequently stakeholder responses in public policy consultations are deemed to be out of scope. Different ‘grades’ of engagement – from simply informing stakeholders of a decision or outcome, through to full co-creation – will each raise different concerns and produce different results. ‘You know that everyone’s going to come in with an agenda, but how do you make sure that that’s still ... everyone’s still getting to a point where it’s productive’ (policy participant).

There is also value in **asking stakeholders difficult questions** and – even if these cannot be addressed immediately – retaining those questions and responses for future consideration; ‘maybe they don’t quite know how to put these ... challenges or questions ... in a language in which people can really engage with.’ (policy participant). Taking complicated questions out of a process acts as a type of filtration, and can further amplify the effects of a lack of diversity and inequitable power-balances. Differing views may provide valuable insights – in particular participatory work may generate conflict, challenges, and trade-offs – but if these conflicts or challenges cannot be addressed or responded to, the Framework needs to provide a mechanism to retain this information such that it may inform later work. Therefore there is a need for **tensions that are surfaced in stakeholder and anticipatory work to be given persistence** – this can be achieved through a combination of *documentation*, and an *iterative* process whereby concerns or tensions are revisited.

Incorporating different viewpoints

The fieldwork demonstrated the wide variety of different viewpoints around questions of responsibility in science, with little consensus even within domains around approaches or desirable outcomes. There is no simple way to align divergent views, but it is important to investigate and understand the various perspectives on the challenges and concerns faced in each domain of the triple helix (ie industry, academia and policy, per Etzkowitz and Leydesdorff 1998), which **may be rooted in similar considerations, but will be experienced differently** and will require different responses or a different application. It is also valuable to understand the pressures that may be experienced within individual projects, companies, and policy teams. For example, on the topic of governance in general, some participants demonstrate scepticism about the value of ‘soft’ governance, ‘you need regulation to prevent actors pursuing profit motive that you don’t want them to’ (industry participant), while others are open to anticipatory work; ‘if we had a full time RRI person, I would keep them really busy’ (industry participant). Others within innovation ecosystems recognise that people may be subject to different pressures at different stages of research and innovation chains, ‘being in a university ecosystem versus being a startup ecosystem, there’s ... different metrics that you’re aiming for in terms of how you’re measured’ (venture funder). A Framework should be able to *record* these different viewpoints and allow for consideration of unaligned (and unalignable) positions in order to *reflect* on ways forward,

Requirement for new methods

Participants believed that in terms of trying to use responsible innovation in practice, there are significant gaps in current understanding of how to apply methods such as

anticipation, engagement, and responsiveness. Even where there is acceptance of the need for ‘thinking quite deeply about the potential impacts of [our work], and the effects both in the near term and potentially in the longer term as well.’ (academic participant) there may be limited expertise for how to carry this out in practice. Additionally, these skills are often identified as being associated with particular individuals – in terms of organisations, this can present a challenge; ‘although [engagements] have been done before, the collective memory of the organisation isn’t good enough to remember how ... to do things like that’ (public funder). For responsible innovation approaches to deliver change in innovation and research in the ways that have been envisaged, there may be a need for a **more programmatic approach** that can reassure publics, create more agile governance, and support the academics, policymakers and commercial organisations working to develop useful, safe novel technologies. A Framework should therefore provide some *structure* and *guidance* for managing responsible innovation approaches in practice.

Tools that translate

Responsible innovation has been mandated in the UK’s publicly-funded research bodies (UKRI) for several years now, and in some areas there is a good level of understanding of its value, ‘I saw the importance of being responsible for your research and being able to explain what you’re doing to people’ (academic participant). However, it also has an increasingly high profile within commercial spaces. This may particularly be the case in areas where there are not current governance structures, but even within areas where there may be a high level of willingness to operationalise RI approaches, people question ‘how you move that conversation forward ... when it comes to the technology’ (industry regulator). RI therefore needs to be a tool that can accompany the technology as and when it turns into a commercial proposition.

