Department for
Business, Energy
& Industrial Strategy

The use of public engagement for technological innovation

Literature review and case studies

BEIS Research Paper Number 2021/003

January 2021

Preface

The aim of this report commissioned by the Department for Business, Energy and Industrial Strategy (BEIS) is to bring together evidence on the current use of public engagement in policy development and regulation of technological innovation. The study provides an evidence base to support the work of the Better Regulation Executive (BRE) at BEIS that leads the regulatory reform agenda across the UK government. In particular, the results from this study are intended to help the BRE in its activities and engagement with government departments and regulators on how to best conduct public engagement with a view to informing and creating a narrative around new and emerging technologies. The findings from this study are thus mainly targeted at policy makers and regulators. The analysis and results, however, are also likely to be of relevance to other stakeholders interested and involved in technological innovation such as funders of research and innovation, academia, industry, and the general public.

This study focuses on three main research questions in the specific context of technological innovation:

- What existing examples are there of public engagement techniques and how and when have they been applied?
- What evidence of impact exists in relation to different types of public engagement on technological innovation (e.g. in terms of informing the design of regulatory frameworks, new business models, market adoption, and public trust)?
- Has the effectiveness of the public engagement techniques around technological innovation been formally evaluated, and what, if any, were the learnings?

This report was written by the following researchers from RAND Europe: Camilla d'Angelo, Advait Deshpande, Emily Ryen Gloinson, Joe Francombe, Cagla Stevenson, Mann Virdee, and Salil Gunashekar. RAND Europe is a not-for-profit research organisation that aims to improve policy and decision making in the public interest, through research and analysis. RAND Europe's clients include European governments, institutions, non-governmental organisations and firms with a need for rigorous, independent, multidisciplinary analysis.

For more information about RAND Europe or this document, please contact:

Dr Salil Gunashekar (Research Leader in Science and Emerging Technology)
RAND Europe,
Westbrook Centre, Milton Road,
Cambridge CB4 1YG, United Kingdom
Tel. +44 (1223) 353 2562
Email: sgunashe@randeurope.org

Acknowledgements

We would like to thank the project team at the Better Regulation Executive for their advice, guidance and support, and for engaging constructively and collaboratively with us over the course of the project. In particular, we would like to thank Kalavati Patel, Dorota Denning, Kim Wager and Stuart Roddam. We are very grateful to the many stakeholders who kindly agreed to be interviewed as part of this study. We would also like to thank to our quality assurance reviewers at RAND Europe, Dr Susan Guthrie and Dr Harriet Teare, for their critical review and valuable comments on this report.

Any enquiries regarding this publication should be sent to us at:
enquiries@beis.gov.uk

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Executive summary

Background

With the promise to improve lives, and the offer of abundant opportunities, technological innovation is regarded as a crucial enabler for the advancement of societies and economies at large. Technologies and their applications, however, also present an array of social, economic and regulatory challenges. How to harness the benefits of technological innovation while addressing the risks associated with these developments is the subject of much discussion by governments, regulators, industry, academia and the general public. A key aspect associated with these discussions and debates is public engagement, which is increasingly being recognised by stakeholders as a critical instrument to encourage transparency and openness, increase representativeness, and build trust in decision making and the technologies themselves.

Public engagement is a broad term that is used in a variety of sectors (e.g. in research, healthcare and policymaking). It encompasses diverse ways in which members of the general public can be brought together to engage with issues that are of public importance. In the context of technological innovation, public engagement is used to describe the involvement of a diverse group of people (the general public, but also other key groups such as lobbyists, civil society organisations and social influencers) in discussions and debates about potential applications of new and emerging technologies, their governance, regulation and the wider issues that could arise from the way that they are developed and adopted.

Study objectives

Understanding what works, in what contexts and for what purpose in relation to public engagement and technological innovation is important to inform policy and regulation. The overarching aim of this study commissioned by BEIS is to bring together evidence on the current use of public engagement for technological innovation. The work reported here focuses on identifying and understanding the types of engagement techniques used in the real world, how these have been applied to technological innovation across different sectors and any potential outcomes they may have, as well as the effectiveness of these approaches.

The study synthesises evidence on the current use of public engagement for technological innovation. The study, which is targeted at regulators and policy makers, provides an evidence base to support the work of the BRE at BEIS that

leads the regulatory reform agenda across the UK government. The work focuses on three main questions in the context of technological innovation:

1. **Research Question 1:** What existing examples are there of public engagement techniques and how and when have they been applied?
2. **Research Question 2:** What evidence of impact exists in relation to different types of public engagement on technological innovation (e.g. in terms of informing the design of regulatory frameworks, new business models, market adoption, and public trust)?
3. **Research Question 3:** Has the effectiveness of the public engagement techniques around technological innovation been formally evaluated, and what, if any, were the learnings?

Methodology

We adopted a mixed-methods approach to address the objectives of the study, which was conducted over a 12-week period. The approach enabled us to rapidly identify, analyse and synthesise evidence related to the use of public engagement techniques in the context of technological innovation. The approach broadly consisted of three distinct but overlapping phases: (i) Phase 1: Desk research; (ii) Phase 2: Case studies; and (iii) Phase 3: Analysis.

In the first phase of the study, we conducted a rapid review of the academic literature covering public engagement techniques applied in the context of technological innovation. The review included academic articles from 2016 to 2020. This was supplemented with targeted searches of the grey literature and scoping consultations (by telephone and e-mail) with experts in the area of public engagement.

In the second phase of the study, we developed ten case studies to provide concrete examples of how public engagement has been applied in the context of technological innovation, whether the techniques have been effective, and if so how. For each case study, the information was gathered through interviews with stakeholders and by reviewing a selection of articles connected to the case study.

In the final phase of the study, we synthesised the evidence from the desk research and case studies by developing a set of key themes regarding approaches to public engagement for technological innovation and their effectiveness. The cross-analysis of the evidence was carried out in an internal workshop attended by core members of the study team.

Case studies illustrating the use of public engagement techniques for technological innovation

Below we present short summaries of the ten case studies developed to demonstrate a deeper understanding of a variety of public engagement techniques applied in different contexts. The case studies span different technology areas, sectors, organisations, country contexts, and time periods.

Case study 1 (CS01): Serious game to crowdsource the public's views on moral decisions faced by autonomous vehicles

A key challenge around the development of autonomous vehicles lies in the moral dilemmas that they are likely to face (e.g. deciding who should live and who should die when faced with a potential collision with a pedestrian). To this end, researchers developed a website, Moral Machine, that used a 'serious game' with scenarios to crowdsource the public's views on moral decisions faced by autonomous vehicles. The aim was to generate a better understanding of the public's views about how autonomous vehicles should solve moral dilemmas, as well as to help raise awareness about this topic amongst the public. The platform was an effective large-scale data gathering exercise, collecting 40 million decisions in ten languages from people in 233 countries and territories. It helped to show that a serious game is an effective method to crowdsource the public's views on a controversial topic. The exercise identified strong universal moral preferences. Although the findings have not led to any formal outcomes, in principle they could be used to contribute to developing global, socially acceptable principles for machine ethics, which could inform considerations by car manufacturers and policy makers.

Case study 2 (CS02): Exploring public perceptions on autonomous vehicles using live public trials, workshops, sentiment mapping, and observational studies

Led by Transport Laboratory London (TRL), the GATEway (Greenwich Automated Transport Environment) project employed a range of public engagement methods to explore public perceptions towards connected and autonomous vehicles (CAVs) in order to understand societal factors affecting the adoption of CAVs. The GATEway Project demonstrates the potential of live public trials as a method for public engagement, while also highlighting the role of diverse engagement techniques in engaging different public audiences. Insights from the GATEway have shaped the work of certain actors, e.g. the vehicle design courses of the Royal College of Art. Engagement techniques used by the project have also been incorporated into market-oriented test-bed environments, as exemplified by the London Smart Mobility Living Lab (SMLL).

Case study 3 (CS03): Citizens' jury to understand public attitudes towards Ethical AI

The ethical use of artificial intelligence (AI) has become increasingly important in automated decision systems that use AI to inform or make decisions on which actions to pursue. The Royal Society for the encouragement of Arts, Manufactures and Commerce (RSA) and Deep Mind partnered on a deliberative engagement exercise using a citizen jury for public engagement on the impacts of ethical AI. The project was not formally assessed, but anecdotal evidence from interviews and desk research indicates that participating citizens felt better informed and had a better understanding of automated decision systems following the project. Interviewees indicated that the public engagement format also illustrated the importance of using public engagement techniques for other organisations, although this impact was not cited in relevant documents.

Case study 4 (CS04): Foresight gaming for multi-stakeholder dialogues to explore nanotechnology and Responsible Research and Innovation practices

Responsible Research and Innovation (RRI) is important to incorporate societal needs and values, and uses deliberative and transparent approaches to develop ethically acceptable and socially desirable products. The project used the Joint Research Centre (JRC) game, the SES, in national multi-stakeholder dialogues to explore nanotechnology and RRI practices. The project ensured that participants could comfortably express their opinion and the technique resulted in greater uptake of public engagement techniques at the science centres that ran the exercise. In the participatory process, recommendations suggested that to open up the nanotechnology system, decision-makers should promote generating interest and motivation for RRI that is genuine, rather than focussing on top-down regulation. It also provided recommendations and directions for the European Commission and other actors on the importance of public engagement in nanotechnology projects, although no evidence was found of the uptake of these recommendations in practice.

Case study 5 (CS05): Determining public perception on the use of virtual reality in healthcare through social listening

Virtual reality (VR) provides an immersive environment that enables users to have an altered experience of reality. It is increasingly used across the healthcare sector to support patients during treatment, however the public perception on its use remains under-studied. Here, the research team used a method called ‘social listening’ in order to collect and analyse Facebook comments in response to a video on the use of VR in healthcare. Analysis of these comments showed that the public was generally excited about the use of VR within a healthcare setting, but also identified several potential concerns of its use. These concerns highlight potential future barriers to this kind of research and provide insight into how this area could progress.

Case study 6 (CS06): Using the vTaiwan platform to carry out a public debate on the regulation of Uber in Taiwan

vTaiwan is a deliberative digital platform. It facilitates constructive debate and helps identify areas of consensus on specific issues amongst citizens, stakeholders, and government – with the intention of increasing engagement, scrutiny and transparency in decision-making. In this example, vTaiwan was used in the regulation of the UberX service from the ride-hailing app Uber. vTaiwan uses a dedicated AI-facilitated social media tool, Pol.is, which allows users to draft ways in which a problem may be addressed – as well as respond to other users' solutions by agreeing or disagreeing with them. The application of the vTaiwan process to the regulation of UberX demonstrated impacts through its ability to diffuse a potential row between Uber drivers and traditional taxi drivers around whether Uber was an app or taxi service in Taiwan. By engaging citizens and stakeholders it reached constructive outputs regarding legal requirements for both traditional taxis and Uber cars, and these outputs subsequently became law. The effectiveness of the vTaiwan process discussed in this case study has been highlighted in a number of published articles.

Case study 7 (CS07): Engaging expert and citizen perspectives on AI using a workshop and online platform

This case study explores a two-stage public engagement process on AI, conducted under the auspices of the Human Brain Project (HBP) and overseen by the Danish Board of Technology (DBT). In the first stage of the public engagement, an expert workshop was organised. The workshop brought together cross-disciplinary experts to consider the ethical, economic, legal political and social impacts of AI using a '360' approach. In the second stage, findings from the expert workshop were used to inform an EU-wide 'citizen consultation' on AI using an online platform. The case study highlights the potential for linked approaches to public engagement drawing on both expert stakeholders and the broader public, as well as the utility of online platforms as mechanisms for engaging public perspectives. The extent, however, to which these recommendations will be taken into account by the European Commission is not clear as of December 2020.

Case study 8 (CS08): Engaging the public on facial analysis and automated decision-making through the use of BioMetric Mirror - an interactive application

Facial analysis applications are increasingly being used to inform decision-making processes, and concerns have been raised regarding the transparency and ethics of these technologies. Here, the research team developed an interactive application 'BioMetric Mirror' which performed facial analysis on the public, and subsequently provided inferences about the participants' demographic and psychometric characteristics. Through this application, the public were able to engage with this

technology in an experiential way, which prompted discussion and reflection on not only the potential for this type of technology but the ethical challenges that must be considered if this were to become more prevalent in society.

Case study 9 (CS09): Citizen and Multi-Actor Consultation on Horizon 2020 (CIMULACT) to formulate science and technology policy research agenda in the European Union

The CIMULACT project focussed on advances in RRI in terms of enhanced cooperation with science and society to promote scientific excellence, and social responsibility and awareness. CIMULACT carried out citizen and multi-actor consultations to contribute to research agenda formulation for science and technology policy in the European Union. The project was well-received by participants. It had an impact on the research agenda in Horizon 2020, as the project results were used in the formulation of H2020 Work Programmes 2018-2020. The project was also acknowledged in the Interim Evaluation of Horizon 2020 and was chosen as a good practice case for citizen engagement in agenda setting in open science at the OECD.

Case study 10 (CS10): Rapid online deliberation to explore public attitudes to the use of COVID-19-related technologies

There appears to be a lack of public trust in some digital technologies developed to address different aspects of COVID-19, including contact tracing apps. To ensure public trust and buy-in of these technologies, it is important to determine under what circumstances the public considers technological solutions such as the COVID-19 contact tracing app to be appropriate. To this end, the Ada Lovelace Institute, together with collaborators, conducted a rapid online deliberation to explore the attitudes of members of the UK public to the use of digital COVID-19 technologies, including the NHS contact tracing app. The process was effective in enabling an informed dialogue with the public in a rapidly changing and uncertain environment. The process demonstrated that it is possible to gather public input in a short space of time and could potentially be applied to other future areas in which time is limited. Although it is too soon to indicate whether the engagement process has impacted on policy or regulation, the engagement exercise identified four requirements that would help to ensure public trust and buy-in regarding future COVID-19 technologies. These were to: (1) provide a transparent evidence base; (2) offer independent review of the technology; (3) clarify data use, rights and responsibilities; and (4) address the risks and needs of vulnerable groups. These requirements fed into a checklist aimed at government, policy makers and technology developers to help them with the future development, design and use of COVID-19 technologies.

Key findings

Below we summarise the key findings from the research.

A diverse range of public engagement techniques could be used in the context of technological innovation

Specifically, we observe that:

- Traditional approaches have been used most frequently. These include well-established methods such as surveys and public dialogues, for which considerable guidance already exists; and
- Atypical approaches have been used in some instances. These generally tend to be innovative, 'digital-enabled' techniques, using online tools or immersive VR technologies and simulations. There is evidence to suggest these could hold potential to be used more in the future. Accordingly, the report and case studies also cover these techniques.
- Public engagement techniques have been applied to a diverse range of technologies (e.g. cognitive technologies (including AI and machine learning), data-driven technologies, medical/biotechnologies, green technologies, nanotechnologies).
- Public engagement techniques applied to technological innovation cover a range of stakeholder types (e.g. the general public, potential users or consumers of the technology, policy makers, regulators, industry and experts from various disciplines).

Different public engagement techniques have, to varying degrees, had an impact on selected outcomes

Overall, the evidence on impacts is strongest for traditional approaches (i.e. surveys, public dialogues), with less evidence around atypical techniques, which tend to consist of proof-of-concepts to demonstrate the feasibility of a particular approach.

- The most reported outcome is to raise awareness and understanding of technological innovation.
- There are several instances in which public engagement has had an impact on policy, regulation, or ethics.
- There are several instances in which public engagement has had an impact on aspects of trust.
- There are limited instances in which public engagement has helped inform market adoption of technological innovation or contributed to changes in business models.

The usefulness of public engagement techniques is contextual

The effectiveness of public engagement techniques with regard to technological innovation is often not formally assessed, and evidence about many approaches is limited. The evidence suggests that:

- Consultative approaches such as surveys, interviews and focus groups are a well-established method to gather information on technological innovation from a selected sample of the public.
- Deliberative methods are particularly useful to explore complex topics in depth, and when there is potential uncertainty or controversy.
- There are multiple innovative methods (e.g. art-based and experiential techniques) that could help to render public engagement more meaningful (i.e. by helping the public to understand how a technological innovation might fit in to their wider everyday lives), and widen participation.
- The use of online and digital-enabled approaches (across the spectrum of engagement) represents a novel approach that can speed up the process of engagement, capture the views of the public at scale and enhance the experience of engagement (e.g. through the use of immersive experiences that enable the public to experience real-world scenarios).

The evidence also highlights that different techniques have been used ‘upstream’ (i.e. at an earlier stage) and ‘downstream’ (i.e. at a later stage):

- Techniques across the engagement spectrum have been used ‘upstream’ to gather the views of the public or discuss issues in-depth to help inform aspects of regulation, ethics and policy. There is evidence that deliberative techniques may be particularly suited for this purpose.
- Techniques across the engagement spectrum have also been used ‘downstream’ to help inform acceptance and potential market adoption of technologies. There is evidence that experiential techniques may be particularly suited for this purpose.

To aid the understanding of the different public engagement techniques identified in this study in the context of technological innovation, we have provided the following information as tables in a separate Excel file published alongside this report (these tables should be read and interpreted in conjunction with the narrative presented in this report):

- Overview of the different public engagement techniques used in the context of technological innovation identified in the literature and case studies (Table 1; this is presented in Chapter 2 and the first sheet in the accompanying Excel file)

- Overview of the evidence presented in this report on effectiveness of public engagement techniques (in the context of technological innovation) in relation to different outcomes (Table 2; this is presented in the second sheet in the accompanying Excel file)
- Overview of the evidence presented in this report on the potential implications of applying the different public engagement techniques in the context of technological innovation (Table 3; this is presented in the third sheet in the accompanying Excel file)

Concluding remarks

On the basis of the analysis, we also offer some cross-cutting lessons:

- The use of multiple techniques over the course of the public engagement process can help to engage different 'publics' appropriately.
- Spreading public engagement over time allows for reflection and embedding of concepts.
- Having an impact on trust in technologies and technological innovation requires time and considered debate to increase accountability and more systematic public engagement.
- A multi-stakeholder, collaborative approach to public engagement helps to develop informed and considered judgements.
- Using online and digital-enabled public engagement techniques can potentially increase the speed, scale, inclusivity, and geographical coverage of engagement.
- Using some atypical techniques can potentially render public engagement more tangible and user-friendly and could also increase the diversity of participation.
- Having an impact on outcomes such as regulation, policy and market adoption of technological innovation typically requires buy-in and engagement with the right stakeholders.
- It is important to build evaluation into public engagement processes to track impacts and outcomes over time.