There is also awareness that RI can operate at a very high strategic level; ‘every area needs to have responsible innovation - like a shield around it’ (stakeholder engagement participant) but where individuals seek guidance and structure is at the day-to-day operational level, to enable them to make good decisions under pressure and where there are competing priorities. It is therefore important to examine responsible innovation at several levels of magnification – the individual, the research-group or small community, and the wider organisation. All will be relevant in terms of assessing how responsible innovation is understood, actioned, and assessed. Accordingly the Framework must be *adaptable* for different levels of magnification, and for different domains.

Documenting and iterating

The final theme that was relevant for the Framework was around the importance of evaluation and assessment. Participants questioned; ‘what should we be requiring the researchers ... to do, to prove that they have thought through the consequences of their activities?’ (academic participant). At present there are no widely accepted tools or standards for documenting responsible innovation work, despite the need for RI approaches to be embedded within research projects. The importance of assessment is linked to the importance of reflection, and also of linearity – there must be space for

the decisions and outcomes of process to be reviewed and assessed. **Building in iteration**, with its necessary reviewing and recombining of different elements, as well as the process of repeatedly ‘going through’, can provide an opportunity for these evaluative processes.

Additional considerations

As was seen in reviewing the literature, one of the critiques of responsible innovation has been that it is too nebulous as a concept, too flexible, too adaptive, with a lack of guidance as to what constitutes ‘successful’ responsible innovation, and a shortage of agreed foundational principles such as a delineation of underlying values (e.g. Boenink and Kudina 2020; de Hoop, Pols, and Romijn 2016; Reber 2018; Wickson and Carew 2014). There is concern that these characteristics raise challenges such as:

1. Responsible innovation being **insufficiently concrete** to be easy to apply in practice, raising questions such as ‘how do you know when you’ve done it?’ or ‘how much responsible innovation is “enough”?’
2. The **difficulty of comparing** even like-for-like projects. In particular the necessary reflexive elements may encourage a decision in a certain direction in one project and in the reverse direction in another, without any means of establishing how this is established or justified.
3. Stakeholders’ input being deemed to be ‘out of scope’ because it **cannot be addressed within the available remit**. This can undermine the credibility of stakeholder engagement and create disillusionment in those who have contributed.
4. The above points have contributed to the challenge of ‘**assessing**’ responsible innovation in practice, which has been identified as a possible roadblock in terms of institutionalising it as a method. (Ten Holter, Stahl, and Jirotka 2022).

Although one tool cannot be expected to address every challenge in a fully satisfactory way, the Framework described here seeks to respond to the some of the concerns raised by stakeholders, the anticipation of future developments, and the collective consideration of these elements. The development of the Framework has thus itself sought to follow a responsible innovation method.

Underlying principles

Overall, after reviewing the Findings above and synthesising them with the literature review, six key factors were identified that underlay the findings. Any framework that attempts to address these requirements must be:

1. **Transparent** – it is critical that the responsible innovation process can be comprehensible from beginning to end, that the deliberations and results can be interrogated by users and third-parties, and that those concerned can be aware of why particular responses were chosen.
2. **Accountable** – this does not only mean that the project or task may be accountable to a funder, or a governing body, but also refers to accountability to the stakeholders

concerned in the process, a key concern in participatory work. This is particularly true for the type of situation discussed above, where stakeholder concerns may be considered to be ‘out of scope’.

3. **Comparable** – projects must be able to establish baselines and comparisons for anticipatory governance work, in order to cumulatively gather evidence, and also to enable decisions to be challenged if necessary. There is also a need to allow for like-for-like comparison between projects.
4. **Adaptable** – the framework will need to be sufficiently flexible that it can be utilised around many different kinds of technology or development process, as well as being translatable across disciplinary and sector boundaries.
5. **Repeatable** – this is allied to comparability, in the sense that if the same process with the same stakeholders was to take place again, then it would be possible to test the outcomes of the earlier exercise. This does not argue that the outcomes would be the same, but any changes would themselves be illuminating.
6. **Documented** – this element underlies many of the others stipulated here and represents a novel addition to responsible innovation work. Documentation of processes is key in many industries and sectors, as has been seen, because of the support it provides not only for decision-making processes, but for principles such as repeatability and transparency.