Chapter 1: Introduction

Background and context

Public engagement is a broad term that is used in a variety of sectors (e.g. in research, healthcare and policymaking). It encompasses numerous and diverse ways in which members of the general public can be brought together to engage with issues that are of public importance. It is a process that involves interaction and listening to generate benefit and includes an aspiration to better connect societies with research and innovation. Benefits include increased accountability, alignment of values with the needs of citizens, building trust and ensuring relevance and responsiveness (NCCPE 2020b). In the context of policymaking, public engagement can help to increase the legitimacy, justice and effectiveness of decision-making (Fung 2006). Challenges with public engagement include: ensuring that the most appropriate methods of engagement are used with diverse stakeholder groups; the availability of funding; having the required time to plan successful projects; ensuring that policy makers and researchers recognise its value; communication; and having the required capacity and skills (University of Reading 2019). As illustrated in Table 4 in Annex B, public engagement encompasses a variety of methods or techniques, and can be applied in a variety of different contexts.

In the context of technology[1] and technological innovation,[2] public engagement is used to describe the involvement of a diverse group of people that are not limited to the general public, but also include other key groups such as lobbyists, civil society organisations, and social influencers in key discussions and debates. These discussions are concerned with the potential applications of new and emerging technologies,[3] their governance, regulation and the wider issues that could arise from the way that they are designed and implemented (Saunders 2018).

Public engagement is a valuable means to get societal perspectives on the potential impacts of science and technology on policy, legal, ethical, and other issues (PytlikZillig & Tomkins 2011) as well as more broadly contribute to the effective oversight of science and technology (Gunashekar et al. 2019; Sutcliffe et al. 2020). It can offer increased legitimacy and accountability, empower communities and increase social cohesion, and develop public services that are more efficient and

[1] Technology involves the application of knowledge, methods and processes for practical purposes (OECD 2001).
[2] In this report, we regard technological innovation to be the applications of technologies within one or more sectors, e.g. the applications of machine learning or blockchain technology in healthcare and financial services.
[3] New and emerging science and technology lacks an accepted definition but typically is characterised as technologies that have the following attributes: novelty; relatively fast growth; impact on society and the economy; and uncertainty (Rotolo et al. 2015).

effective, and create personal benefits to citizens (Brodie et al. 2009; Selin et al. 2017). These benefits are of particular importance to technological innovation where scientific uncertainties often depend on diverse and value-based perspectives, where the values of experts as well as citizens should be considered (Zhao et al. 2015). Public engagement in science and technology development is increasingly being recognised by policy makers as an important mechanism to bring openness and regulatory transparency in decision making and to help address issues like public mistrust in science (Eaton et al. 2014; Rempel et al. 2018).

Lack of public engagement, or decision making without public support, tends to result in a lack of legitimacy, which takes the form of public distrust (Clift 2019; Zhao et al. 2015). Technological innovation is increasingly regarded as 'political' due to its potential impact on society, which is associated with risks and benefits, and ethical disagreement about what constitutes the common good and responsible research (Zhao et al. 2015). For instance, lack of engagement has contributed to some high-profile public controversies in the UK, with a negative impact on the public acceptance of technologies and technological innovation such as nuclear power, genetically modified organisms, and nanotechnologies, amongst others (Clift 2019). Globally, citizens have tended to trust scientists, although there has been a perception amongst the public in European countries that science does not 'speak truth to power', and there is distrust of some technological innovation and scientific fields (Funk et al. 2020; Hendriks et al. 2016; Hennen 2013; Kabat 2017). This has established the importance of public engagement to build trust, manage risks and ethical problems, and to understand the legal and socioeconomic challenges related to new technologies and their applications (Gunashekar et al. 2019).

Traditionally, public engagement has focussed on the mobilisation of fixed public opinions where the public is perceived to operate with a 'blank slate' to develop opinions (Lezaun & Soneryd 2007; Selin et al. 2017; Welp et al. 2006). The public are perceived to have a deficit or lack of knowledge on science and technology which influences their rejection of technology and scientific ideals (Selin et al. 2017; Stilgoe et al. 2014). The focus on public engagement in these models have been to build trust to support public acceptance of science and technology (Stilgoe et al. 2014). In the early 2000s, there was a shift towards a view of engagement as happening with multiple subgroups of the publics. These different subgroups, however, were still perceived as 'anti-scientific', 'concerned' or as providing 'barriers' to innovation (Selin et al. 2017).

Public engagement has since seen a shift from the 'one-way' communication of information to improve the public understanding of science and technology to a 'two-way' communication process. More participatory methods aim to actively gather inputs (i.e. opinions, expertise and values) from the public and stimulate debate (Wilsdon & Willis 2004). There has also been an increasing focus on public

engagement at different phases of both policy development and implementation (PytlikZillig & Tomkins 2011). For instance, the shift towards a focus on responsible research and innovation in public engagement has built on ideas of "*anticipatory governance, real-time technology assessment, constructive technology assessment, value-sensitive design and open innovation*" that incorporates the public and user engagement (Stilgoe et al. 2014). Newer and atypical forms of public engagement that focus on creating new experiences for the public may help to strengthen this shift towards responsible research and innovation.

As noted above, the methods and approaches to engage the public and the topics covered can vary widely. Examples of more traditional methods include surveys, public consultations, workshops, focus groups, town hall meetings, notice and comment opportunities and citizen juries (Involve 2018; PytlikZillig & Tomkins 2011; Saunders 2018; Ward 2009). More recent, innovative methods include the use of creative arts-based approaches, serious games and digital technologies/online platforms (Involve 2018; Saunders 2018; Ward 2009). Innovative methods often have a less direct link to scientific processes, but have been found to create several benefits (Rask et al. 2012). In a review of several innovative public engagement cases, innovative methods have been found to also involve a number of diverse actors with representation from the third sector (i.e. a social sector that consists of stakeholders who come from neither the private nor the public sectors (National Audit Office, n.d.)) and the fourth sector (an emerging field of hybrid groups of people with established interests and who can bring about social cooperation through hybrid networking) (Rask et al. 2012). Innovative methods are often also oriented towards addressing societal challenges and are versatile and practical in nature (Rask et al. 2012).

In this evolving context of increasing recognition of the importance of public engagement in relation to technological innovation, the BRE at BEIS is leading the regulatory reform agenda across UK government. The White Paper on Regulation for the Fourth Industrial Revolution sets out plans to transform the UK's regulatory system to support innovation while protecting citizens and the environment (BEIS 2019). As part of this agenda, BRE aims to better understand which public engagement techniques, particularly novel and creative techniques, can support appropriate regulation of technological innovation, and provide advice to regulators and policy makers. This work is intended to identify relevant evidence to support the BRE's commitment to "*provide support, advice and share best practice with policy makers and regulators on public engagement techniques to support appropriate regulation of technological innovation*" (BEIS 2019).

Study objectives

Understanding what works, in what contexts and for what purpose in relation to public engagement and technological innovation is important to inform policy and regulation. The overarching aim of this study is to bring together evidence on the current use of public engagement for technological innovation (e.g. to support policy and regulation development, and market adoption of technological innovation). The work focuses on identifying and understanding the types of engagement approaches/techniques used in the real world, how these have been applied to technological innovation across different sectors and any potential outcomes, as well as the effectiveness of these approaches (e.g. in terms of influencing regulation).

The study synthesises evidence on the current use of public engagement for technological innovation. The study, which is targeted at regulators and policy makers will provide an evidence base to support the work of the BRE. The work focuses on three main questions in the context of technological innovation:

1. **Research Question 1:** What existing examples are there of public engagement techniques, and how and when have they been applied?
2. **Research Question 2:** What evidence of impact exists in relation to different types of public engagement on technological innovation (e.g. in terms of informing the design of regulatory frameworks, new business models, market adoption, and public trust)?
3. **Research Question 3:** Has the effectiveness of the public engagement techniques around technological innovation been formally evaluated, and what, if any, were the learnings?

We explore the whole spectrum of public engagement methods or techniques that could be used in the context of technological innovation – from the more traditional approaches to innovative, creative ones. We also present an understanding of the range and nature of stakeholders involved in the engagement process. Furthermore, we provide insights into the effectiveness of the techniques that could support the decision-making of regulators and policy makers.

Summary of the methodology

We adopted a mixed-methods approach to address the objectives of the study which was conducted over a 12-week period. The approach enabled us to rapidly identify, analyse and synthesise evidence related to the use of public engagement techniques in the context of technological innovation. The approach broadly consisted of three distinct but overlapping phases: (i) Phase 1: Desk research; (ii) Phase 2: Case studies; and (iii) Phase 3: Analysis.

In the first phase of the study, we conducted a rapid review of the academic literature covering public engagement techniques applied in the context of technological innovation. The review included academic articles from 2016 to 2020. This was supplemented with targeted searches of the grey literature and scoping consultations (by telephone and e-mail) with experts in the area of public engagement.[4] The primary aim of the scoping consultations was to identify potentially relevant literature and examples of potential case studies.

In the second phase of the study, we developed ten case studies to provide concrete and recent illustrations of how public engagement has been applied in the context of technological innovation and whether and how the techniques have been effective. As the case studies spanned different public engagement techniques, technology areas, countries, sectors, organisations and time periods, they enabled us to paint a rich and diverse 'on the ground' picture associated with emerging developments in public engagement practices. For each case study, the information was gathered through interviews with stakeholders and by reviewing a selection of articles connected to the case study.[5] Detailed descriptions of the case studies are provided in Annex A.

In the final phase of the study, we synthesised the evidence from the desk research and case studies by developing a set of key themes regarding approaches to public engagement for technological innovation and their effectiveness. The cross-analysis of the evidence was carried out in an internal workshop attended by core members of the study team.

The methods for this study are described in detail in Annex C along with the limitations of the analysis.

Structure of this report

The rest of the report is structured as follows:

- Chapter 2 focuses on Research Question 1, and provides a detailed overview of examples of public engagement techniques and how and when they have been applied in the context of technological innovation.
- Chapter 3 addresses Research Question 2, and focusses on existing evidence of impact in relation to different types of public engagement on technological innovation.

[4] Throughout the report, scoping consultation interviewee inputs are cited using the identifier INTXX where XX is a number between 01 and 07.
[5] Throughout the report, case study interviewee inputs are cited using the identifier CSXX-YY where XX is a number between 01 and 10, and YY is a number between 01 and 03.

- Chapter 4 addresses Research Question 3, and considers key insights from the evidence as they relate to whether the effectiveness of public engagement techniques around technological innovation have been formally evaluated, and any potential learnings that may have been made.
- In Chapter 5, we provide some concluding remarks, and reflect on the implications of the findings for regulators and policy makers.
- In Annex A, we present the ten case studies we developed to highlight a deeper understanding of a variety of public engagement techniques applied to technological innovation in different contexts.
- In Annex B, we provide an overview of a selection of general public engagement techniques (including those that have been used in contexts outside of technological innovation).
- In Annex C, we provide a detailed description of the methodological approach to implement the study along with key caveats of the analysis.
- In Annex D, we present the long-list of case studies from which the final ten case studies were short-listed.

Chapter 2: Examples of public engagement techniques applied in the context of technological innovation

In this section, we present the key findings associated with Research Question 1.

Research Question 1: What existing examples are there of public engagement techniques and how and when have they been applied?

Box 1: Summary of evidence on examples of public engagement techniques from the literature

Summary of evidence on existing examples of public engagement

A range of traditional and atypical public engagement techniques have been used in the context of technological innovation.

Public engagement techniques applied to technological innovation cover both 'one-way' methods (i.e. the flow of information is unidirectional) and 'two-way' methods (i.e. the flow of information is bidirectional).

Public engagement techniques have been applied to a diverse range of technologies (e.g. cognitive technologies (including AI and machine learning), data-driven technologies, medical/biotechnologies, green technologies, nanotechnologies).

Public engagement techniques applied to technological innovation cover a range of stakeholder types (e.g. the general public, potential users or consumers of the technology, policy makers, regulators, industry and experts from various disciplines).

Public engagement techniques have been applied to varying degrees across the technology development and adoption pathway:

- Different techniques have been used 'upstream' to explore aspects of policy, ethics, regulation and trust.

- Different techniques have been used ‘downstream’ to explore potential acceptability and market adoption, i.e. bringing existing technology into the marketplace.

- Some techniques could be used to gather long-term perspectives over time across the development and adoption pathway.

A range of traditional and atypical public engagement techniques have been used in the context of technological innovation

Most of the examples covered in the literature consist of so-called ‘traditional’ or classical public engagement techniques.[6] These include well-established methods to communicate with the public using educational content (e.g. videos) (Middleton 2017) or through events such as science festivals (Pint of Science 2020). There are also methods to consult and listen to the public’s views and attitudes, such as surveys (both online and face-to-face), interviews and public consultations (BEIS 2020). There are also many examples of face-to-face and online participatory methods (e.g. public dialogues, future workshops and citizens’ juries).

In addition to the more traditional examples, the literature contains several examples of creative, experimental and atypical public engagement techniques. These generally tend to be innovative, ‘digital-enabled’ techniques and include approaches to consult and listen such as social listening (e.g. using text mining and content analysis of comments on social media) (Keller et al. 2017) and participatory approaches using various experimental tools (e.g. algorithms) or online discussion platforms (vTaiwan, n.d.). Newer methods include gamification (e.g. face to face games and online games with scenarios) (Bontoux et al. 2016), participatory futures approaches (i.e. techniques incorporating futures methods) (Ramos et al. 2019), and experimental approaches or ‘living labs’ involving experiments with people using or experiencing a technology (e.g. live trials of prototypes, lab-based testing of prototypes or VR simulations) (Dupont et al. 2016).

[6] In this report, public engagement techniques have been grouped into three broad overarching categories: (1) **Communicate,** which are characterised by the delivery of information to the public to inform or educate. These include techniques such as educational tools (e.g. videos, presentations, blogs) and festivals; (2) **Consult**, which are characterised by the active or passive collection of information from the public to listen, gain knowledge and understanding. These include techniques such as surveys, interviews, crowdsourcing, social listening, focus groups, public consultation; and (3) **Participate**, which are characterised by discussion, collaboration and co-creation with the public. These include techniques such as deliberative techniques, experiential techniques, arts-based techniques. The three categories broadly map onto the International Association of Public Participation (IAP2) spectrum of public participation (IAP2 2018) that is comprised of the following categories: inform, consult, involve, collaborate, and empower. ‘Communicate’ and ‘consult’ roughly correspond to the IAP2 categories ‘inform’ and ‘consult’, respectively. The category ‘participate’ broadly includes the three IAP2 spectrum categories ‘involve’, ‘collaborate’ and ‘empower’.

Table 1 provides an overview of the different public engagement techniques identified in the literature and case studies in relation to technological innovation (this table is also presented in the first sheet in the accompanying Excel file). As noted previously (see note 6), in this report, public engagement techniques have been broadly grouped into three overarching categories: communicate, consult, and participate. The techniques are also grouped according to whether they consist of typical or atypical techniques. Examples of the types of technologies to which the techniques have been applied are also indicated.

Table 1: Overview of the different public engagement techniques used in the context of technological innovation identified in the literature and case studies

High level public engagement category	Public engagement technique	Specific example	Established	Atypical	Description and distinctive features	Exemplar context within which the technique has been applied (technological innovation; sector; country)	Key sources
Communicate	Arts-based	Images of connected and autonomous vehicles		✓	Techniques to engage the public that span: the visual arts, performing arts, games, art installations and other techniques. In this case the technique consisted of creating images of connected and autonomous vehicles to be	Technological innovation: Connected and autonomous vehicles Sector: Transport Country: UK	Case study 02; Annex B.

High level public engagement category	Public engagement technique	Specific example	Established	Atypical	Description and distinctive features	Exemplar context within which the technique has been applied (technological innovation; sector; country)	Key sources
					displayed in London's Transport Museum. The images were designed to reflect the views of the public on connected and autonomous vehicles (which had been collected as part of the vehicle design courses of the Royal College of Art).		

High level public engagement category	Public engagement technique	Specific example	Established	Atypical	Description and distinctive features	Exemplar context within which the technique has been applied (technological innovation; sector; country)	Key sources
Communicate	Festival	Pint of Science	✓		Forum to engage the public and make use of diverse formats for public engagement, including talks, discussions, workshops, hands-on activities and performance. Pint of Science is an international science festival in which researchers communicate their	Technological innovation: Multiple science and technology topics Sector: Multiple Country: Global	(Pint of Science 2020)

High level public engagement category	Public engagement technique	Specific example	Established	Atypical	Description and distinctive features	Exemplar context within which the technique has been applied (technological innovation; sector; country)	Key sources
					research to the public in a pub setting.		
Communicate	Video	Your DNA Your Say	✓		Video designed to educate and inform the public on a particular topic. Provides information on a particular topic in a manner that is engaging and interesting (i.e. using metaphors and lay language to	Technological innovation: Genomics; CRISPR-mediated somatic genome editing Sector: Health Country: Global	(Middleton 2017)

High level public engagement category	Public engagement technique	Specific example	Established	Atypical	Description and distinctive features	Exemplar context within which the technique has been applied (technological innovation; sector; country)	Key sources
					demystify genomic data sharing and a child as the main character to give the videos a non-threatening and positive feel). The video was translated into Polish, French, German, Russian, Arabic, Swedish, Icelandic, Portuguese, Italian, Japanese, Mandarin, Spanish and Urdu, and can		

High level public engagement category	Public engagement technique	Specific example	Established	Atypical	Description and distinctive features	Exemplar context within which the technique has been applied (technological innovation; sector; country)	Key sources
					therefore be used to reach audiences that are not conversant with English.		
Consult	Conversation café	Synthetic biology science café	✓		Informal dialogue where people are invited to discuss an issue in an informal setting (which could help to ensure that the process is as open and accessible as possible to anybody who is	Technological innovation: Synthetic biology Sector: Health Country: Canada	(Navid & Einsiedel 2012)

High level public engagement category	Public engagement technique	Specific example	Established	Atypical	Description and distinctive features	Exemplar context within which the technique has been applied (technological innovation; sector; country)	Key sources
					interested in the topic).		
Consult	Crowdsourcing	Moral Machine		✓	Process to gather ideas, functions, services, or contacts from a large and undefined network of people. The principle of openness underpins the exercise and uses bottom-up process to find goals that are often top-	Technological innovation: Autonomous vehicles Sector: Transport Country: Global	(Awad et al. 2018)

High level public engagement category	Public engagement technique	Specific example	Established	Atypical	Description and distinctive features	Exemplar context within which the technique has been applied (technological innovation; sector; country)	Key sources
					down. Tends to happen online. Moral Machine is a crowdsourcing website that also contains serious gaming elements (see below)		
Consult	Crowdsourcing	vTaiwan		✓	Process to gather ideas, functions, services, or contacts from a large and undefined network of people. The	Technological innovation: Ride-hailing/car-pooling apps; Fintech	Case study 06; Annex B

High level public engagement category	Public engagement technique	Specific example	Established	Atypical	Description and distinctive features	Exemplar context within which the technique has been applied (technological innovation; sector; country)	Key sources
					principle of openness underpins the exercise and uses bottom-up process to find goals that are often top-down. Tends to happen online. vTaiwan is a crowdsourcing platform that also contains deliberative elements (see below).	Sector: Transport; financial services Country: Taiwan	

High level public engagement category	Public engagement technique	Specific example	Established	Atypical	Description and distinctive features	Exemplar context within which the technique has been applied (technological innovation; sector; country)	Key sources
Consult	Focus group	Focus group	✓		Guided discussion of a small group of the public to gather information on a particular topic. Can be conducted face to face or online.	Technological innovation: CRISPR-mediated somatic genome editing Sector: Health Country: US	(Persaud et al. 2019)
Consult	Interview	Interview	✓		Structured conversation to gather information from the public on a particular topic. Explores views,	Technological innovation: Facial analysis technology; Smart cities	(Wouters et al. 2019)

High level public engagement category	Public engagement technique	Specific example	Established	Atypical	Description and distinctive features	Exemplar context within which the technique has been applied (technological innovation; sector; country)	Key sources
					normative positions, beliefs, experiences, and motivations of an individual participant. The technique provides an in-depth understanding of a certain topic. Can be conducted face to face or online.	Sector: surveillance; urban planning Country: France; US	

High level public engagement category	Public engagement technique	Specific example	Established	Atypical	Description and distinctive features	Exemplar context within which the technique has been applied (technological innovation; sector; country)	Key sources
Consult	Public consultation	Citizen consultation	✓		Technique used to ask groups of people to discuss their opinion on issues. Unlimited numbers of participants can be sent information about the subject, download it online, and respond via email or comment on the website. Formal consultations can	Technological innovation: AI Sector: Multiple Country: EU-wide	Case study 07; Annex B.