These are the shaping elements that the Framework will need to satisfy.

Introducing the beehive framework

The literature, fieldwork and discussion above on the nature of the frameworks used by the various strands of the triple helix (as well as others) have all contributed shaping factors to the design of the Framework.

The Beehive Framework, shown in [Figure 2](#), is based around a ‘process model’ approach to RI, which means that it formalises one way in which RI can be carried out. There is no implication of normativity, and it is not proposed that this Framework is the way in which RI ‘should’ be operationalised, rather that the Beehive Framework creates a layer of process that can structure RI approaches. This is designed for ease of use; for translation purposes into commercial environments; and to address some of the challenges identified earlier in the case studies and outlined above. It draws on the Double Diamond approach in order to illustrate the diverging and converging elements, as this sense of ‘opening up’, then reflecting, and ‘closing down’ is vital. However, unlike the Double Diamond it is a single process that is then iterated upon. This means that the central figure only requires one repetition rather than two, because the intention is that this process is revisited. The purpose of this repetition is to re-reflect on and re-process the considerations and discussions from earlier rounds, as well as potentially widen discussion, for example with a new or expanded set of stakeholders.

In another departure from the Double Diamond, the Beehive Framework draws upon the strategic and management frameworks discussed in 2.4 for one of its most important features, which is the *recording* of information. This is discussed in more detail below, and serves to address several of the challenges identified during the fieldwork. The purpose of the areas grouped around the central ‘process’ cell is to provide a workspace

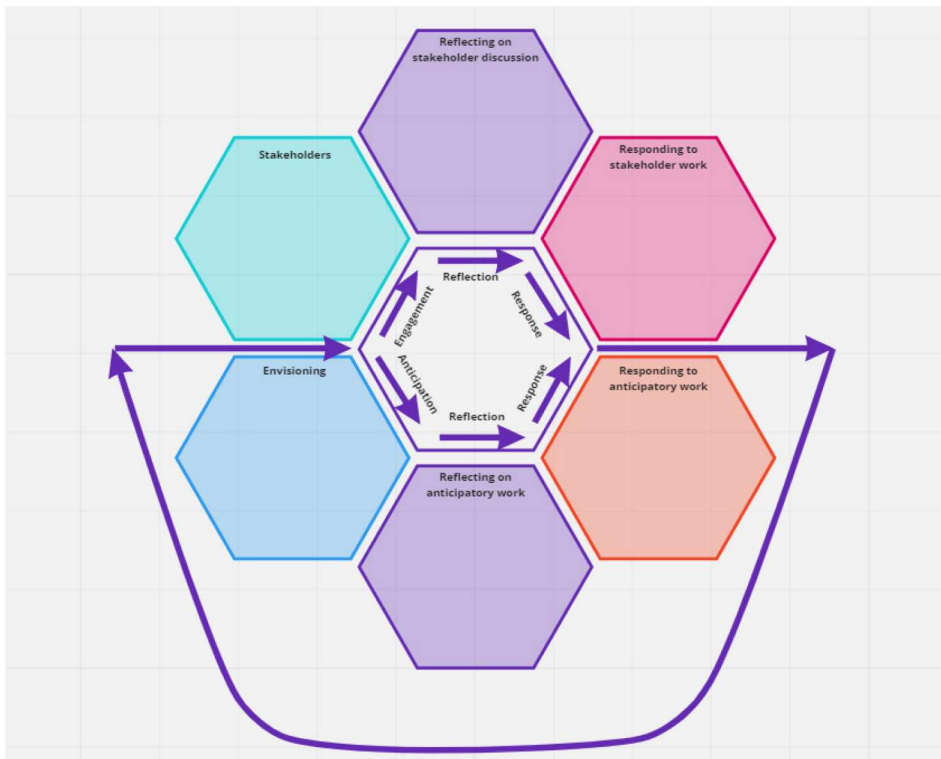


Figure 2. The Beehive Framework.