High level public engagement category	Public engagement technique	Specific example	Established	Atypical	Description and distinctive features	Exemplar context within which the technique has been applied (technological innovation; sector; country)	Key sources
					also consist of regulatory tools that are often undertaken as part of the legislative process (Cabinet Office 2018).		
Consult	Sentiment mapping	Sentiment mapping		✓	Technique to gather and analyse sentiments of public perceptions data. The technique uses natural language processing to identify the emotions	Technological innovation: Connected and autonomous vehicles Sector: Transport	Case study 02; Annex B.

High level public engagement category	Public engagement technique	Specific example	Established	Atypical	Description and distinctive features	Exemplar context within which the technique has been applied (technological innovation; sector; country)	Key sources
					expressed in text (e.g. through the analysis of comments on social media platforms) (Hauthal et al. 2020).	Country: UK	
Consult	Social listening	Text mining and content analysis of social media (e.g. Twitter, Facebook)		✓	Technique to gather the 'natural' unfiltered opinions of the public on a particular topic. Views are gathered via text mining or content analysis of	Technological innovation: VR; CRISPR-mediated genome editing Sector: Health	(Calabrese et al. 2019; Keller et al. 2017)

High level public engagement category	Public engagement technique	Specific example	Established	Atypical	Description and distinctive features	Exemplar context within which the technique has been applied (technological innovation; sector; country)	Key sources
					comments posted by the public (typically on social media e.g. Facebook, Twitter).	Country: US CRISPR-mediated genome editing	
Consult	Survey	Traditional survey	✓		Tool used to gather quantitative or qualitative information from a given population. Can be conducted face to face or online.	Technological innovation: Multiple science and technology topics Sector: Multiple Country: Multiple	(BEIS 2020)

High level public engagement category	Public engagement technique	Specific example	Established	Atypical	Description and distinctive features	Exemplar context within which the technique has been applied (technological innovation; sector; country)	Key sources
Consult	Survey	AttrakDiff questionnaire (with a specific User eXperience (UX) method)		✓	Online survey that evaluates a potential product (e.g. software or a consumer product) by gauging how the attractiveness of the product (e.g. in terms of its usability or appearance) is experienced by potential users. In this example, the survey was used to understand how different groups	Technological innovation: Electric cars Sector: Transport Country: France	(Dupont et al. 2016)

High level public engagement category	Public engagement technique	Specific example	Established	Atypical	Description and distinctive features	Exemplar context within which the technique has been applied (technological innovation; sector; country)	Key sources
					perceive electric cars, with a view to informing acceptability for different groups and in turn inform dissemination.		
Consult	Survey	Stated preference survey		✓	Online survey incorporating a best-worst choice experiment to explore the participants' most and least preferred attributes of	Technological innovation: Autonomous vehicles Sector: Transport Country: US	(Shabanpour et al. 2018)

High level public engagement category	Public engagement technique	Specific example	Established	Atypical	Description and distinctive features	Exemplar context within which the technique has been applied (technological innovation; sector; country)	Key sources
					autonomous vehicles.		
Participate	Arts-based	Participatory theatre e.g. European Theatre Lab		✓	Techniques that use creative approaches to bring complex issues alive with audiences who would not take part in more traditional processes. It encourages audience interaction and explores different approaches	Technological innovation: AI; Smart cities Sector: Urban planning Country: EU-wide	(Engasser & Saunders 2018)

High level public engagement category	Public engagement technique	Specific example	Established	Atypical	Description and distinctive features	Exemplar context within which the technique has been applied (technological innovation; sector; country)	Key sources
					to deal with an issue. One new form of participatory process is immersive theatre, which encourages public participation and co-creation. For example, the Stage Your City Project led by the European Theatre Lab uses immersive and participatory theatre		

High level public engagement category	Public engagement technique	Specific example	Established	Atypical	Description and distinctive features	Exemplar context within which the technique has been applied (technological innovation; sector; country)	Key sources
					to engage the public in the future of cities and technology such as AI (Engasser and Saunders 2018).		
Participate	Arts-based	Urban walk and photography		✓	Techniques to engage the public that span: the visual arts, performing arts, games, art installations and other techniques. This approach uses photography to help	Technological innovation: Smart cities Sector: Urban planning Country: US	(Altamirano-Allende & Selin 2016)

High level public engagement category	Public engagement technique	Specific example	Established	Atypical	Description and distinctive features	Exemplar context within which the technique has been applied (technological innovation; sector; country)	Key sources
					participants capture and reflect on a particular topic. In this example participants took part in an urban walk and were invited to take photographs of their surroundings. Creative method that can facilitate deeper reflections and a more meaningful engagement and		

High level public engagement category	Public engagement technique	Specific example	Established	Atypical	Description and distinctive features	Exemplar context within which the technique has been applied (technological innovation; sector; country)	Key sources
					conversation around technological innovation and the future.		
Participate	Deliberative	Deliberative workshops/ Public Dialogue Workshops/ Deliberative Policy Workshops	✓		Dialogue events that focus on in-depth and informed discussions of issues that are either complex or controversial. Can be conducted face to face or online. Deliberative techniques often	Technological innovation: Connected and autonomous vehicles; Digital technologies to combat COVID-19; Drones; Genomics; Machine learning; Mitochondrial replacement therapy;	(Ada Lovelace Institute 2020; Cameron & Maguire 2017; CDEI 2020; Drew 2016; McCool 2019; Mil et al. 2019)

High level public engagement category	Public engagement technique	Specific example	Established	Atypical	Description and distinctive features	Exemplar context within which the technique has been applied (technological innovation; sector; country)	Key sources
					involve a 'mini-public' (i.e. a relatively small sample of the public that is demographically representative of the larger population) but can also extend to larger samples (e.g. in the case of consensus conferences or citizens' summits).	Neural interfaces; Online targeting Sector: Transport; public health; data science; health Country: EU; Taiwan; UK	

High level public engagement category	Public engagement technique	Specific example	Established	Atypical	Description and distinctive features	Exemplar context within which the technique has been applied (technological innovation; sector; country)	Key sources
Participate	Deliberative	Citizens'/ community jury	✓		Technique in which the public discuss and deliberate over a topic (typically one clearly framed question) in depth. The aim is to reach a decision following deliberation on the issue, either by consensus or voting. Typically conducted face to face.	Technological innovation: Automated decision systems; Whole Genome Sequencing; Big Data Analytics Sector: Health; Data science Country: Australia; UK	(Degeling et al. 2020; Newson et al. 2019; RSA 2019)

High level public engagement category	Public engagement technique	Specific example	Established	Atypical	Description and distinctive features	Exemplar context within which the technique has been applied (technological innovation; sector; country)	Key sources
Participate	Deliberative	Deliberative mapping	✓		Technique that combines varied approaches and involves both experts (around 20 participants) and the public (around 40 participants) to rate diverse policy options against a set of criteria. The objective is to create a process that allows for more democratic, robust and accountable	Technological innovation: Geoengineering; Xenotransplantation; Energy-related technologies Sector: Energy; Health Country: UK	(Bellamy et al. 2016)

High level public engagement category	Public engagement technique	Specific example	Established	Atypical	Description and distinctive features	Exemplar context within which the technique has been applied (technological innovation; sector; country)	Key sources
					decision making that reflects public values. The citizens and experts discuss issues separately and then together at a workshop.		
Participate	Deliberative	Distributed dialogue		✓	Decentralised approach that aims to develop discussions that are dispersed, ongoing and embedded on a topic. Some of the engagement is	Technological innovation: Bioenergy Sector: Energy Country: UK	(BBSRC 2013)

High level public engagement category	Public engagement technique	Specific example	Established	Atypical	Description and distinctive features	Exemplar context within which the technique has been applied (technological innovation; sector; country)	Key sources
					organised by participants or groups themselves. It engages research communities, stakeholders and the public for strategy and policy development. It often involves several dialogue events organised by researchers and interested parties, in different geographical areas		

High level public engagement category	Public engagement technique	Specific example	Established	Atypical	Description and distinctive features	Exemplar context within which the technique has been applied (technological innovation; sector; country)	Key sources
					and using diverse mediums, to engage a wide range of communities on a given issue.		
Participate	Deliberative	vTaiwan		✓	Dedicated AI-facilitated social media tool, Pol.is, which crowdsources proposals from the public, and also allows the public to vote on other people's proposals by agreeing or	Technological innovation: Ride-hailing/car-pooling apps; Fintech Sector: Transport; financial services Country: Taiwan	Case study 06; Annex B.

High level public engagement category	Public engagement technique	Specific example	Established	Atypical	Description and distinctive features	Exemplar context within which the technique has been applied (technological innovation; sector; country)	Key sources
					disagreeing with them. This technique also incorporates aspects of crowdsourcing (see above).		
Participate	Experiential	BioMetric Mirror		✓	Techniques that enable the public to experience a technology (either a test prototype in the real world, interactive applications, or	Technological innovation: Facial analysis technology Sector: Multiple (surveillance)	Case study 08; Annex B.

High level public engagement category	Public engagement technique	Specific example	Established	Atypical	Description and distinctive features	Exemplar context within which the technique has been applied (technological innovation; sector; country)	Key sources
					using VR simulations). BioMetric Mirror consists of an interactive application that simulates facial analysis technology.	Country: US	
Participate	Experiential	VR simulation		✓	Techniques that enable the public to experience a technology (either a test prototype in the	Technological innovation: Autonomous boats Sector: Transport	(Venverloo et al. 2020)

High level public engagement category	Public engagement technique	Specific example	Established	Atypical	Description and distinctive features	Exemplar context within which the technique has been applied (technological innovation; sector; country)	Key sources
					real world or using VR simulations). In this case it was a VR simulation of autonomous boats.	Country: US	

High level public engagement category	Public engagement technique	Specific example	Established	Atypical	Description and distinctive features	Exemplar context within which the technique has been applied (technological innovation; sector; country)	Key sources
Participate	Experiential	Living lab e.g. Fab Living Lab		✓	Techniques that enable the public to experience a technology (either a test prototype in the real world or using VR simulations). Fab Living Lab is a platform that combines the concept of a 'living lab' with a 'Fab Lab' (Fabrication Laboratory – i.e. an open prototyping	Technological innovation: Smart cities Sector: Urban governance Country: France	(Dupont et al. 2016)

High level public engagement category	Public engagement technique	Specific example	Established	Atypical	Description and distinctive features	Exemplar context within which the technique has been applied (technological innovation; sector; country)	Key sources
					space, similar to the concept of a digital manufacturing workshop initiated by the Massachusetts Institute of Technology). The platform is used to prospectively evaluate the potential uses and acceptability of innovation, i.e. concepts, technologies or		

High level public engagement category	Public engagement technique	Specific example	Established	Atypical	Description and distinctive features	Exemplar context within which the technique has been applied (technological innovation; sector; country)	Key sources
					projects, and enables multiple stakeholders to participate together to co-create, prototype and test future products and services.		
Participate	Experiential	Living lab e.g. GATEway		✓	Techniques that enable the public to experience a technology (either a test prototype in the	Technological innovation: Connected and autonomous vehicles	Case study 02; Annex B.

High level public engagement category	Public engagement technique	Specific example	Established	Atypical	Description and distinctive features	Exemplar context within which the technique has been applied (technological innovation; sector; country)	Key sources
					real world or using VR simulations). GATEway consisted of live public trials of connected and autonomous vehicles.	Sector: Transport Country: UK	
Participate	Future workshop	Card-based workshop IMAGINE		✓	Technique to plan and form a vision of the future. Future workshops are usually focussed on local issues or challenges, or on	Technological innovation: Nanotechnology Sector: Multiple Country: Austria	(Felt et al. 2014)

High level public engagement category	Public engagement technique	Specific example	Established	Atypical	Description and distinctive features	Exemplar context within which the technique has been applied (technological innovation; sector; country)	Key sources
					the planning of a local action concerning a particular development. The aim is to involve participants who are directly affected by a problem and could offer solutions. This specific technique uses sets of cards as support material to allow the public to develop		

High level public engagement category	Public engagement technique	Specific example	Established	Atypical	Description and distinctive features	Exemplar context within which the technique has been applied (technological innovation; sector; country)	Key sources
					visions of a particular topic.		
Participate	Future workshop	CIMULACT	✓		Technique to plan and form a vision of the future, and to set out and prioritise the steps required to achieve the vision.	Technological innovation: R&I policy Sector: Multiple Country: EU-wide	Case study 09; Annex B.
Participate	Serious gaming	Moral Machine		✓	Techniques that serve as tools to gain complex knowledge and stimulate real-life	Technological innovation: Autonomous vehicles Sector: Transport	(Awad et al. 2018)

High level public engagement category	Public engagement technique	Specific example	Established	Atypical	Description and distinctive features	Exemplar context within which the technique has been applied (technological innovation; sector; country)	Key sources
					events and/or processes, and to provide the participant with a problem-solving environment for training. Moral Machine is a website that features a 'serious game' to crowdsource the public's views on how they would want autonomous	Country: Global	

High level public engagement category	Public engagement technique	Specific example	Established	Atypical	Description and distinctive features	Exemplar context within which the technique has been applied (technological innovation; sector; country)	Key sources
					vehicles to solve moral dilemmas in the context of unavoidable accidents.		

High level public engagement category	Public engagement technique	Specific example	Established	Atypical	Description and distinctive features	Exemplar context within which the technique has been applied (technological innovation; sector; country)	Key sources
Participate	Serious gaming	Joint Research Centre Scenario Exploration System		✓	Techniques that serve as tools to gain complex knowledge and stimulate real-life events and/or processes, and to provide the participant with a problem-solving environment for training. Role-playing game developed for the application of	Technological innovation: Nanotechnology Sector: Multiple Country: EU-wide	Case study 04; Annex B.

High level public engagement category	Public engagement technique	Specific example	Established	Atypical	Description and distinctive features	Exemplar context within which the technique has been applied (technological innovation; sector; country)	Key sources
					futures thinking to policy-making. Actors from three stakeholder groups (businesses, policy makers and civil society organisations) try to achieve long-term objectives whilst being observed by the public.		

Source: RAND Europe analysis

The range of public engagement techniques applied to technological innovation cover both 'one-way' methods and 'two-way' methods

'One-way' methods consist of techniques that have unidirectional information flow between the public/users and the designers/experts of the engagement exercise. These include techniques for communicating information to the public (e.g. through science festivals or educational materials such as videos), and techniques that can gather or track the views of the public (e.g. through surveys, interviews, focus groups and social listening). Certain types of one-way public engagement techniques that ensure clear-cut answers, such as surveys,[7] can be helpful when aiming to understand public acceptance related to a set of specific or narrow questions about technological innovation (Dupont et al. 2016, Shabanpour et al. 2018). For example, surveys have been used to consult the public on the most and least attractive features of autonomous vehicles (Shabanpour et al. 2018) and the perceptions the public has of electric cars to inform their adoption (Dupont et al. 2019). Techniques for communicating to the public, such as science festivals, talks or videos, can represent a fun and effective mechanism to convey complex topics to a large number of people (NCCPE 2020a). For example, the Genome Editing Public Engagement Synergy (GEPES) project, a partnership between the Wellcome Genome Campus and the National Coordinating Centre for Public Engagement, has collated a series of educational resources (e.g. talks, seminars, films, websites, online courses, publications etc.) to engage the public with genome editing (NCCPE 2018). Innovative and creative one-way methods also exist. These methods include: serious games, such as the Moral Machine experiment, to crowdsource the public's views on moral decisions related to AI (Awad et al. 2018); and scientific or conversation cafés, which aim to discuss topics with the public in an informal setting, such as a café or bar (Involve 2018).

'Two-way' public engagement techniques consist of bidirectional information flow and facilitate an exchange between the user/public and the tool/administrator in order to capture nuances and the diversity of views and opinions of participants. Well-established methods in this category include certain types of consultative methods, such as public consultations and citizens' panels, and face-to-face participatory methods,[8] such as deliberative workshops, public dialogues and citizens' juries (Involve 2018). Different types of participatory techniques facilitate in-depth, informed discussion with the public that captures deeper underlying values and trade-offs. These types of techniques are particularly useful to explore complex and controversial questions around technology and technological innovation, where knowledge is contested and there might be important ethical and social

[7] This report has included a wide and inclusive definition of public engagement. It should, however, be noted that in many contexts, techniques such as surveys are considered to be a research tool, rather than a public engagement technique, particularly in an academic setting or market research (when companies are gathering information from consumers).
[8] Techniques that allow collaboration and co-creation with the public (both online and offline).

considerations (Involve 2018). Newer or innovative participatory techniques include the testing of real-world prototypes through living labs (Dupont et al. 2016), experiential techniques using VR and immersive experiences (Venverloo et al. 2020), experimental interactive applications (Wouters et al. 2019) and gamified approaches. These types of experiential techniques have been used to enable the public to experience the technological innovation, either in a real world or a lab setting, and facilitate an exchange between participants and those responsible for the public engagement process. For example, live trials of autonomous vehicles in London through the GATEway Project gave the public the opportunity to experience (and provide feedback on) the technological innovation. In another example, the Fab Living Lab platform, which uses immersive VR combined with a living lab approach, has been used to engage the public and other relevant stakeholders (e.g. urban planners) in the city of Nantes in France to co-design, prototype and test future products and services to develop smart cities (Dupont et al. 2016).