that is intended to be populated – to act as a storage space for the stakeholder-mapping, reflective, political questioning, and consensus or conflict elements. Populating the model in this way addresses the challenge of both identifying and *retaining* the tensions, trade-offs, concerns and other information gleaned from stakeholder work, anticipation, and reflection as these move forward through the decision-making process, with the intention that these can be revisited at a later stage as the process iterates. This was a key principle seen through the fieldwork – that information, competing priorities, and challenges should not be lost or discarded even if they cannot influence the process in its present iteration. It is not possible to say definitively what will be of value in future iterations, or how a particular technology, process, or policy, may develop in the future. Accordingly, these factors need to be retained and revisited. A crucial difference between this and other frameworks, therefore, is that the Beehive Framework acts as a living document for continuing use, in the same way as a project management plan serves as an ongoing outline for guidance and referral. The stages of the process are discussed in more detail below, but the objective is to ensure that, unlike a decision-tree, or stage-gate process, previous work is not discarded as decisions are made, but instead is built upon, and insights gathered and developed during the ‘opening up’ process are retained.

A further purpose for this recording of information is to provide transparency around decision-making, and comparability between projects – the Beehive Framework can act as a record that is available for similar projects to consult, and perhaps to critique.

For the purposes of design, and the evaluation described in section 6 below, the Miro online whiteboard tool has been utilised as a mechanism for creating templates, recording, and storing the various elements that populate the surrounding hexagons – however, any widespread propagation of the Framework and its toolkit would require a more robust and permanent delivery and storage system. Miro’s functionality is particularly valuable for several reasons. It is shareable online, meaning that multiple parties and stakeholders are able to collaborate, improving accessibility. It is simple and intuitive to use, but provides features that can add layers of complexity. It also has the potential to provide a vast workspace and supports users in adding increased levels of detail by zooming in or spreading out to create more workspace. A Miro board also allows for workshoping – whether online or in person – and the capture of ideas during discussion that can then be used for populating the workspaces at a later point.

In these ways, the overall Framework meets the following concerns identified in the fieldwork, as well as the underlying principles identified in 4.7.

- A more programmatic approach that systematises (to some degree) the process of working through RI and allows for simpler operationalising during processes of transfer (eg between academia and industry).
- Multiple iterations allow the use of different ‘lenses’ of magnification for governance, as well as being useable both for fine-grained projects and for high-level strategic discussion.
- The creation of a space for evaluation and assessment, as well as repeatability.

The ways in which the elements of the Beehive Framework answer the other challenges raised by the field studies are elaborated below in the discussion of how it is used in practice.

Diverging – anticipation and engagement

The process element of the Beehive Framework is illustrated by the arrowed pathway. As can be seen in [Figure 3](#), when the pathway enters the central hexagon, there is an initial diverging phase. This is the ‘opening up’ point – both to stakeholders and to anticipatory processes. It is during this anticipatory stage of the Framework that stakeholders are selected and invited to participate. Bearing in mind the political challenges identified earlier, this is the opportunity to engage in a broad range of activities including speculation, envisioning, use of moral imagination and so on. The related hexagons are then used to record both the stakeholders invited, and the questions they raised, the scenarios that were suggested, the challenges, possible solutions, roadblocks, tensions. The users can populate the framework with the details of those who were involved, and the work that was undertaken.

This phase addresses the following challenges identified in the fieldwork:

- Different perspectives on issues – this is achieved through the inclusion of stakeholders.
- Retaining a variety of viewpoints – these are recorded in the model.
- Retaining ‘messiness’ and redundancy – ensuring that concerns are not lost
- Identifying ‘difficult’ questions – even if these cannot be answered



Figure 3. Diverging – anticipation and stakeholder engagement.