Public engagement techniques have been applied to a diverse range of technologies

Public engagement techniques have been used across different areas of emerging science and technology. Cognitive technologies (including AI and machine learning), data-driven technologies, and medical/biotechnologies are the most common types of technologies covered in the reviewed literature. Other types of technologies include nanotechnologies, neurotechnologies and green technologies.

The public engagement techniques applied to technological innovation cover a range of stakeholder types

In some of the more traditional examples of public engagement, steps are often taken to ensure that the people involved represent a diverse cross-section of society (this can be a mini-public).[9] In this connection, deliberative techniques such as face-to-face public dialogues have typically aimed to engage with a diverse and representative group of the general public who are not necessarily familiar with the science or technology. In several of these examples, the engagement was careful to include groups that are either frequent or infrequent users of a technological innovation to ensure that views are balanced. For example, a public dialogue about genomics included groups expected to be both less (black and minority ethnic groups) and more enthusiastic (heavy users of the NHS) about genomics and data sharing (Ipsos MORI 2019). Similarly, surveys, such as the well-established British Social Attitudes survey (NatCen 2021) and Public Attitudes to Science survey (BEIS 2020), as well as others (Ada Lovelace Institute 2019), typically aim to ensure that the samples are representative.

In some cases, a specific subset of the population is engaged to better understand specific concerns. For instance, a number of deliberative public dialogues have sought to include specific groups of interest (e.g. minorities or vulnerable groups) in order to better understand specific concerns amongst these groups. In one example, a public dialogue on online targeting included four specific interest groups: young people, ethnic minorities, those with experience of mental health issues and those with financial vulnerability (CDEI 2020). In some cases, where the technological innovation is more clearly defined, techniques have been used to engage potential users of the technology. For example, focus groups were carried out to gauge the views and concerns of sickle cell disease patients on participation in future CRISPR-mediated somatic genome editing clinical trials (Persaud et al. 2019). In another example, civil servants were involved as ‘the public’ in a public engagement process to determine principles for an ethical framework around data science in government (Drew 2016). At very early stages of development when the technological innovation and potential publics are poorly defined, public engagement has also been directed at experts who are very familiar with the technology to help determine emergent publics and potential ethical concerns that could arise (Buckley et al. 2017). Experts are also used as part of deliberative processes (e.g. as part of an expert panel) to provide information to the public on a particular topic (Involve 2018).

[9] A sample of the public that is demographically representative of the larger population that is randomly selected to discuss an issue of public concern (Smith and Setälä 2018).

Public engagement techniques have been applied to varying degrees across the technology development and adoption pathway

Box 2: Defining upstream and downstream public engagement techniques

Upstream and downstream public engagement techniques

In the following discussion:

'Upstream' public engagement refers to engagement with the public around potentially controversial science and technology, at an earlier stage of development before eventual applications are clearly determined

'Downstream' public engagement takes place at a stage where a technology is more mature, for example in prototype form, and may be waiting to be exploited.

Source: (Wilsdon and Willis 2004)

A number of techniques have been used 'upstream' to gather the views of the public or discuss issues in depth to help inform aspects of regulation, ethics and policy

Surveys are a well-established and relatively straightforward method to gather the public's views and concerns related to different types of technological innovation

Surveys are a well-established technique to collect input from a sample of the public, including for example the perception of trust related to a particular technological innovation, concern and acceptability of a technological innovation, opinions on the role of the technological innovation in society, and the introduction of new technologies to certain sectors. Several longstanding surveys, including the British Social Attitudes survey (NatCen 2021), and the Public Attitudes to Science Survey (BEIS 2020), have been used to gather public perceptions of a range of issues, including emerging science and technology (e.g. nanotechnology, GM foods and attitudes to science regulation). Other examples have included surveys to understand the public's level of concern for the potential applications of brain-computer interfaces (Sample et al. 2020) and public awareness and acceptability of hydrogen energy technologies (Hienuki et al. 2019). Surveys can be used to determine broad, general information on a large number of people, or answers to more specific, issue-based questions amongst a smaller, targeted group of individuals. Although they can be used as a standalone method, they can also form a component of a broader engagement process (e.g. as a follow-up to other types of engagement methods). In general, surveys are a relatively low-cost technique that can be applied at scale, particularly when conducted online, and can be used to gather both qualitative and quantitative information.

Deliberative methods have been used to provide in-depth insight into the views of the public to inform aspects of ethics, policy and regulation

Deliberative methods consist of different types of methods that enable the public to consider a topic in depth, typically through facilitated discussion, with a view to arriving at an informed opinion or decision (Involve 2018). Deliberative methods facilitate an exchange between the user/public and the method and tool, in order to capture nuances and the diversity of views and opinions of participants, and so are particularly useful in exploring complex or controversial topics related to technological innovation, including early on in development (Involve 2018). Well-established examples of methods that involve deliberation include public dialogues, citizens' juries, and deliberative mapping. These techniques fall in the 'involve' 'collaborate' and 'empower' categories of the IAP2 spectrum.

Several interviewees highlighted that public dialogues have frequently been used to explore the public's views and concerns around technological innovation (INT01; INT06). Deliberative public dialogues have also been used to inform aspects of policy, ethics, regulation and alternatives to regulation concerning science and technology in a number of sectors, including health, transport and data science. One interviewee noted that they have been used typically to inform a specific decision or inform principles by which a decision can be taken, rather than to inform regulation (INT01). In the UK, there are several recent instances of upstream public dialogue exercises (such as workshops) being used to inform ethics concerning AI and data-driven technologies (CDEI 2020; Drew 2016). The Royal Society conducted a public dialogue in 2019 to understand public opinion on the field of neural interfaces, how it may develop in the future and to co-create realistic visions for the future of this emerging technology (Mil et al. 2019). In the US, researchers conducted a workshop with experts in nanobiosensors to carry out an early ethics assessment of nanobiosensors applied to the management of livestock disease risks in the early stages of their development. The aim was to gather the views of experts on any ethical concerns of future publics (e.g. future users of a technological innovation) to inform aspects of anticipatory governance (Buckley et al. 2017). In the UK, the Human Fertilisation and Embryology Authority (HFEA) used a breadth of engagement tools including workshops, a public survey, open meetings and focus groups to determine public acceptability of mitochondrial replacement therapy with a view to informing the HFEA's advice to the UK government on proposed regulations (Sheikh 2013).

Citizens' juries have also been used to explore complex ethical questions related to technological innovation. For example, in 2018 to 2019, a community jury of members of a university in Australia was used to consider the acceptability and legitimacy of using pathogen whole genome sequencing and big data analytics to enhance public health research and communicable disease surveillance (Degeling et al. 2020). In another example, the RSA convened a citizens' jury in 2018 to

deliberate on the ethical use of AI and its use to help make decisions for DeepMind on its services (RSA 2019) (see Case study 03; Annex A). Citizens' juries are typically used to explore particularly controversial or polarising topics with ethical considerations (Involve 2018). The aim of these exercises is to reach a consensus on a clearly framed question (Involve 2018). This technique can be considered to fall in the categories 'involve' and 'empower' as it typically aims to implement the decisions of the public.

More innovative examples of deliberative methods include digital-enabled deliberative approaches. In 2015, the government of Taiwan used an online platform ('vTaiwan') to engage the public in a large-scale deliberation exercise on the regulation of Uber in Taiwan (Centre for Public Impact 2019) (see Case study 06; Annex A). The platform uses an AI-facilitated social media tool, Pol.is, which allows users to propose, vote and reach consensus on solutions. This approach represents a relatively novel approach to deliberation in that it is both large-scale (e.g. in one exercise 31,115 votes were made on different proposals) and online. Unlike some of the more established deliberative techniques, this technique can be considered to fall in the category 'empower' as it aims to implement the decisions of the public. In another example, the Ada Lovelace Institute in collaboration with others ran a rapid online deliberation with 28 members of the public to explore the use of digital technologies to combat COVID-19 (Ada Lovelace Institute et al. 2020) (see Case study 10; Annex A). The process was conducted online using two online platforms. One interviewee noted that this may represent a particularly useful approach to conduct deliberation rapidly (i.e. over a period of 10 weeks rather than months), such as in crisis situations or a rapidly evolving topic (CS10-02).

Deliberative approaches provide informed and considered public opinion data, and typically involve the development of views over time, to get beyond initial, surface reactions (Ada Lovelace Institute et al. 2020) (INT01; INT06). They are particularly useful to explore topics in-depth (e.g. challenges, concerns, opportunities, ethical questions, future uses), consider nuances, and propose solutions (Involve 2018). As these processes typically take place over a relatively long period of time (i.e. several weeks to months) and require considerable resource to set up and facilitate, they are typically costly (Involve 2018). Newer online approaches, however, may represent a more cost-effective approach (Ada Lovelace Institute 2020).

Deliberative mapping is a technique to increase the diversity of framings

Deliberative mapping typically takes place during meetings and workshops and involves experts and members of the public using economic, social, ethical and scientific criteria to rate different policy options in situations where there is no obvious way forward (Involve 2018). Deliberative mapping represents a method that has been used in the context of energy and medical technologies. This is an 'upstream' method that aims to 'open up' the discussion to a broader diversity of

framings (i.e. decisions on how a topic is presented) and future pathways (Bellamy et al. 2016). In 2012, researchers conducted a deliberative mapping exercise to engage both experts and the public on geoengineering (Bellamy et al. 2016). The technique has also been applied to other emerging technologies such as xenotransplantation (Davies et al. 2003) and energy-related technologies (Burgess et al. 2004). This technique helps to broaden perspectives rather than focus on single solutions and is particularly useful when considering a complex policy issue where there is no obvious way forward (Involve 2018). This approach can be relatively costly since it involves considerable time and resources to organise several meetings and expert input (Involve 2018). Deliberative mapping can be considered to fall in the category 'collaborate' as it typically aims to co-create solutions with the public.

Social listening can be useful for exploring unfiltered views online and at scale

Social listening represents a relatively novel unstructured method of 'listening' that can enable the collection of unfiltered and 'natural' views (Calabrese et al. 2019; Keller et al. 2017) (see Case study 05; Annex A). Social media represents one such tool that can be used to understand and analyse public discussion around technological innovation (Calabrese et al. 2019; Keller et al. 2017). The method typically involves analysis of a set of comments from the public on online forums (e.g. social media such as Facebook or Twitter) either via text mining or content analysis. One study in the US used social listening to analyse Facebook comments to examine public opinion about the use of VR technology in healthcare (such as to help patients control pain, treat anxiety disorders, support physical rehabilitation, and to distract patients during treatment) (Keller et al. 2017). Another study conducted content analysis on Twitter to understand the public's perceptions surrounding CRISPR-mediated genome editing (Calabrese et al. 2019). This technique represents a low-cost method to gather large-scale views. This technique could be used to give policy makers a rapid 'snapshot' of data on public views at a given time on a particular topic, or to inform further public engagement. Indeed, one case study interviewee noted that it would be useful to combine social listening with more focused discussion (e.g. using participatory methods) with participants to probe some of the issues and opinions raised to ultimately explore the underlying views and concerns (CS05-01; see Case study 05; Annex A).

Experimental techniques have been used to enable the public to experience a new technology or a prototype

Newer experiential-based techniques include experimental methods and living labs. Experimental methods include the use of VR simulations and immersive experiences (Venverloo et al. 2020), and experimental interactive applications (Wouters et al. 2019) (see Case study 08; Annex A) that enable the public to experience a prototype of a technological innovation typically in a lab-based setting. For example, researchers in Australia conducted public engagement around facial analysis technology using an interactive application (Biometric Mirror), a demonstrator that

enabled people to experience the potential impacts of facial analysis technology (Wouters et al. 2019) (see Case study 08; Annex A). In another example, researchers conducted an immersive VR experiment to assess the public's perceptions of autonomous boats that are intended to be deployed in the Netherlands (Venverloo et al. 2020). In the UK, the GATEway Project invited members of the public to participate in live 'public trials' of connected and autonomous vehicles (CAVs) (see Case study 02; Annex A). The project enabled lay people to experience different types of CAVs in a real-world setting, using, for example, driverless pod shuttle services, automated valet parking, and automated delivery services. Living labs aim to collaborate with the public to co-design solutions.

These types of experiential techniques offer creative ways that allow people to place themselves in a future world and experiment with new behaviours or values (Ramos et al. 2019). By providing simulated real-world experiences, some of these techniques provide emotional and evocative experiences for the public, and can better support them to reflect on how technological innovation will impact their everyday lives (INT07). These types of experiential techniques deploy public engagement 'in the field' to enable participants to engage with realistic application scenarios (Wouters et al. 2019). They are useful to explore technological innovations that have hardware associated with them and can be experienced. These techniques are likely to require considerable time and resources to set up and run. It can be useful to supplement these types of methods with other engagement approaches (e.g. survey, interviews, consultation meeting or deliberative methods) to further probe and understand the public's perceptions and concerns around their experience (see Case studies 02, 08; Annex A).

Arts-based techniques represent an alternative, creative approach to engage a wider spectrum of the public

Arts-based methods span multiple approaches including the visual arts, performing arts, games, immersive art installations and other approaches (e.g. poetry and books). Together, these techniques represent a user-friendly and creative approach to engage a wider spectrum of the public on complex and controversial topics (Altamirano-Allende & Selin 2016; Engasser & Saunders 2018). Creative methods can elicit reflection from the public on complex technological innovations in a way that is fun (Altamirano-Allende & Selin 2016, Engasser & Saunders 2018). For example, in the US, a large-scale public engagement exercise aimed to explore the development of technology in the urban environment and invited participants to take photographs during a city tour and explore their findings during facilitated sessions (Altamirano-Allende & Selin 2016). Other approaches involve the use of participatory and immersive theatre which uses digital elements such as augmented reality and smartphone apps to engage and encourage feedback from the audience in real-time. For example, the Stage Your City project, led by the European Theatre Lab

(https://www.europeantheatrelab.eu/), used participatory and immersive theatre to engage the public in the future of cities (Engasser & Saunders 2018). These types of techniques aim to involve and collaborate with the public to co-create solutions.

Games represent a fun and engaging way to raise awareness of a topic or to involve the public in future scenarios. They have also been used to consult the public – for example, researchers in the US developed Moral Machine, an online platform and game for gathering the public's views on moral decisions made by machine intelligence, such as self-driving cars (Awad et al. 2018) (see Case study 01; Annex A). The aim was to crowdsource the public's views on how they would want autonomous vehicles to solve moral dilemmas in the context of unavoidable accidents. This was a large-scale and global exercise that gathered the views of nearly 40 million people. In another example, the Joint Research Centre developed a role-playing game, the Scenario Exploration System, a foresight gaming system developed for the application of futures thinking to policy making (Bontoux et al. 2016; Bontoux et al. 2020) (see Case study 04; Annex A). The role-playing game was used as part of the NANO2ALL project to engage the public and other stakeholders (e.g. policy makers) to reflect in-depth about future applications of nanotechnologies, and to ensure that research and innovation is more responsible in this area. Through playing the game, users gain an emotional connection to their assigned role in the game. This connection may thus facilitate constructive engagement with stakeholder groups who might not otherwise engage with complex issues. These types of techniques range across different categories, from informing and consulting the public to involving them and collaborating with them to develop solutions.

Participatory futures techniques refer to a range of approaches that can be considered a crossover between public engagement and the field of futures studies (Ramos et al. 2019).[10] They typically combine conventional futures methods (e.g. scenario-based methods) with games, immersive experiences, art and writing (Ramos et al. 2019). Participatory futures also include deliberative methods by combining workshops and discussion with creative or digital-enabled approaches. They have been used with the public to explore or shape potential futures (Ramos et al. 2019). As highlighted by one interviewee, the aim of participatory futures is to enable the public to experience the future in a tangible and meaningful manner by engaging people's emotions in a non-analytical manner (INT07). By moving away from a narrow view of the technological innovation in isolation, they can facilitate discussions around social and cultures issues and assumptions that surround a technological innovation. These types of approaches aim to involve and collaborate together with the public to develop solutions.

[10] The field of futures studies uses multiple methods to systematically explore emerging technological, social, economic and political trends; visions and scenarios of the future; and potential policy options.

To date, arts-based approaches have largely been used in the context of communicating information to enhance public understanding of science and technology. These approaches have also been used less in the context of technological innovation. Going forwards, they have the potential to be used to a greater extent in a participatory manner to have informed and inclusive discussions (Engasser & Saunders 2018). For example, new forms of theatre such as participatory and immersive theatre represents potential for participation and co-creation, which could help to improve the inclusiveness of policymaking (Engasser & Saunders 2018). Arts-based approaches are relatively costly to run as they require considerable skill to set up (as in the case of theatre) or the hiring of professional staff (e.g. a game designer).

A number of techniques have also been used 'downstream' to help inform acceptance and potential market adoption of technological innovation

Surveys (some with experimental components) have been used to analyse factors that could help inform decisions regarding market adoption of technologies

Surveys may be useful for informing market adoption of a new technological innovation as they permit the gathering of views at scale for the segmentation of consumers. This can help to identify different subgroups of the public and the factors that are likely to influence acceptability of a technological innovation. There are several examples of such use of surveys in the literature.

An online survey in Germany was used to analyse factors that might influence the likelihood of adoption of a new product, in this case a carbon derived foam mattress (using carbon capture and utilisation technology) (Arning et al. 2018). Numerous studies have also used surveys to determine acceptability of new transport technology, such as driverless and electric cars. In the US, an online survey incorporating a best-worst choice experiment was used to investigate participants' preferences about the most and least attractive features of driverless cars (Shabanpour et al. 2018). In Switzerland, a survey incorporating a method called 'phenomenology' aimed to identify users' perceptions of risks related to driverless cars, which can affect the efficiency and the perception of the service (Pfeiffer et al. 2020). A study in France used a novel survey tool, the AttrakDiff-2 questionnaire, a specific 'User eXperience (UX) method',[11] to identify factors that determine potential acceptability of electric cars enabling their uptake by consumers with a view to supporting smart city policies (Dupont et al. 2019). These types of technique aim to consult the public to gather information or views on different options to inform decision-making.

[11] Online survey that evaluates a potential product (e.g. software, consumer products) by gauging how the attractiveness of the product (e.g. in terms of usability, appearance) is experienced by potential users.

Living labs have been used to test prototypes with a view to informing market adoption

Living labs[12] are defined as interaction spaces in which multiple stakeholders from academia, industry, the public sector and the public come together to test prototypes of a technological innovation in a 'real-world' environment potentially to help inform the scaling up and roll-out of that technological innovation. They have been used in the context of autonomous vehicles and smart cities (Venverloo et al. 2020). For example, the GATEway Project, a partnership between industry and the public sector, conducted live trials of connected and autonomous vehicles over a three-year period in London (Smart Mobility Living Lab 2020) (see Case study 02; Annex A). These trials provided the public with the opportunity to experience (and provide feedback on) different types of connected and autonomous vehicles in a live, real-world setting. Alongside public trials, the GATEway Project also employed other engagement methods (see Case study 02; Annex A). In collaboration with the Royal College of Art, the project ran a series of public workshops. to understand people's perceptions towards CAVs and to explore how the design of CAVs might influence public attitudes towards them. In another example, researchers developed the 'Fab Living Lab' platform to enable multiple stakeholders to collaborate to co-design, prototype and test future products and services (Dupont et al. 2016). The platform has been used in a participatory process to rebuild an eco-neighbourhood in the city of Nancy in France.

Living labs give the public an opportunity to experience a new technological innovation or a prototype and inform its development in a safe and acceptable manner. These methods involve controlled experiments in a live setting, and so require considerable time and resources, and are therefore costly. They are particularly useful in the later stages of development of a technological innovation to help inform acceptability, with a view to scaling up the innovation. It is useful to supplement the live trial approach with other public engagement approaches (e.g. survey, interviews, consultation or deliberative methods) to further understand and probe the public's views, perceptions and concerns around their experience (see Case study 02; Annex A). These types of approaches aim to involve and collaborate with the public to develop solutions.

Distributed dialogue has been used to conduct public engagement with science and technology over time

Distributed dialogue consists of a decentralised approach to public engagement that aims to develop ongoing discussions around a topic, with multiple engagement events or processes happening in different geographical areas (Involve 2018). The Biotechnology and Biological Sciences Research Council (BBSRC) organised a

[12] Living labs do not have a universally accepted definition. They have been defined as environments and interaction spaces in which different stakeholders (e.g. the public, industry, government and academia) can come together to test and scale up new products or services (often in a real-world setting).

‘Bioenergy Distributed Dialogue’ to develop an ongoing discussion around bioenergy research with its research community and members of the public (BBSRC 2013). This technique falls into the category ‘involve’ as it aims to understand and take into account the views and concerns of the public.

This approach recognises that public engagement does not necessarily consist of a one-off discrete event but can happen on an ongoing basis. It acknowledges that the public’s views on emerging technology is not fixed, but typically evolves over time. Therefore, these approaches can be useful for both developing ongoing informed discussions and tracking public opinion over time. There are examples of innovative approaches that aim to collect and map public engagement over time in contexts outside of technological innovation (INT02). Box 3 provides an example of a longitudinal approach to public engagement in the context of energy and the net-zero transition (INT02). A long-term approach, however, may not be appropriate in the context of technological innovation due to the ‘pacing problem’.[13] It is usually acknowledged that engaging the public early on in the technological innovation pathway can help to mitigate potential negative unforeseen consequences.

Box 3: Example of a longitudinal approach to public engagement in energy and the net zero-transition

Mapping public engagement over time: energy and net-zero transition

Mapping approaches aim to analyse diverse forms of public engagement on an ongoing basis to form a more comprehensive evidence base of public views and concerns around emerging science and technology. In the UK, the Observatory for Societal Engagement with Energy aims to map diverse forms of societal engagement in energy and net-zero transitions (UKERC 2021). This approach aims to develop digital, systematic review and crowdsourcing methods to map societal engagement with energy and net-zero transitions across the whole UK energy system and around key emerging issues. While not explicitly used in the context of technological innovation, this represents a ‘whole-systems approach’ to generate evidence about different forms of public participation on an ongoing basis (UKERC 2021.

[13] The pacing problem refers to the gap between the development of a technology and social, political, ethical and regulatory developments.

Chapter 3: Existing evidence of impact in relation to different types of public engagement techniques on technological innovation

In this section, we present the key findings associated with Research Question 2.

Research Question 2: What evidence of impact exists in relation to different types of public engagement on technological innovation?

Box 4: Summary of evidence on impacts from public engagement techniques applied to technological innovation

Evidence on impacts from public engagement techniques

Most of the evidence on impacts of public engagement techniques is found in the grey literature, and relates to well-established methods, in particular, deliberative techniques (e.g. public dialogues).

- Various participatory methods, in particular deliberative techniques (e.g. public dialogues and citizens' juries) have informed aspects of regulation, ethics, policy and trust in relation to technological innovation. Experiential techniques have also been used to explore trust and confidence.

-Consultative (i.e. surveys) and participatory (i.e. living labs) techniques have been used to determine acceptance of technological innovation and test prototypes respectively, and the results could be used to inform market adoption (i.e. bringing existing technological innovation into the marketplace), but the evidence is lacking.

There is currently limited evidence on the impacts of some of the more innovative atypical approaches (e.g. games, experiential approaches and arts-based approaches).

Most of the evidence on the impacts of public engagement techniques is found in the grey literature, and relates to well-established methods, in particular deliberative methods such as public dialogues. For example, Sciencewise has conducted formal

evaluations of a number of their engagement processes, in line with their stated aim of supporting dialogue in areas where there is a clear commitment to the project findings informing policy development (Sciencewise 2021e). This evidence suggests that face-to-face deliberative methods have had an impact on aspects of policy, ethics, and regulation (Arning et al. 2018; CDEI 2020; RSA 2019; Sciencewise 2021e; Shabanpour et al. 2018). Table 2 (presented in the second sheet in the accompanying Excel file) presents an overview of the evidence presented in this report on the impacts in relation to different outcomes for the different public engagement techniques covered in the literature and case studies.

There is evidence that different public engagement techniques have had an impact on different outcomes associated with a technological innovation

Deliberative methods have informed aspects of regulation, alternatives to regulation, ethics and policy in relation to a technological innovation

Deliberative methods, such as public dialogues, future workshops and citizens' juries, have had an impact on informing aspects of policy, ethics, regulation and alternatives to regulation[14] concerning science and technology in a number of sectors, including health, transport, data science and general research and innovation policy (Centre for Public Impact 2019; Drew 2016; Hebáková et al. 2018; RSA 2019; Sciencewise 2021e). Overall, as noted by an interviewee, deliberative methods have been effective at providing robust perspectives from a broad sample of the public (INT01). They have typically been used to inform a specific decision or inform principles by which a decision can be taken (INT01).

Public dialogues have been used to inform alternatives to regulation such as ethical guidelines related to the development of technologies

In the UK, there are several recent instances of public dialogues being used to inform ethics concerning AI and data-driven technologies. For example, in 2019, the Centre for Data Ethics and Innovation, together with Sciencewise, ran a series of workshops across the UK in order to understand opinions and perspectives held by members of the public concerning online targeting (CDEI 2020). This informed recommendations to the UK government, focusing on the governance and

[14] Alternatives to regulation consist of two broad categories: (1) alternatives to regulation; and (2) alternative models of regulation. Alternatives to regulation include: no new intervention/do nothing; information and education; and incentive/market-based structures. Alternative models of regulation include: self-regulation; goals-based regulation; and co-regulation (National Audit Office 2014; OECD 2021). Examples of alternative models of regulation include: independent recommendation schemes; rating systems; and labelling (National Audit Office 2014). An example of information and education includes the Food Standards Agency 'Food Hygiene Rating Scheme' translates the results of food safety inspections into a food hygiene score that establishments can display (National Audit Office 2014). An example of a self-regulatory system currently operating within industry is the Lion Quality Mark Egg Assurance scheme, which ensures eggs have been produced to high standards of food safety (National Audit Office 2014).

implementation of online targeting practices (CDEI 2020). In 2019, the Royal Society for Arts, Manufactures and Commerce (RSA) and Deep Mind convened a citizens' jury to deliberate on the ethical use of AI, which fed into a toolkit on conducting public engagement around ethics (RSA 2019) (see Case study 03; Annex A). The Government Data Science Partnership ran a public dialogue on data science ethics, including deliberative workshops, which informed the principles for the Data Science Ethical Framework for the UK Government, which guides responsible data use in government and the wider public sector (Drew 2016).

Deliberative methods have been used to inform the design of consultations, policy and strategy

As highlighted by interviewees, in the UK and internationally, deliberative techniques (e.g. public dialogues and workshops) have been used to inform and develop policy and strategy around technological innovation, and research and innovation more generally (INT06). For example, in 2018, Genomics England ran a public dialogue with support from Sciencewise to explore public attitudes to mainstreaming genomic medicine into the NHS. The results of the exercise were provided to the 100,000 Genomes Project participants' panel, the Association of British Insurers and the Genomics England senior leadership team (Sciencewise 2021c). This is expected to have a number of future impacts on policy around the NHS Genomic Medicine Service, including informing revisions of the NHS Constitution, the National Genomics Healthcare Strategy 2019, and the Science and Technology Committee Inquiry into Commercial Genomic Testing (Sciencewise 2021c). In another example, a Sciencewise public dialogue on drones informed the Department for Transport's consultation on drones (Collier 2016). In the EU context, 'visioning' (a futures method to imagine the future) workshops were held throughout 2015 and 2016 with 1000 participants in 30 different European countries as part of the CIMULACT (Citizen and Multi-Actor Consultation on Horizon 2020) project (Hebáková et al. 2018) (see Case study 09; Annex A). The results informed the design and implementation of Horizon 2020 work programmes 2018-2020 and Framework Programme 9 (Hebáková et al. 2018). A number of stakeholders, including the public, developed their visions of sustainable and desirable futures and translated these into 23 suggestions for Horizon 2020 topics, along with policy recommendations.

Deliberative methods have been used to inform regulatory frameworks

Deliberative methods (including public dialogue and online deliberative methods) in the UK and internationally have informed the development of regulation. In the UK, the Human Fertilisation and Embryology Authority used a breadth of engagement tools including workshops, a public survey, open meetings and focus groups to determine public acceptability of mitochondrial replacement therapy Sheikh 2013). The outputs of the dialogue informed the HFEA's advice to the UK government on its regulatory framework, with the government including the safeguards raised by the dialogue into the resulting regulations (Sciencewise 2021d). In 2015, the government

of Taiwan used an online platform (called vTaiwan) to engage the public in large-scale deliberation on the regulation of Uber in Taiwan, which led to concrete recommendations to the government on its regulatory framework (Centre for Public Impact 2019) (see Case study 06; Annex A). The process resulted in the government adopting new regulations in line with the recommendations (Centre for Public Impact 2019).

Various participatory methods have been used to explore public trust and confidence

There is some evidence in the literature that suggests that various participatory approaches (both traditional face-to-face deliberative methods as well as more atypical approaches) have been used to explore public trust. For example, public dialogues have been used to explore trust and confidence in using a particular technological innovation, and have also helped to increase public trust and confidence in a technological innovation (Degeling et al. 2020; Food Standards Agency 2020; McCool 2019; Mil et al. 2019). The Food Standards Agency conducted a public dialogue on emerging food technologies (GM foods, nanotechnology in foods, food from cloned animals and cultured meat) and as part of the process investigated before and after views to determine if these had changed (i.e. were they negative, positive, neutral) as a result of the engagement (Food Standards Agency 2020). In another example, looking at public views of neural interfaces, public trust of the technological innovation significantly increased over the course of the workshops (Mil et al. 2019). Recently, the Ada Lovelace Institute ran an online deliberative process, which identified four requirements that would help to ensure public trust and buy-in regarding future COVID-19 technologies (i.e. provide a transparent evidence base; offer independent review of the technology; clarify data use, rights and responsibilities; and address the risks and needs of vulnerable groups) (Ada Lovelace Institute 2020) (see Case study 10; Annex A). These findings fed into the development of a checklist (based around the four requirements outlined above) aimed at government, policy makers and technology developers to help them with the future development, design and use of COVID-19 technologies, including contact tracing apps, to ensure public trust and buy-in (Ada Lovelace Institute 2020).

Similarly, citizens' juries have also helped to increased public trust in technological innovation. For example, community juries were conducted to consider the acceptability and legitimacy of using new technologies to enhance public health research and communicable disease surveillance, and the process of deliberation increased support for using big data analytics to enhance communicable disease surveillance, because participants were able to articulate their concerns and think through different conditions that would need to be met for them to accept its implementation (Degeling et al. 2020). In another example, the RSA ran a citizens' jury on automated decision-making systems. As a result of this engagement, interviewees who facilitated the exercise felt that the trust in automated decision-

making systems increased (INT02, INT03) (see Case study 03; Annex A). One study also suggested that communicating to the public through trusted channels and processes that are inclusive (e.g. news channels, social media, talk shows, and other frequently used information distribution platforms) could increase public trust in technological innovation (Sutcliffe et al. 2020).

There is one example of an atypical technique being used to explore trust. The exercise used Google Autodraw (an AI-enabled smartphone app) to examine users' perception of trust (Bitkina et al. 2020). The study aimed to examine and evaluate the acceptance of AI technology (i.e. the Google Autodraw app) by encouraging users to engage with the AI-based tool, and looked specifically at perceived characteristics such as trust, usability and utility related to this technology. The insights from the study could be used by AI developers to improve their product attractiveness amongst users and increase the trust in their technologies.

Atypical public engagement techniques and market outcomes lack evidence

Online surveys and living labs have been used to determine acceptance of technological innovation and could be used to inform market adoption

There is some evidence from the academic literature on how certain techniques, in particular surveys as well as social listening, could hypothetically be used to inform aspects of market adoption (i.e. bringing existing technological innovation into the market place) (Arning et al. 2018; Shabanpour et al. 2018). It remains, however, to be determined whether these forms of engagement have had an impact on outcomes. Surveys can help to gather clear-cut answers and can be helpful to understand public acceptance related to a set of clearly defined questions associated with technologies or a specific technology application. They can also be administered at scale and relatively quickly. For example, an online survey in Germany was used to analyse factors that might influence the likelihood of adoption of a carbon derived foam mattress (using carbon capture and utilisation technology) (Arning et al. 2018). In the US, an online survey of 1,253 participants incorporating a best-worst choice experiment, was used to investigate people's preferences about the most and least attractive features of driverless cars (Shabanpour et al. 2018). Researchers in France used a novel survey tool (the AttrakDiff-2 questionnaire, a specific UX method) to identify factors that determine how different groups perceive electric cars (Dupont et al. 2019). The aim was to inform factors influencing acceptability with a view to supporting smart city policies.

Social listening has been used to gather views from a large sample of the public on acceptance of technological innovation. For example, analysis of comments by users on social media platforms such as Facebook and Twitter have been used to

understand public discussions around new technological innovation such as the use of VR in healthcare (Keller et al. 2017) and CRISPR-mediated genome editing (Calabrese et al. 2019).These techniques could potentially offer useful insights for bringing emerging applications of technologies into the marketplace at scale. This, however, remains hypothetical at present, with examples cited in the literature having been used as 'proof-of-concepts' in research contexts.

There is currently limited evidence on the impacts of some of the more atypical approaches

There is currently limited evidence from the literature on the impacts of arts-based and experiential techniques on specific outcomes, which tend to represent 'proof-of-concept' approaches. The Moral Machine experiment, which used a game to crowdsource the public's views, resulted in global insights on moral preferences around AI. The experiment also helped to increase awareness of ethical considerations surrounding autonomous vehicles and machines in general (CS01-01; see Case study 01; Annex A). The findings could in future be used to inform global principles around machine ethics and inform considerations by car manufacturers and policy makers, but this has not happened to date (Awad et al. 2018). Biometric mirror (the facial analysis application) succeeded in raising awareness of this technological innovation amongst the public in an engaging and thought-provoking manner (Wouters et al. 2019) (see Case study 08; Annex A). The BioMetric Mirror application also continues to be exhibited in both art and science exhibitions globally, continuing to stimulate conversation around the use of this technological innovation and the potential ethical concerns. There is, however, no evidence that this approach has led to concrete outcomes as yet. The GATEway Project, in which the public was invited to take part in live trials of connected and autonomous vehicles produced wide-ranging insights on public perspectives towards connected and autonomous vehicles (see Case study 02; Annex A). There is, however, limited evidence that the GATEway Project has had a significant impact on actors within the CAV ecosystem or on regulatory frameworks relating to CAVs, though this could change as the CAV market matures.

Chapter 4: Evidence of whether the effectiveness of public engagement techniques around technological innovation has been formally assessed, and associated learnings

In this section, we present the key findings associated with Research Question 3.

Research Question 3: Has the effectiveness of the public engagement techniques around technological innovation been formally evaluated, and what, if any, were the learnings?

Box 5: Summary of evidence and key learnings on the effectiveness of public engagement techniques applied to technological innovation

Upstream and downstream public engagement techniques

Formal evaluations of deliberative techniques (e.g. public dialogues, futures workshops) offer some learnings on the effectiveness of these methods, namely:

- Deliberative techniques are effective at exploring in-depth questions related to technological innovation.

- Public dialogues are effective at producing robust perspectives from a representative sample of the public.

- Having a clear purpose is important to the success of public dialogues.

- Exploring complex questions around technology requires sufficient time and resources.

Anecdotal evidence from the academic literature reviewed offers some informal assessments of other types of public engagement techniques. Key learnings from these methods include:

- Surveys are a well-established method to gather perspectives on technological innovation from a sample of the public.

- Experiential techniques (e.g. immersive simulations using VR, experimental applications and living labs) give the public an opportunity to experience a technological innovation or test a prototype in 'real-world' scenarios.

- Arts-based and gamified techniques may provide fun and user-friendly experiences to effectively engage a more diverse public.

- Distributed dialogue may be effective at gathering long-term perspectives over time.

Few public engagement processes have been formally evaluated

Based on the evidence collected in this study, the effectiveness of public engagement techniques is rarely assessed formally, and evidence about many approaches is limited. Most of the evidence of the effectiveness of public engagement techniques is found in the grey literature (see, e.g. Involve 2018; Sciencewise 2021e) from a number of key organisations that are active in this area (Ada Lovelace Institute, Involve, The Royal Society and Sciencewise). These organisations have conducted some formal evaluations of some of the deliberative methods, which offer some learnings on the effectiveness of these methods. In addition to formal evaluations, anecdotal evidence from the academic literature reviewed offers some informal assessments of other types of public engagement techniques. These can offer some learnings concerning factors that can contribute to effectiveness and success. Table 3 (presented in the third sheet in the accompanying Excel file) presents an array of criteria (i.e. scale, resources of time and cost, inclusivity, user friendliness and flexibility) based on the evidence in the literature and case studies to highlight the implications of applying the different public engagement techniques covered in the literature and case studies.