These elements also reflect the concern from the policy study about the need to record decision-making processes in case of review – as this Framework is designed to be used iteratively, such review and evaluation is built-in and therefore the recording element allows for progressive building-up of a knowledge-base. **Figure 3** shows this part of the Framework, populated with data from a project. It can be seen that re-iterations of the process suggested different stakeholders, and that those stakeholders brought different concerns around the research questions to the fore.

Stakeholder engagement

One of the challenges for the ‘diverging’ stage of the framework is the stakeholder engagement process. However, although these participatory processes may be difficult, they are essential. This is not just for the practical expertise to be gained by drawing on a multiplicity of viewpoints, but for the purposes of testing ideas, investigating impacts on diverse populations, and engaging with societal actors to improve trust.

This is a key element, not least because in this as in many contexts, increasing the weight of numbers adds depth and complexity to these cultural and societal questions (Powell, Shennan, and Thomas 2009). There are many methods of doing this – for example full co-creation; or participatory design; or consultation – and the particular method chosen will be context-specific, but the process is essential. A stakeholder mapping exercise, including the ‘circles of engagement’ approach (Ten Holter et al. 2022), can also provide a useful guide as to who may potentially be involved in this phase of the process (or indeed in later iterations).

Reflecting – surfacing concerns

It is inevitable that not all stakeholder considerations and apprehensions can be acted upon – as has been seen in discussions around policy and the difficulties of engagement, some concerns may conflict or outweigh each other, some may need to be subservient to other factors – a wide variety of elements can influence outcomes. Any decision-making, strategic, or policy process needs to move forward, however, and in order to do so it must ‘converge’ again – which also means closing off some of the available options. But before doing so, the rationales for this should be carefully considered, and should be recorded. If a particular path is chosen, the reasoning for that should be documented in the Framework – it may be that these choices can be revisited during further iterations or could gain additional weight from new discussions with stakeholders.

The reflection phase of the work addresses the need for evaluation – by requiring recording of the reflective process (as is the case in reflective practice in many professions, e.g. Schön 1983) it creates a bounded space where reflection and consideration not only can but *must* take place before moving on to the final stage.

Converging – response

Any decision-making, strategic, or policy process needs to move forward, however, and so after the opening up and reflecting phases, it must ‘converge’ again in order to make decisions. This inevitably means closing off some of the available options. But before doing so, the rationales for these choices should be carefully considered and recorded. If a particular path is chosen, the reasoning for that should be documented in the Framework – it may be that these choices can be revisited during further iterations, may be affected by the development of the project, or could gain additional weight from discussions with new stakeholders. It is important to note again that although the Framework’s demarcated spaces may suggest separation of the various ideas and processes, these are not hard boundaries. For example it is not crucial that an issue be recorded in the southern hexagon of the ‘closing down’ stage as opposed to the northern. At the point of the process where the arrowed pathways come together and rejoin, therefore, the various concerns and challenges may be assumed to be part of one single process. In particular it is key at this point to record tensions and trade-offs. These are inevitable in any decision-making process as there are always compromises that need to be made.

An example of such a trade-off is illustrated in the work briefly described in Figures 3–5. Within this project, our research showed that citizens require, or expect, that autonomous vehicles will be recording data as they deploy in order to facilitate accident-investigation.



Figure 4. Reflecting – surfacing concerns.

However, this data-recording, if carried out at the required level of detail, would create terabytes of data every time the vehicle was operating. This would have significant implications for the privacy of other citizens who may be recorded as the vehicle drives around, problems of data-provenance if cases need to be tried in court, security and storage of colossal volumes of data, (and the carbon-footprint of this), as well as technical challenges for manufacturers. There is therefore a necessary trade-off to be made, and this must be noted, particularly given the likelihood that as this particular technology develops, solutions to some of these challenges may be found. Unless this tension and the expectations

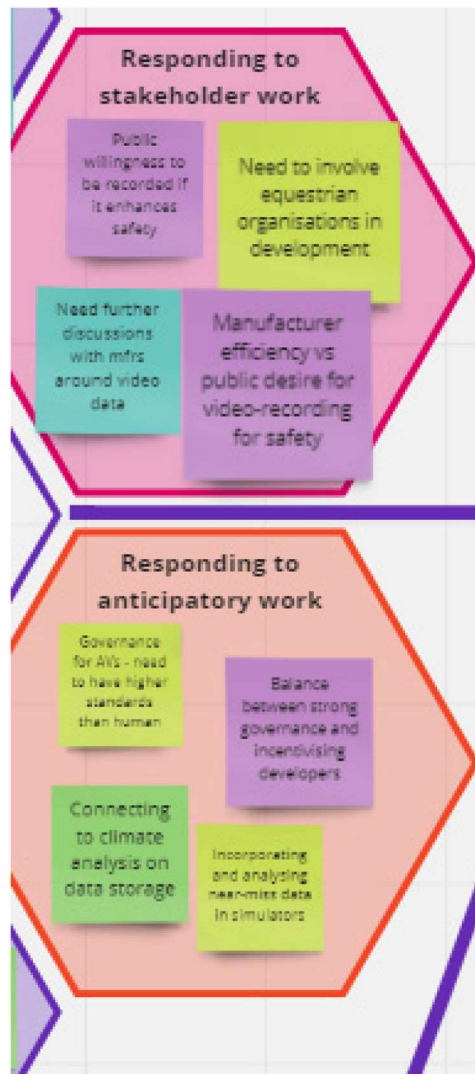


Figure 5. Converging – response.

of society in relation to this issue are recorded, it may not be regarded as a question for further research.

Recording and reporting

As discussed, this element is key for the Beehive Framework, and sets it apart from many other frameworks – this ‘recording’ element draws on diverse antecedents, such as the participatory design ‘diary’ described by Pilemalm (2018), and classical project management methodologies drawn from the management literature that emphasise the importance of clear communication and scoping (for example Sargeant et al. 2010; Spundak, 2014; Tinoco, Sato, and Hasan 2016), as well as ‘requirements’ processes in software engineering. It also reflects the point raised by policy participants about the importance

of reporting the factors taken into consideration in a decision, in case of later audit or judicial review, and is similarly informed by the systems of precedent within legal frameworks, which likewise explain their reasoning. These systems all emphasise the necessity of documenting the processes undertaken and the considerations acknowledged, partly as a means of providing transparency and accountability, but also to enable comparison and assessment.

The ‘recording’ element thus addresses many of the challenges identified in the preceding chapters, as well as supporting other aspects of RI:

1. Documenting processes can help to illuminate gaps, such as stakeholders that may not yet have been consulted.
2. Listing the parties consulted and their inputs can act as a prompt for reflection and thus as a form of data analysis. In this way, the Framework can support the processes of insight and evaluation that are such a significant part of RI work.
3. Recording the RI work, in a format applicable across many different project types and disciplines, will allow for simpler processes of comparison and assessment, identified as necessary for embedding RI in to institutions and projects.

However, it is important to note that the tool is designed to be used as a ‘living’ document that can be readily referred to and shared, and therefore the requirements for its completion must not be too onerous. There is a necessary trade-off here between usability and the provision of a ‘complete’ record, but the balance must lean in favour of the former in order to ensure the Framework’s ongoing utility as a record and a reference. This ease of use factor will be particularly important for the iterative element.