Existing evaluations and assessments provide some key learnings related to specific techniques

Deliberative methods are effective at exploring in-depth questions related to technological innovation

The evidence from formal evaluations of the Sciencewise public dialogues (e.g. genomic medicines, mitochondrial replacement therapy and drones) (Collier 2016; Ipsos MORI 2019; Watermeyer & Rowe 2013),[15] and from the literature suggests that deliberative methods are an effective method of public engagement. By providing extensive information from a range of experts that engage with the public

[15] See the Sciencewise library for a full list of evaluations (Sciencewise 2021e)

as part of this process and ensuring conditions for reasonable and extended debate, deliberative methods elicit more considered judgements than other methods (Degeling et al. 2020; Involve 2018). In addition, one interviewee mentioned that by employing a formal recruitment process, they typically contain a representative sample of the wider public (INT01). As was also noted by several interviewees (INT01, INT02, INT05), deliberative methods are typically more costly than other methods due to the amount of time and resources that are needed to design and implement them (Involve 2018). Below are some key learnings on factors that contributed to effectiveness.

Exploring complex questions around a technological innovation requires sufficient time and resources

Successful examples of public dialogue facilitated extensive, open-ended discussions between the public and experts, providing the public with information and time to voice and discuss their concerns (Watermeyer & Rowe 2013). Evaluations of the Sciencewise public dialogue on mitochondrial replacement therapy (Watermeyer & Rowe 2013) and the public dialogue organised by the Royal Society on neural interfaces (Mil et al. 2019) concluded that participants were broadly given enough time. In contrast, an evaluation of a Sciencewise public dialogue on drones found that tight (externally imposed) programme timescales probably impacted on the quality of citizens' proposals (Collier 2016). This is important when discussing complex ethical and social aspects of new technologies and technological innovation (Sutcliffe et al. 2020). Researchers who conducted a community jury in Australia on the use of whole genome sequencing and Big Data analytics in public health concluded that allowing time for extended and open-ended dialogue provided the public with sufficient information and time to voice and discuss their concerns, which helped to increase understanding and acceptability (Degeling et al. 2020). In particular, the design of an engagement process that takes place over several rounds allows participants time to think beyond their initial responses (Mil et al. 2019). The design of a two-round process as part of the Royal Society dialogue on neural interfaces, with a two week gap between each round, allowed participants time to think beyond their initial responses, and typically this resulted in increased trust, acceptability and excitement around the potential benefits of the technological innovation (Mil et al. 2019) (INT04). In another example, the Department for Transport and Sciencewise conducted a public engagement process about connected and autonomous vehicles that incorporated a multi-round process and participants who were interviewed after the final workshop reflected that their perspectives changed over the course of the dialogue (McCool 2019). In a rapid online deliberation conducted by the Ada Lovelace Institute and others, having the engagement take place over multiple sessions enabled participants to reflect and embed learning between meetings (see Case study 10; Annex A).

One interviewee also noted that robust public dialogue requires enough time to gather the experts needed to adequately frame the dialogue, including to develop materials that are high-quality and understandable (INT01). For this reason, a number of interviewees highlighted that this type of engagement process tends to be relatively costly and requires significant investment of resources (INT01, INT02, INT05).

Having a clear purpose is important to the success of public dialogues

Successful examples of public dialogue had clarity on the outcome that was being influenced (e.g. policy, regulation), the value that the public could bring, and the parameters that could be influenced (Allan 2016). The public may be sceptical about public engagement if they lack clarity about how the engagement will influence the ultimate decision-making process (Salisbury & Nicholas 2005). The failure of public engagement can be due to lack of clarity about why the engagement is being held, which can lead to a lack of trust on the part of the public (Salisbury & Nicholas 2005). For example, an evaluation of the GM Nation debate on GM crops in 2003 found that the public engagement process suffered from poorly drafted objectives and lack of clarity on how the findings were used by government (Horlick-Jones et al. 2006).

Surveys are a well-established method to gather information on a technological innovation from a sample of the public

Surveys are useful for gathering information on a technological innovation from different samples of the public. Surveys represent a method that is cost-effective and potentially statistically representative of a population (Sample et al. 2020). Surveys are also versatile in that they can be used in a standalone manner, but are also useful when used as part of a larger engagement process, either at their inception to inform subsequent engagement processes using alternative methods (e.g. deliberative methods) or as a follow-up to probe specific themes more deeply (Participedia 2021a). For example, having conducted a survey on the use of facial recognition technology, the Ada Lovelace Institute is organising a Citizen Biometrics' Council to provide public perspectives and values on biometrics and to co-produce practical recommendations in collaboration with policy makers, regulators and other stakeholders (Participedia 2021b). Surveys can also permit the gathering of views at scale (with no limit on the number of questionnaire participants), which may be useful to segment consumers into subgroups and factors that influence them, to inform policy or the adoption of a new technology. Here, a number of studies have used surveys with experimental components that assess users' experiences of a technological innovation to examine and identify different groups of users, in terms of acceptability and preferences regarding electric cars (Dupont et al. 2019) and driverless cars (Shabanpour et al. 2018).

Experiential techniques give the public an opportunity to experience a technological innovation or prototype and can help to elicit insightful responses about potential ethical implications

By providing real or simulated real-world experiences, experiential methods (both experimental and living lab-based approaches) enable public engagement to be conducted 'in the field', allowing participants to engage with realistic application scenarios or real prototypes (see Case studies 02 and 08; Annex A). In the case of experimental approaches (that use lab-based prototypes of a technological innovation or VR simulations), the 'provocative' nature of the engagement can provide a thought-provoking and entertaining application which enable engagement from the public on complex ethical issues. For example, in the case of the Biometric Mirror interactive application, the researchers were able to demonstrate to the public the potential for facial analysis technology, enabling the public to form a reasoned opinion on this type of technological innovation before it reaches full maturity (see Case study 08; Annex A). The interactive nature of these approaches can enable the public to better recognise the potential impacts and challenges posed by a particular technological innovation. Living labs go a step further by enabling the public to test a technological innovation or prototype in a real-world setting. This method is particularly useful to obtain stakeholder input on a technological innovation. It is, however, useful to supplement these methods with other approaches (e.g. surveys, interviews, consultation or deliberative methods) to further probe and understand the public's perceptions and concerns.

Arts-based and gamified techniques may provide fun and user-friendly experiences

Arts-based and gamified techniques represent user-friendly and creative approaches to engage a wider section of the public on complex and controversial topics (Altamirano-Allende & Selin 2016; Engasser & Saunders 2018) (see case studies 01, 04; Annex A). For example, participatory theatre is a technique that can help to promote audience engagement and participation, particularly groups that may not participate in formal techniques, and could potentially make policymaking around technological innovation more inclusive (Engasser & Saunders 2018). Creative methods can elicit reflection from the public on complex technology in a way that is fun (Altamirano-Allende & Selin 2016; Engasser & Saunders 2018). Games represent a fun and engaging way to raise awareness of a topic or to involve the public in future scenarios. Similarly, participatory futures, which sometimes include gamified approaches, allow people to place themselves in a future world and experiment with new behaviours or values (Ramos et al. 2019). Therefore, together these techniques can better support the public to reflect on how technological innovation could impact their everyday lives (Wouters et al. 2019).

Distributed dialogue may be effective at gathering long-term perspectives on a technological innovation over time

Distributed dialogue can be used to engage with the public over time rather than through a one-off engagement event or exercise. The length of this varies but approaches could take place over several months to years. Similarly, distributed dialogue represents a deliberative technique that has been used to gather ongoing views of the public on science and technology, although costs for this technique may be slightly higher (BBSRC 2013). It has been recognised that public engagement does not have to be a discrete one-off process, and public perspectives are constantly changing over time (INT01). Therefore, as noted by two interviewees, longitudinal approaches could provide a more comprehensive evidence base and contribute to developing a sustained conversation with multiple publics (INT01, INT02). It is, however, unclear how the findings from these examples have been used, and so it remains to be determined how longitudinal approaches can help to inform science and technology policy in practice.

Chapter 5: Discussion and concluding remarks

Technologies are proliferating the world over with an array of applications that span many sectors and services. With the promise to improve lives, and the offer of abundant opportunities, technological innovation is regarded as a crucial enabler for the advancement of societies and economies at large. At the same time, however, as the world becomes progressively more dependent on technologies and their applications, such innovations also present an array of social, economic and regulatory challenges. How to harness the benefits of technological innovation while addressing the risks associated with these developments, is the subject of much discussion by governments, regulators, industry, academia and the general public. A key aspect of these discussions and debates is public engagement in the context of technologies and technological innovation. As we have seen in this report, such engagement is increasingly being recognised by stakeholders as a critical instrument to encourage transparency and openness, increase representativeness, and build trust in decision making and the technologies themselves. Integrating public engagement into regulatory processes could also reinforce confidence in regulatory bodies.

Against this backdrop, this study has collated and analysed evidence on the use and application of a range of public engagement techniques for technological innovation. Through a focussed review of the recent literature and ten detailed case studies, the study highlights various elements associated with the spectrum of public engagement techniques that are being used around technological innovation (see Table 1 in Chapter 2 for an overview of this evidence). The literature review provides an overview of the breadth of evidence associated with this topic, focussing on the different types of public engagement techniques that have been applied to technological innovation, their effectiveness and any lessons that might be learnt from applying the techniques. The case studies offer a deeper and more concrete understanding of how a selection of public engagement techniques have been used in specific contexts in the UK and globally.

While the findings from this study are primarily targeted at policy makers and regulators involved in technological innovation, we note that they may also be of interest to other stakeholders, such as funders of research and innovation, academia, industry and the general public.

In the sections below, we summarise the key findings from the research and offer some concluding reflections.

What does the evidence say about public engagement in the context of technological innovation?

A diverse spectrum of public engagement techniques could be used in the context of a technological innovation

Specifically, we observe that:

- Traditional approaches have been used most frequently. These include well-established methods such as surveys and public dialogues; and
- Atypical approaches have been used in some instances. These tend to be innovative, 'digital-enabled' techniques, using online tools or immersive VR technologies and simulations. There is evidence to suggest these approaches could hold potential to be used more in the future.
- Public engagement techniques have been applied to a diverse range of technologies (e.g. cognitive technologies (including AI and machine learning), data-driven technologies, medical/biotechnologies, green technologies, nanotechnologies).
- Public engagement techniques applied to technological innovation cover a range of stakeholder types (e.g. the general public, potential users or consumers of the technology, policy makers, regulators, industry and experts from various disciplines).

Different public engagement techniques have, to varying degrees, had an impact on selected outcomes

Overall, the evidence is strongest for traditional approaches (i.e. surveys, public dialogues), with less evidence around atypical techniques, which tend to consist of proof-of-concepts to demonstrate the feasibility of a particular approach.

- **The most reported outcome is to raise awareness and understanding of technological innovation.** Public engagement techniques in the categories 'communicate' and 'participate' were found to help in raising awareness and understanding of a particular technological innovation amongst the public. Techniques in the category 'consult' were less likely to have an impact on awareness, since these techniques typically aim to gather information from the public rather than inform.
- **There are several instances in which public engagement has had an impact on policy, regulation or ethics.** Participatory methods that include deliberation, in particular public dialogues, but also future workshops and citizens' juries, have had the most impact on informing aspects of policy (both

research but also around the use of technological innovation), regulation and informing ethical frameworks.

- **There are several instances in which public engagement has had an impact on aspects of trust.** Participatory methods that include deliberation, and in particular, public dialogues and citizens' juries, have been used to measure aspects of trust in a particular technological innovation, but have also directly led to increased trust as a result of the process. These approaches have been used to consider trust, both as standalone methods but also as part of wider engagement processes using other techniques, including some of the more atypical experiential approaches using simulations and immersive methods. This suggests that deliberative methods are particularly helpful to nurture public trust in technological innovation.
- **There are limited instances in which public engagement has helped inform market adoption of a technological innovation or contributed to change in business models** and this is the outcome which lacks the most evidence in the literature reviewed. Experiential techniques like living labs, hold potential to inform the scale up of a specific technological innovation, but currently lack evidence of impact.

The usefulness of public engagement techniques is contextual

The effectiveness of public engagement techniques with regard to technological innovation is often not formally assessed, and evidence about many approaches is limited. The evidence suggests that:

- **Consultative approaches such as surveys, interviews and focus groups are a well-established method to gather information from a selected sample of the public.** These approaches represent versatile tools that can be used as a standalone method or as part of a wider engagement process. For example, surveys can be used to inform a deliberative process or as a follow-up to experiential techniques to further probe the public's views following the experience.
- **Deliberative methods are particularly useful to explore complex topics in-depth, and when there is potential uncertainty or controversy.** These techniques provide the time and space for the public to voice and discuss their concerns and consider an issue from multiple angles. Therefore, these techniques have been particularly useful at earlier stages of technology development, to inform aspects of policy, regulation or ethical principles. In addition, by allowing time for debate and reflection, these techniques are particularly useful to explore questions of trust around a particular technology or technological innovation.

- **There are multiple innovative methods that could help to render public engagement more meaningful, and widen participation.** In particular, arts-based approaches and experiential techniques represent potentially effective and creative approaches to engage a wider spectrum of the public with complex and controversial issues. By making the technological innovation more tangible or stimulating creative thinking, these approaches can help the public to consider how a technological innovation could impact their lives.
- **The use of online and digital-enabled approaches (across the spectrum of engagement, involving communicate, consult and participate) represents a novel approach that can speed up the process of engagement, capture the views of the public at scale, and enhance the experience of engagement.** Consultative methods such as social listening and crowdsourcing platforms are effective methods of capturing views at scale. Combining traditional deliberative approaches with digital elements can help to speed up the process of engagement in cases where the public's opinion may need to be sought more quickly. The use of VR to create simulations and immersive environments can enable the public to experience a technological innovation and facilitate engagement.

Taking all the evidence together, several cross-cutting learnings emerge

The use of multiple techniques over the course of the public engagement process can help to engage different 'publics' appropriately

Engagement processes that employed multiple public engagement techniques tended to be effective. These approaches included the combination of deliberative techniques or experiential techniques (such as living labs) with consultative techniques (such as surveys or interviews). Combining multiple methods (e.g. formal techniques with innovative methods) makes the engagement more relevant to multiple groups and can therefore engage a range of different audiences at once, and potentially increases the robustness and relevance of the data that are collected. For example, the GATEway Project used multiple methods to engage a range of different audiences, from those with a stated interest in connected and autonomous vehicles to those with less awareness, who engaged spontaneously upon encountering the project (see Case study 02; Annex A). The GATEway Project showcases the way in which public trials may be combined with other engagement methods, including creative workshops, public exhibitions, sentiment mapping and observational studies, and a means by which multi-dimensional engagement approaches may be used to incorporate diverse perspectives and varied stakeholder groups. Similarly, after users had experienced the BioMetric Mirror application,

interviews were carried out with a subset of the users to enable discussion around how accurate users felt the technology was as well as ethical implications of the technological innovation (see Case study 08; Annex A).

Spreading public engagement over time allows for reflection and embedding of concepts

Engagement processes that took place over a longer period of time tended to be effective. CIMULACT (see Case study 09; Annex A) and AI 360 (see Case study 07; Annex A) are examples of extended public engagement processes that took place over several months and employed multiple methods and stages. Similarly, a number of public dialogues in the UK employed an extended approach over multiple sessions, which gave the public sufficient time to learn and embed information, and helped to increase public understanding and trust around a particular technological innovation (Cameron & Maguire 2017; Food Standards Agency 2020; Mil et al. 2019). In addition, conducting public engagement over a period of time, as in the case of public dialogues, ensures that considered public opinion is sought, and potentially helps to increase trust.

Having an impact on trust in a technological innovation requires time and considered debate to increase accountability and more systematic public engagement

There are several instances in which deliberative techniques, in particular public dialogues, have had an impact on trust. For example, participants reported increased trust as a result of the Royal Society dialogues on neural interfaces (Mil et al. 2019) and machine learning (Cameron & Maguire 2017), and the FSA engagement on food technologies (Food Standards Agency 2020). The RSA citizens' jury also led to increased trust in automated decision-making systems (see Case study 05; Annex A). A key feature of these processes that helped to increase trust is the multi-step process, which gave the participants time to reflect on their views and incorporate and embed learning between sessions. In the example of AI 360, there is also some evidence that the process may have helped to increase trust in AI systems (see Case study 07; Annex A). Although there is some evidence that certain types of public engagement techniques have helped to increase trust, it should be noted that trust is often not formally assessed as part of these methods but rather anecdotally captured as part of feedback from participants. It is also important to consider that there is evidence of short-term increases in trust, but it remains to be seen whether that increase is maintained over time. Therefore, in order to build public trust at a societal level, there is a need for more systematic public engagement processes involving actors and organisations across the ecosystem, with the power and influence to shape the course of the technology's future development (CS07-01).

A multi-stakeholder, collaborative approach to public engagement helps to develop informed and considered judgements

Examples of engagement that involved the public and other stakeholders, such as experts, tended to be effective. For example, the AI 360 workshop and citizen consultation demonstrate the possibility of a linked, two-step approach to public engagement, incorporating both expert opinion and broader public views (see Case study 07; Annex A). Similarly, a distinctive feature of deliberative mapping approaches is the public-specialist interaction through a joint workshop (Bellamy et al. 2016). The multiple examples of deliberative techniques typically involved experts who presented information to the public, including public dialogues (Ada Lovelace Institute 2020) and the RSA citizens' jury (RSA 2019). The JRC's Scenario Exploration System role-playing scenario game involved policy makers and industry representatives playing alongside members of the public, with participants reporting that they appreciated the 'realism' of the conversations (see Case study 04; Annex A). In these examples, the presence of experts helped to ground the discussion in what is feasible rather than 'fantasy', which can help to develop informed and considered judgements.

Using online and digital-enabled public engagement techniques can potentially increase the speed, scale, inclusivity and geographical coverage of engagement

Online and digital techniques can help to engage the public at scale and much faster than face-to-face or more traditional approaches. For example, online approaches (including surveys, crowdsourcing platforms and games) can collect the views of an unlimited number of participants (sometimes up to millions of participants) at much lower cost than traditional face-to-face surveys or interviews. For example, the Moral Machine website, which combines crowdsourcing with gamification was able to collect close to 40 million data points from 233 countries (see Case study 01; Annex A). It is also possible to combine digital tools with traditional approaches, as in the case of the rapid online deliberation run by the Ada Lovelace Institute, which ran a deliberative process in 10 weeks compared to several months (see Case study 10; Annex A). The online platform vTaiwan combines crowdsourcing and online deliberation and can support up to 100,000 comments from participants (see Case study 06; Annex A).

Digital-enabled public engagement techniques that employ user-friendly and engaging platforms could also help to widen participation. For example, social listening has used popular social media platforms such as Facebook and Twitter (see Case study 05; Annex A), Moral Machine featured an engaging game (see Case study 01; Annex A), and the vTaiwan platform uses elements of gamification (such as allowing users to vote) (see Case study 06; Annex A). In this way, these types of atypical techniques could help to widen participation to more groups of

people than more traditional, formal approaches, which many people may not choose to engage with. A caveat to digital approaches is that although they can serve to widen participation, they can also limit participation to those members of the public that have access to the internet, or those that are already comfortable working online (or those that have a social media account). Therefore, careful consideration needs to be made during recruitment or sampling.