Iterating – a circular process

As previously stressed, the Beehive Framework is designed specifically to be re-used and iterated upon during any development or decision-making process. This is for several reasons:

1. The work to identify and document stakeholders; the ‘opening-up’ process that foregrounds anticipatory concerns, tensions, and multi-disciplinary inputs; the reflective and responsive processes that create a decision – all these elements form part of the groundwork for the decision. It is critical not to leave behind these understanding and rationales once a decision is made or a development processed, but to retain and take them forward – revisiting them through iteration serves as a reminder of the previous opening-up and reflective phases.
2. A strong rationale for iteration is not just to revisit earlier decisions, but to *assess* those decisions. The policy fieldwork in particular demonstrated that once a process (whether messy or linear) is complete, there is often a lack of effort to evaluate, and metrics or indicators for success are frequently not considered or built-in. Iterating on the 7-H process provides a means of evaluation by re-assessing and potentially re-opening the process.
3. The reflective and converging stages of the process are likely to recognise gaps that were not identified in the first phase, and will offer the opportunity to revisit and enrich the initial considerations.

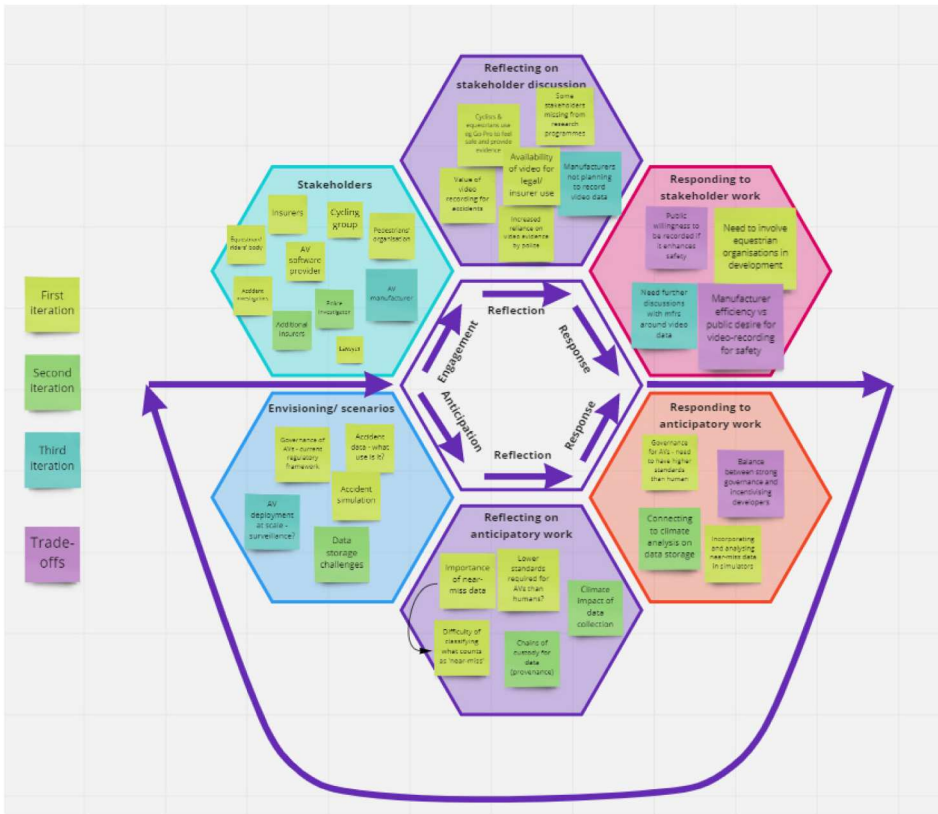


Figure 6. Sample populated Framework.

There is not necessarily a logical end-point for these iterative processes, but it is suggested that two to three iterations will offer sufficient opportunities for analysis.

Framing the process

Figure 6 shows the completed Beehive Framework for the small research project referred to above. This has been through three iterations, indicated by different notepad colours. The colour-coding has been retained to indicate the concerns raised by given stakeholders. Should more space for recording be required, additional cells could be added – the Beehive Framework could also be enlarged by adding wider circles of cells as an alternative way to denote later iterations, as it could reflect widening groups of stakeholders.