Using some atypical techniques can potentially render public engagement more tangible and user-friendly and could also increase the diversity of participation

Multiple types of atypical techniques represent novel and effective methods to engage the public in a more tangible and user-friendly manner. A key aspect of atypical techniques, such as experiential and arts-based techniques, is their ability to enhance the relevance of the technological innovation to people's everyday lives, and thus render public engagement more tangible and meaningful to people. Arts-based approaches often use creative means to help the public consider the future of a technological innovation and can generate emotional and cognitive engagement, allowing participants to relate to a particular story and topic through personal experience. In doing so, these techniques can help to reach groups of people who may not be interested in a topic or participate in more formal engagement techniques. For example, participatory theatre is a technique that can help to promote audience engagement and participation on complex topics (e.g. AI). This type of technique could potentially make policymaking around technological innovation more inclusive. Similarly, experiential techniques, such as BioMetric Mirror (see Case study 08; Annex A), or VR simulations (Venverloo et al. 2020), that enable the public to experience a realistic version of a technological innovation can make engagement more thought-provoking and elicit emotional responses. Nonetheless, it can be useful to supplement experiential or arts-based methods with more formal methods (such as a survey, interview or dialogue) to capture the public's views following an experience.

Having an impact on outcomes such as regulation, policy and market adoption of a technological innovation typically requires buy-in and engagement with the right stakeholders

For public engagement to have an impact on a particular outcome, it is important to engage with and have buy-in from appropriate stakeholders. For example, while there is some evidence that the GATEway Project has shaped thinking among those organizations directly involved in the project), the evidence of wider impact on the CAV ecosystem is limited (see Case study 02; Annex A). In part, this may be attributed to the fact that CAVs remain at an early stage of development. At the same time, according to one interviewee, the project could also have done more to engage key audiences (such as policymaking audiences) with its findings (CS02-01;

see Case study 02; Annex A). In another example, the rapid online deliberation about online technologies to combat COVID-19 also showed that policy maker support and buy-in is important (see Case study 10; Annex A). The tight timeframes meant there was less time for policy makers to be involved. It was noted, however, that going forwards it would be important to have policy maker buy-in and engagement, and clarity on how the work will feed into the decision-making process (CS10-01; CS10-02; see Case study 10; Annex A).

It is important to build evaluation into public engagement processes to track impacts and outcomes over time

It is notable that there is relatively limited good-quality evidence that evaluates the effectiveness of public engagement processes available in the literature. In particular, most evaluations of public engagement processes typically only include short-term follow-up and many often look at intermediate rather than final outcomes (e.g. the production of a policy brief or recommendations rather than whether and how these have been taken up). For example, certain assessments do follow up to consider impacts on trust, but this is only carried out in the short-term. Whether or not increased trust persists over the long term is not clear.

It is also apparent from the literature that few categories of public engagement techniques have been evaluated. Most formal evaluations are focussed on deliberative methods. There are some informal assessments through participant feedback or researcher observations of some of the more atypical techniques.

It is important to incorporate appropriate evaluation into public engagement processes to be able to track the impact on participants engaged in the process, as well as the longer-term outcomes of the process. Improving the evidence base through longer-term follow-up would not just help us to understand whether existing public engagement is working, it would also enable us to better design public engagement that is effective at improving the range of different outcomes. There is also likely to be scope for learning across contexts and purposes, as well as across different evaluations themselves.

Final reflections

Table 2 and Table 3 (provided as two sheets in the accompanying Excel file) provide an overview of the evidence presented in the report and summarised above. Table 2 provides a summary of evidence on the effectiveness of the different public engagement techniques in relation to different outcomes. Table 3 provides a summary of evidence on the implications of applying the different public engagement techniques discussed in the report. The information in the tables is intended to help policy makers and regulators in identifying appropriate public engagement

techniques to use in specific contexts. To this effect, they provide a menu of different options to consider. Each technique has its own strengths and weaknesses that need to be factored in when selecting one or more public engagement techniques to implement. The most suitable technique to adopt is very much dependent on the specific contextual factors that relate to the technology in question and the geographical context, sector and intended audience(s) involved. It is also important to recognise that all technologies are not the same and therefore bring disparate challenges for engagement. Ultimately there is no 'one-size-fits all' public engagement technique that can be used in all circumstances. Indeed, as highlighted by the evidence presented in this report, public engagement processes that employ a combination of different techniques have tended to be more effective.

It should be noted that the tables are based on evidence cited in the literature reviewed and the case studies. The literature reviewed and technological innovation featured in the review were defined by the scope of the search strategy. As such, the tables are not intended as a definitive guide and cannot be used to draw predictable conclusions about which public engagement technique to use in which context.

Table 2: Overview of the evidence presented in this report on effectiveness of public engagement techniques (in the context of technological innovation) in relation to different outcomes

This table is presented in the second sheet in the accompanying Excel file.

Table 3: Overview of the evidence presented in this report on the potential implications of applying the different public engagement techniques in the context of technological innovation

This table is presented in the third sheet in the accompanying Excel file.

Annex A: Case studies illustrating the use of public engagement techniques in the context of technological innovation

In this section, we present the ten case studies we developed to demonstrate a deeper and more concrete understanding of a variety of public engagement techniques applied in different contexts. The ten case studies span different technological innovations, sectors, organisations, geographical contexts, and time periods. The case studies thus paint a richer and more diverse 'on the ground' picture associated with public engagement techniques for technological innovation. As noted in Annex C, the final selection of ten case studies was agreed in an iterative manner in collaboration with BRE by working through a long-list of potential case studies. The long-list was identified using the focussed literature review and suggestions we received from public engagement experts we consulted.

For each case study, we collated and analysed the following information based on interviews with stakeholders and a focussed review of a selection of articles connected to each case study:

- **What is the technological innovation?**

  This covers a brief description of the (new) technological innovation in the context of this example (i.e. in this country/region, sector and time period).

- **What was the purpose of the public engagement?**

  Why was the public engagement exercise carried out? For example, what were the issues with the technological innovation in the context of this example (i.e. insights into regulation, cultural, sector and time period influences)?

- **How was the public engagement carried out?**

  What public engagement method or approach was used (i.e. how are engagement techniques being applied)?

  Which bodies and stakeholders were involved in the engagement process?

- **How effective was the public engagement?**

  What effect did the engagement approach have on (for example): (a) design and implementation of regulatory frameworks for the technological innovation; (b) new business models in relation to technological innovation; and (c) public

trust and confidence in technological innovation and relevant regulatory frameworks?

Has effectiveness of the public engagement technique been formally assessed?

- **What 'lessons' can be learnt from this example?**

  Why was the engagement technique effective or not effective?

  What, if any, were the learnings from the assessment?

Below we present a list of the ten case studies. Each of these is presented in turn in the rest of this annex.

- **Case study 1 (CS01):** *Serious game to crowdsource the public's views on moral decisions faced by autonomous vehicles*
- **Case study 2 (CS02):** *Exploring public perceptions on autonomous vehicles using live public trials, workshops, sentiment mapping, and observational studies*
- **Case study 3 (CS03):** *Citizens' jury to understand public attitudes towards Ethical AI*
- **Case study 4 (CS04):** *Foresight gaming for multi-stakeholder dialogues to explore nanotechnology and Responsible Research and Innovation practices*
- **Case study 5 (CS05):** *Determining public perception on the use of virtual reality in healthcare through social listening*
- **Case study 6 (CS06):** *Using the vTaiwan platform to carry out a public debate on the regulation of Uber in Taiwan*
- **Case study 7 (CS07):** *Engaging expert and citizen perspectives on AI using a workshop and online platform*
- **Case study 8 (CS08):** *Engaging the public on facial analysis and automated decision-making through the use of BioMetric Mirror – an interactive application*
- **Case study 9 (CS09):** *Citizen and Multi-Actor Consultation on Horizon 2020 (CIMULACT) to formulate science and technology policy research agenda in the European Union*
- **Case study 10 (CS10):** *Rapid online deliberation to explore public attitudes to the use of COVID-19-related technologies*

A.1. Case study 1 (CS01): Serious game to crowdsource the public's views on moral decisions faced by autonomous vehicles

Case study title	Serious game to crowdsource the public's views on moral decisions faced by autonomous vehicles		
Concise summary of the case study	A key challenge around the development of autonomous vehicles lies in the moral dilemmas that they are likely to face (e.g. deciding who should live and who should die when faced with a potential collision with a pedestrian). To this end, researchers developed a website, Moral Machine, that used a 'serious game' with scenarios to crowdsource the public's views on moral decisions faced by autonomous vehicles. The aim was to generate a better understanding of the public's views about how autonomous vehicles should solve moral dilemmas, as well as to help raise awareness about this topic amongst the public. The platform was an effective large-scale data gathering exercise that collected 40 million decisions in ten languages from people in 233 countries and territories. It helped to show that a serious game is an effective method to crowdsource the public's views on a controversial topic. The exercise identified strong universal moral preferences. Although the findings have not led to any formal outcomes, they could in principle be used to contribute to developing global, socially acceptable principles for machine ethics that could feed into considerations by car manufacturers and policy makers.		
Technology area	**Sector / organisation**	**Public engagement techniques**	**Country and timescale**
Autonomous vehicles	Transport	Serious game	Global (233 countries)
What is the technological innovation?			
The technological innovation in this example consisted of autonomous vehicles. Autonomous vehicles are developing rapidly and are nearing market adoption (Shabanpour et al. 2018). They are expected to greatly transform mobility and the way transportation systems operate (Shabanpour et al. 2018). There are, however, a number of challenges associated with developing and adopting autonomous			

vehicles, including around liability, privacy, and security of this technology (Shabanpour et al. 2018).

What was the purpose of the public engagement?

A key challenge around the development of autonomous vehicles lies in the moral dilemmas that they are likely to face – e.g., deciding who should live and who should die when faced with a potential collision with a pedestrian (Awad et al. 2018). Car manufacturers and policy makers are currently struggling with these moral dilemmas, which require the development of ethical guidelines. It has been recognised that public acceptance of autonomous vehicles will require their understanding and acceptance of the ethical principles programmed into autonomous vehicles (Awad et al. 2018). This, in turn, requires a good understanding of the public's views about how autonomous vehicles should solve moral dilemmas.

Therefore, the goal of the public engagement exercise was to crowdsource the public's views on how they would want autonomous vehicles to solve moral dilemmas in the context of unavoidable accidents (Awad, Dsouza et al. 2018). The aim was to gather views, raise awareness and promote discussion about this topic amongst the public (CS01-01).

How was the public engagement carried out?

A team of researchers designed a website, Moral Machine, to collect data on the moral acceptability of decisions made by autonomous vehicles in situations of unavoidable accidents, in which they must decide who is spared and who is sacrificed (Awad et al. 2018). The website featured a 'serious game' that used images to show users randomly generated unavoidable accident scenarios (based on the 'trolley problem')[16] with two possible outcomes, depending on whether the autonomous vehicle swerves or stays on course (CS01-01). Users clicked on the outcome that they found preferable. After completing a session of 13 accident scenarios, participants could then complete a survey that collected, amongst other variables, demographic information such as gender, age, income, and education, as well as religious and political attitudes. Originally written in English, the website was progressively translated into nine languages (Arabic, Chinese, French, German, Japanese, Korean, Portuguese, Russian and Spanish) between November 2016 and March 2017 (Awad et al. 2018) (CS01-01). The country from which users accessed the website was geo-localized through the IP address of their computer or mobile device to conduct a geographical analysis of moral preferences.

[16] The trolley problem is a thought experiment in ethics involving ethical dilemmas of whether to sacrifice one person to save a larger number.

Data were collected between June 2016 and March 2017 (Awad et al. 2018). The researchers used various social media channels to promote the website on a monthly basis, and this also subsequently got picked up by other online channels (e.g. YouTube, Reddit), enabling the website to go viral (CS10-01). The platform aimed to collect the views of users all over the world with no account or log-in details needed to participate (CS01-01).

How effective was the public engagement?

The public engagement process has not been assessed formally but the authors offer some key observations.

One interviewee felt that the public engagement process helped to increase awareness amongst the public of ethical considerations surrounding autonomous vehicles and machines in general (CS01-01).

The website was effective at collecting large-scale views, gathering approximately 40 million decisions in ten languages from people in 233 countries and territories (Awad et al. 2018) (CS01-01). Based on these data, the researchers were able to identify three strong universal moral preferences: the preference for sparing human lives, the preference for sparing more lives, and the preference for sparing young lives. The authors also identified moral preferences that varied across countries such as preferences based on gender or social status (Awad et al. 2018). Although the findings have not led to any formal outcomes, the data collected could, in principle, be used to contribute to developing global, socially acceptable principles for machine ethics that could feed into considerations by car manufacturers and policy makers (CS01-01).

One interviewee reported that a key factor that contributed to the success of the engagement was the gamified aspect, which consisted of an engaging game (CS01-01). In addition, the researchers hired a professional designer to create an appealing website (CS01-01). The game itself consisted of relatively simple experimental scenarios that required a choice between two options (CS01-01).

Other important factors highlighted by an interviewee as contributing to the success of the platform included: the choice of an interesting and controversial topic that helped to garner interest and attention; the choice of using a website to make the game widely accessible to gather views at scale; and the translation into multiple languages, which widened outreach (CS01-01).

A key caveat of the approach used for the engagement was that the sample was self-selected, and not representative of the socio-demographics of each country (Awad et al. 2018) (CS01-01). The authors argue that the sample was likely to reflect a population that is interested in driverless car technology, and more likely to

participate in early adoption, which may have implications for the moral views collected, and hence potential users of this study such as car manufacturers and policy makers (Awad et al. 2018).

What 'lessons' can be learnt from this example?

A serious game can be used to gather large-scale views: This was an experimental process that demonstrated the feasibility of crowdsourcing the public's views on a controversial topic (CS01-01).

It is important to choose an interesting research question or topic: The project was costly and time-consuming, and required the hiring of a web designer (CS01-01). The researchers chose a controversial topic that garnered considerable attention from the public, which they considered made the use of resources worthwhile (CS01-01). Therefore, if choosing this type of engagement approach (i.e. to design a game from scratch), it would be worth considering the type of topic and question(s) carefully to ensure maximal interest.

It is important to be clear on the purpose of the engagement: The purpose should be to help to determine how best to design the engagement. For example, is it for scientific data collection, engagement, or both? If the purpose is solely engagement, then the website could be made simpler. In contrast, if data collection is more important, then this might not be the best tool (CS01-01).

It is important to decide on the reach of the engagement: This tool was effective at gathering large-scale global views. If the goal of the engagement is to understand more local views, then other channels and techniques of engagement might be more appropriate (CS01-01). Here, a caveat to note is that if participants are self-selecting then this will drive the sample.

A.2. Case study 2 (CS02): Exploring public perceptions on autonomous vehicles using live public trials, workshops, sentiment mapping, and observational studies

Case study title	Exploring public perceptions on autonomous vehicles using live public trials		
Concise summary of the case study	Led by Transport Laboratory London (TRL), the GATEway (Greenwich Automated Transport Environment) project employed a range of public engagement methods to explore public perceptions towards connected and autonomous vehicles (CAVs) in order to understand societal factors affecting the adoption of CAVs. The GATEway Project demonstrates the potential of live public trials as a method for public engagement, while also highlighting the role of diverse engagement techniques in engaging different public audiences. Insights from the GATEway have shaped the work of certain actors, e.g. the vehicle design courses of the Royal College of Art. Engagement techniques used by the project have also been incorporated into market-oriented test-bed environments, as exemplified by the London Smart Mobility Living Lab (SMLL).		
Technology area	**Sector / organisation**	**Public engagement techniques**	**Country and timescale**
Connected and autonomous vehicles (CAVs)	Transport	Live trials, creative workshops, exhibitions, sentiment mapping, observational studies	United Kingdom, 2015 – 2018
What is the technological innovation?			
The GATEway Project responded to the rapid technological development of CAVs and the potential for this to bring significant changes to the future of transport globally (TRLpublish 2018a). Specifically, the GATEway Project focussed on three types of CAV: driverless pods, self-parking (auto-valet) services, and automated delivery services (TRLpublish 2018a). In its final report, the GATEway Project identified six key drivers of growth in the use of CAVs: (1) the digital revolution, including smart devices, the Internet of Things (IoT), wireless connectivity, AI and big data; (2) societal trends, including increasing moves towards shared ownership; (3) air quality challenges; (4) safety and welfare; (5) capacity limits, including urban		

population growth and congestion; and (6) growing investment in CAVs (TRLpublish 2018a).

What was the purpose of the public engagement?

Broadly, the GATEway Project aimed to 'demonstrate the safe and efficient integration of sophisticated automated transport systems within complex real-world smart city environments' (TRLpublish 2018a). As part of this, a key aim of the project was to explore public perceptions of CAVs in order to understand societal factors affecting adoption of automated vehicles (TRLpublish 2018a).[17] The insights gained through the project were intended to inform the decisions made by actors from different sectors of the CAV ecosystem, including insurance, vehicle design, connectivity and urban planning (TRLpublish 2018a). Partners in the project included Royal Sun Alliance (RSA), O2 Telefónica, the Royal Borough of Greenwich and DG Cities (TRLpublish 2018a).

How was the public engagement carried out?

The key method used by the project was a series of live 'public trials' of CAVs. These public trials provided members of the general public the opportunity to experience (and provide feedback on) different types of CAV in a live, real-world setting. The trials included:

A driverless pod shuttle service operated on the Thames Path of the Greenwich Peninsula in London, designed to provide a linking service between transport hubs. Members of the public were invited to use the service either on a pre-booked or 'walk-up' basis and provide feedback through qualitative surveys (TRLpublish 2018a). Around 320 members of public participated in this trial, with 118 completing the survey (TRLpublish 2018a).[18]

An automated valet parking trial in which 35 participants (including participants with additional mobility needs) gained direct experience of the automated parking functionality of a CAV. The trial included pre-trial interviews, and post-trial

[17] More broadly, the GATEway Project had six key objectives: (1) to understand the technical, cultural, societal and legal challenges and barriers to the implementation and adoption of automated vehicles; (2) to inspire over 35,000 individuals engaged with automated transport technology; (3) to generate valuable, exploitable knowledge of the systems required for the effective and safe validation, deployment and integration of automated transport in a Smart City 'real-world' environment; (4) to create the first fully validated test bed in the heart of London, the Smart Mobility Living Lab: London; (5) to position UK PLC at the forefront of the global CAV marketplace; and (6) to demonstrate the safe and efficient integration of sophisticated automated transport systems into complex real-world Smart City environments (TRLpublish 2018a).