The challenges and issues raised at each stage of the process are highlighted, and the particular trade-offs or tensions between stakeholders are noted. As this is a Miro board, there would have been scope for many additional notes and contextual factors to be recorded.

Logistics

Use

Although the Beehive Framework could potentially be instantiated in various forms (for example it could simply be printed out and filled in, if an offline version was required),

for the above-described evaluations and presentations the Framework was created as a Miro board template to which the participants were given access. Miro was used for several reasons. As outlined above it was considered to be ideal for this process as it offers a large area for working and the ability to zoom in and out to various levels of magnification. A key benefit is also that, just as the RI process is designedly consultative and collaborative, a Miro board is specifically set up to be used in this way – its shareable nature means it can be worked on by several people at once. The ‘sticky-note’ facility provides a means for multiple participants to populate the ‘recording’ portions of the Framework.

Limitations

No framework can fully meet all possible RI requirements (for example, it cannot inter-rogate the values underpinning a particular design approach, only record challenges for it, and possible improvements), and the use of the Beehive Framework will therefore be highly context-dependent. This means its use will need to be situated within a wider understanding of RI processes and commitment to engaging with the challenges of participatory work. However, in the above-mentioned projects it was found to be easy to understand, straightforward to use, and readily comprehensible for those without an in-depth understanding of RI. This latter group also included industry partners in some of the projects, although it was not possible to introduce it to all partners. It can thus serve as an introduction to the concepts and approaches of RI, and may potentially be valuable as an aid in institutionalising its processes.

Conclusions

The design of this Framework has been informed and shaped by the fieldwork, and by a review of the literature on RI. Its aim has been to try to solve for some of the challenges identified both as part of the RI/ novel technologies discourse and those additionally identified during the fieldwork.

These challenges included: the difficulty of knowing in what order to carry out RI activities, scoping those activities, directing them to obtain the most useful and societally aligned results, and evaluating or assessing the RI work carried out in order to ascertain whether it was of sufficient quality and quantity. The underlying themes that emerged demonstrated that RI work needed to be transparent, accountable, comparable, adaptive, repeatable, and documented. These were the key challenges that the Beehive Framework was designed to address. The Beehive should therefore provide a model that can be used and adapted in various fields – it is hoped that its worth will be particularly apparent in areas where traditional governance is not yet a significant part of the ecosystem, for example responsible machine learning.

However, it is important to stress that the Beehive may be regarded as a necessary – but not sufficient – response to the challenges discussed above. Many of the difficulties identified around following RI approaches are *not* due to a lack of tools, but rather are rooted in behaviours that respond to the prevailing incentives. For the Beehive to be a useful addition to the anticipatory governance toolkit, it must be grounded in changed or changing behaviours that understand it is not a tick-box exercise, but rather is designed to encourage developers, policymakers, and researchers to think in new

directions about the way in which they design, develop, and deploy technology, and to support those new directions. It is also important to add that the Beehive Framework cannot guide decisions in one direction or another – as discussed earlier, it does not interrogate the values underpinning given choices, rather, there is an underlying assumption that the adoption of such a Framework itself indicates a commitment to responsible approaches. However, the methods described here can increase the chances that a responsive, considered, and informed path can be chosen, assuming there are incentives to do so. Those who work in novel technologies will need to be both empowered and encouraged to consider additional factors in their development, otherwise any tool such as the Beehive will fail to make a difference.

Finally, it is believed that the Beehive offers a novel contribution to the RI discourse and can act as a catalyst for discussion around the need for granularity in RI, as well as providing a possible template for future development work.

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Appendix A: Interviewees

Academia	28
Cybersecurity specialist	1
Government incubator	1
Industry	4
Industry/academia	2
Industry analyst	1
Industry lobbyist	1
Industry regulator	2
Policy adviser	3
Policy consultant	2
Public funder	2
Recruitment analyst	1
Research lab head	2
Science adviser	1
Stakeholder engagement	2
Technology transfer officer	2
Think tank	3
Venture funder	3
Total	61