[18] As part of this trial, 33 participants completed interviews before and after their experience of using the service (Fernández Medina & Jenkins 2017).

workshops and questionnaires to explore the impact of the experience on user attitudes (Harrow 2018; TRLpublish 2018a).

An automated delivery service trial, undertaken in collaboration with Ocado, in which 108 residents within the Royal Borough of Greenwich received grocery deliveries via CAV 'pods'.19 A survey captured participants' immediate perceptions on the experience (Tong 2017; TRLpublish 2018a).

Alongside public trials, the GATEway Project also employed other engagement methods. In collaboration with the Royal College of Art (RCA), the project ran a series of public workshops to understand people's perceptions towards CAVs and to explore how the design of CAVs might influence public attitudes towards them (Phillips & Roberts 2016; TRLpublish 2018a). Designers from the RCA used insights gained through the workshops to create a series of images of CAVs, which were then displayed in London's Transport Museum for six weeks, reaching over 30,000 visitors (TRLpublish 2018a).

Another dimension of the GATEway Project was 'sentiment mapping' (TRLpublish 2018a; TRLpublish 2018b). Here, focusing on the driverless shuttle service trial, the project gathered and analysed data on perceptions towards CAVs before, during and after the trial. Sentiment mapping was conducted by encouraging people to visit sentiment mapping websites where they could provide their opinions and their location (TRLpublish 2018b). Capturing location data enabled the mapping of where positive, negative or neutral comments had been received. For the trial-based sentiment mapping, this enabled analysis of the way in which comments differed at different points on the trial route (TRLpublish 2018b). During the trial, the websites were used to capture views of both users and onlookers on the GATEway CAVs (TRLpublish 2018a).[20] In total, there were over 21,279 visits to the sentiment mapping websites and 746 comments left by participants (TRLpublish 2018b).

Finally, the GATEway Project also conducted observational studies on how pedestrians and cyclists behaved around the automated vehicles, again focussing on the driverless shuttle service (TRLpublish 2018a).

How effective was the public engagement?

The principal aim of the public engagement undertaken by the GATEway Project was to produce new social knowledge regarding public attitudes towards CAVs

[19] While the pods were driverless, a safety driver was present and could take control at any point if necessary.

[20] A sentiment mapping website was also designed to accompany the RCA exhibition at the Transport Museum https://www.rca.ac.uk/news-and-events/news/rca-explores-sentiment-mapping-travel-management/

(TRLpublish 2018a) (CS02-01). In this respect, the project was both effective and also exemplary in its use of innovative engagement methods to explore public views.

Firstly, the GATEway Project demonstrated the way in which live public trials can be used as an effective technique for public engagement with new technologies. The project's live trials not only reached a wide audience (comprised both of those who pre-registered to participate and those who encountered the trials spontaneously), but also provided opportunities to explore the impact of first-hand user experience on public attitudes towards the technology (Fernández Medina & Jenkins 2017) (CS02-01, CS02-02). The conduct of live public trials also enabled the project to consider public attitudes towards CAVs from different perspectives. While the trials themselves focused on user experience, observational studies conducted in parallel examined the views of pedestrians and cyclists towards CAVs (CS02-01, CS02-02).

Secondly, and relatedly, the GATEway Project also demonstrated the effectiveness of a combined, mixed-method approach – including live public trials, workshops, exhibitions, surveys and sentiment mapping – in order to reach a wide range of public audiences (CS02-01, CS02-02). While further helping to ensure the participation of the more general public (as well as proactive CAV enthusiasts), the range of engagement methods also helped to ensure the coverage of different demographic groups, including those with additional mobility needs (CS02-01).

In certain cases, insights produced by the GATEway Project have shaped the work of organisations involved in the development of CAVs. The RCA, for example, has incorporated learnings from the project into its courses on autonomous vehicle design (CS02-01). More broadly, however, there is limited evidence that the results of the GATEway have had a significant impact on actors within the CAV ecosystem or on the regulatory frameworks surrounding CAVs, though this could change as the CAV market matures (CS02-01 CS02-02). According to one interviewee, one challenge faced by the project has been to get its work in front of the right audiences (both in terms of technology development and policymaking audiences), something that a greater emphasis on marketing and communicating may have helped to address (CS02-01).

While evidence that the GATEway's public engagement has impacted directly upon the CAV ecosystem is fairly limited, the project has had impact in other ways. Most notably, public engagement techniques used within the GATEway Project have subsequently been incorporated into the London Smart Mobility Living Lab (SMLL). Building on the GATEway, and based in the Royal Borough of Greenwich, the SMLL is a comprehensive testbed environment enabling manufacturers and operators to develop new CAV systems in a complex, real-world environment (TRLpublish 2018a).[21] CAV testing performed within the SMLL, including the recent trial of the

[21] The SMLL is based in the Royal Borough of Greenwich and Queen Elizabeth Olympic Park.

UK's first open-architecture vehicle, has followed the GATEway in using live public trials and user surveys (Smart Mobility Living Lab: London 2020). Other SMLL trials, while not using live public trials, have accompanied vehicle testing with detailed analysis of customer perspectives towards CAVs through workshops and surveys (MERGE Greenwich 2018). While SMLL CAV trials have not necessarily had the same explicit focus on public engagement as the GATEway Project, nor employed the same range of engagement techniques, the use of the GATEway's methods within the SMLL demonstrates the way in which the GATEway's public engagement has been taken up by actors at the leading edge of the CAV development process (CS02-02).

What 'lessons' can be learnt from this example?

Live public trials provide an effective technique for obtaining stakeholder perspectives on a new technological innovation: In the context of the GATEway, live trials helped to engage a wide audience, including those who engaged upon encountering the trial spontaneously. The live trials also provided opportunities for exploring the impact of first-hand experience of a technology and for exploring public attitudes from different perspectives (CS02-01, CS02-02).

A multi-dimensional approach can help to further ensure that public engagement covers different public audiences: The combination of public trials, creative workshops, public exhibitions and sentiment mapping helped to ensure the participation of diverse audiences, including from across different demographic groups and among those with additional mobility needs (CS02-01, CS02-02).

To help ensure that the insights produced by public engagement reach the right audiences, effective marketing and communications strategies are needed: While findings of the GATEway have shaped the work of certain actors with the CAV ecosystem, according to one interviewee, the project could also have done more to engage policymaking audiences with its findings(CS02-01). More effective marketing and communication may have increased the opportunity for the project to inform policy and regulatory frameworks surrounding CAVs, for example those relating to vehicle design (CS02-01)

Innovation testbeds provide one way in which public engagement techniques can be incorporated into a technology development process: Public engagement techniques used by the GATEway have, in some cases, been incorporated into CAV trials conducted within the SMLL (MERGE Greenwich 2018; Smart Mobility Living Lab: London 2020) (CS02-02).

A.3. Case study 3 (CS03): Citizens' jury to understand public attitudes towards Ethical AI

Case study title	Citizens' jury to understand public attitudes towards Ethical AI		
Concise summary of the case study	The ethical use of AI has become increasingly important in automated decision systems that use AI to inform or make decisions on which actions to pursue. The Royal Society for the encouragement of Arts, Manufactures and Commerce (RSA) and Deep Mind partnered on a deliberative engagement exercise using a citizen jury for public engagement on the impacts of ethical AI. The project was not formally assessed, but anecdotal evidence from interviews and desk research indicates that participating citizens felt better informed and had a better understanding of automated decision systems following the project. Interviewees indicated that the public engagement format also illustrated the importance of using public engagement techniques for other organisations, although this impact was not cited in relevant documents.		
Technology area	**Sector / organisation**	**Public engagement techniques**	**Country and timescale**
Artificial Intelligence	N/A	Citizen jury	United Kingdom, 2018
What is the technological innovation?			
This case study addresses Ethical AI in the context of automated decision systems. In this context: Ethical AI is defined as: "*AI that is designed and implemented based on the public's values, as articulated through a deliberative and inclusive dialogue between experts and citizens*" (Balaram et al. 2018, 9). Automated decision systems (ADS), or computer systems, inform or make decisions on which actions to pursue related to an individual or business (Balaram et al. 2018). ADS do not have to use AI, but increasingly do so to improve the accuracy of predictions (RSA 2019). For example, ADS have been used by the private sector to grant loans, and the public sector is exploring the use of ADS for planning and managing new infrastructure, to reduce tax fraud, and rating the performance of schools and hospitals (RSA 2019). AI refers to the field of computer science that focusses on			

solving cognitive problems that are commonly associated with human intelligence (Balaram et al. 2018).

What was the purpose of the public engagement?

The RSA convened a citizen's jury in 2018 to enter into a deliberative dialogue to understand the ethical use and ethical questions of AI to help make decisions for DeepMind, and how other companies, organisations and public institutions should respond to ethical questions on AI.[22] The project explored the use of AI systems based on the values of the public, examining how citizens understand AI in its contemporary uses, and how ethical reasoning is applied to its potential uses in the delivery of both private and public services (Balaram et al. 2018) (CS03-02, CS03-03).

How was the public engagement carried out?

The public engagement exercise was carried out by the RSA in three stages in April, May, June and October of 2018. These stages were: a survey, a citizen jury, and two workshops. Details of each stage are as follows:

Survey: RSA partnered with YouGov to carry out an online survey of 2,000 people in April 2018.23 The survey questions focussed on the public's familiarity with, concern and support for, AI and ADS (Balaram et al. 2018).

Citizen jury: The RSA brought together a group of 25-29[24] people from across England and Wales to understand people's views about concrete uses of AI for automated decision-making (Balaram et al. 2018; RSA, n.d.) (CS03-01).[25,26] This number was slightly higher than citizen juries that normally comprise between 12-24 people (CS03-01). The jury consisted of three sessions that took place over four days in total. Session 1 took place over one long weekend (Friday evening until Sunday); sessions 2 and 3 took place over two Saturdays. The same participants came together on different occasions. The first two sessions were held one month apart, and the final session took place four months later. This was in line with best practice for juries that normally last between two to seven days (Balaram et al. 2018):

[22] DeepMind is an AI-based company and research laboratory in the UK that was funded in 2010 and acquired by Google in 2014. DeepMind provides research and builds artificial intelligence systems that are safe and aim to 'solve intelligence and advance scientific discovery for all' (DeepMind 2021a).
[23] The survey was carried out online and took place between 16 and 17 April 2018 and was carried out with 2,074 adults of different ages, genders, and ethnicities (RSA 2019) (CS-03-02).
[24] The range reflects the different number of participants at the events held in four sessions.
[25] The participants included a representative range of ages, abilities, ethnicities and were of different socio-economic backgrounds. The participants were also split equally in terms of attitudes towards technology.
[26] 12 and 13 May, 2 June, and 13 October 2018.

- On the first day of the first session, the RSA focussed on building trust with participants and encouraged them to participate in a speed dating exercise with experts to ask questions (CS03-02).
- The second day of the first session focussed on case studies and the specific application of ADS in different fields (CS03-02).
- The third day and second session focussed on participants creating conditions and recommendations for ADS that was presented to a panel consisting of stakeholders from the Citizen Advice Bureau, other think tanks, TechUK and academia (CS03-02).
- The third and final session focussed on celebrating jurors' contributions and networking between jurors and experts (CS03-02).

The deliberations consisted of citizens spending time to learn about the problem of ethical AI and discuss it from different perspectives, with input from 24 expert witnesses who explained key information and answered questions from the jurors (Balaram et al. 2018).[27] One interviewee noted that it was in line with best practice for citizens' juries as it had a single question, experts were present, and there was an opportunity to explore citizens' views (CS03-01). The deliberations in the jury were summarised by the RSA after each session and fed back to the participating citizens for agreement before a new session started (CS03-01). The final project report was based upon summaries that were agreed by the participating citizens and were presented to a panel of relevant stakeholders, as well as at a final networking event (CSO3-01, CS03-02).[28] The jury was led by a professional facilitator and supported by RSA staff (Balaram et al. 2018) (CS03-02).

Workshops: Two workshops were held with Black, Asian and Minority Ethnic people, mainly men, who were considered to be more likely to be affected by the issues under discussion, such as being disproportionately affected by facial recognition technology in policing (Balaram et al. 2018).

How effective was the public engagement?

The public engagement technique was not formally assessed. Feedback from participants, however, and those who facilitated the jury suggested that the process was effective because (RSA 2019):

- Anecdotal evidence indicates that participating citizens felt better informed and had a better understanding of ADS after the jury (CS03-01). As a result of the engagement, interviewees who facilitated the exercise felt that the

[27] This included a presentation of case studies on the use of ADS in the recruitment, healthcare and criminal justice sectors.
[28] Including representatives from Ada Lovelace, the Citizens Advice Bureau, DeepMind, the Information Commissioner's Authority and TechUK, and representatives from academia (CS-03-02).

trust in ADS increased (CS03-02, CS03-03). One interviewee, however, said that there would not be a significant level of distrust or trust for ADS after the process due to a lack of awareness about ADS amongst participants prior to the process (CS03-01).

- Participating citizens valued the variety of inputs from different stakeholders who participated in the process, including citizens and experts (RSA 2019).
- Participating citizens said that they had developed their thoughts and that their opinions had converged following the process (RSA 2019)
- Participants learnt quickly from the process, and scaled up and aligned their responses to be reflective of those who are experts in ADS, which, according to facilitators, reflected their ability to understand the issues under discussion (CS03-02, CS03-03)

After the engagement, the participating citizens devised a list of questions they would recommend their peers to ask about ADS. The RSA created a toolkit[29] for institutions and citizens detailing the conditions that participants would like to see built-in to the automated decision-making process, which captured conditions and considerations at the design stage, creation stage, and the application stage of ADS (RSA 2019).[30] According to the facilitators, the jury illustrated the importance of using public engagement to other organisations, such as The Alan Turing Institute, DeepMind, the Information Commissioner's Office and the National Health Service (CS03-02, CS03-03). This is reflected in: (1) the subsequent work of DeepMind's ethics and society team, which is presented on DeepMind's website (DeepMind 2021b); (2) the inspiration of a project between the RSA and the National Health Service on patient AI (Singh 2019); and (3) the adoption of public engagement approaches for explaining AI projects by both The Alan Turing Institute and the Information Commissioner's Office, so attended the final event (ICO & The Alan Turing Institute 2021). It is noted, however, that the RSA's citizen jury has not yet been cited in relevant documents.

What 'lessons' can be learnt from this example?

The RSA summarised several key lessons and benefits and challenges related to their use of citizen juries for technological innovation (RSA 2019):

Citizen juries are not necessarily the best way to learn from minority groups: as their unique experiences can be silenced in group discussions (RSA 2019).

[29] See https://www.thersa.org/reports/democratising-decisions-technology-toolkit.
[30] These included: (1) 'What impact will ADS have on broader social structures and interactions?'; (2) 'Is it safe in way my details are being shared?'; (3) 'Will I know what ADS is being used?'; (4) 'How, or is it regulated?'; (5) 'How can I can challenge it?'; and (6) 'How does it benefit me?'

Jurors should receive information of a high quality that is unbiased: A way to circumvent bias is to use an independent facilitator and advisory group in the design and facilitation of the exercise, and to provide information to jurors from expert witnesses (RSA 2019).

Consider the technology design stage at which a public engagement exercise is most useful, the complexities of the questions being asked and how the results can best be incorporated into improving an existing system: Results should be acknowledged and acted upon to engender public trust (RSA 2019).

A shorter timeline can be conducive to facilitate on-going engagement: The first session took place from Friday to Sunday in May 2018 to make jurors comfortable with the process, build trust with the delivery team and other jurors, provide concentrated time to hear from experts, and facilitate a proper understanding of the complexity of ADS. The later sessions, however, took place several months later (in June and October), which might have influenced the levels of engagement of participants (RSA 2019).

Re-consider the facilitation team's role in synthesising the discussion: In the future, participating citizens should be empowered to write their own summaries to ensure ownership of the outcomes of the process (RSA 2019).

Deliberative methods are resource intensive and require 'in-depth, long-term planning, integration and facilitation' (p.51): RSA argues that the deliberative dialogue was helpful in eliciting recommendations and insights that the jurors came up with collectively, but that these methods should be carefully planned and integrated before commencing the process.

Decide on the public engagement technique based on the problem and perspectives that should be involved: Fully develop and understand the public engagement technique before engaging with it to avoid the risk of a lack of understanding of what the process fully involves (CS03-01).[31]

Build in an evaluation of the public engagement exercise: One interviewee said it is important to build in a proper evaluation to track the impact of the citizen jury on a change in practice for participants and commissioners (CS03-01).

Make the focus on the public engagement exercise specific: Two interviewees said a citizen jury should focus on specific issues, as it is difficult to reach consensus when looking at several sectors at once (CS03-02, CS03-03).

[31] For instance, there were more participants in the citizen jury convened by the RSA than a citizen jury normally would have (INT01).

A.4. Case study 4 (CS04): Foresight gaming for multi-stakeholder dialogues to explore nanotechnology and Responsible Research and Innovation practices

Case study title	The European Commission (EC) Joint Research Centre's (JRC) Scenario Exploration System (SES) in NANO2ALL's multi-stakeholder dialogues for Responsible Research and Innovation (RRI) practices in nanotechnology.		
Concise summary of the case study	RRI is important to incorporate societal needs and values, and uses deliberative and transparent approaches to develop ethically acceptable and socially desirable products. The project used the JRC game, the SES, in national multi-stakeholder dialogues to explore nanotechnology and RRI practices. The project ensured that participants could comfortably express their opinion and resulted in the uptake of public engagement techniques at the science centres that ran the exercise. In the participatory process, recommendations suggested that to open up the nanotechnology research and innovation system (which is important to ensure research considers society's needs and values), decision-makers should aim to create genuine interest and motivation for RRI rather than enforcement by top-down regulation, especially as regards the private sector. It also provided recommendations and directions for the European Commission and other actors on the importance of public engagement in nanotechnology projects, although no evidence was found of the uptake of these recommendations in practice.		
Technology area	**Sector / organisation**	**Public engagement techniques**	**Country and timescale**
Nanotechnology	Medicine	Serious games: scenarios	Belgium, France, Israel, Italy, Poland, Spain, Sweden in 2017-2018
What is the technological innovation?			
The project focussed on nanotechnology and the establishment of RRI practices within this field. The focus was on the application of nanotechnology in			

nanomedicine, nanotextiles, and nano-enabled brain computer interfaces (Kupper & Schuijer 2018a; Kupper & Schuijer 2018b). RRI is based on the general idea that research and innovation should incorporate societal needs and values, and requires deliberative and transparent processes with a focus on the collective responsibility of research, innovators and societal actors in developing (ethically) acceptable and socially desirable products (Kupper & Schuijer 2016).

What was the purpose of the public engagement?

The purpose of the NANO2ALL project was to make the public and other stakeholders reflect in depth about future applications of nanotechnologies and to ensure that research and innovation is more responsible in this area (Bontoux et al. 2020). The focus on RRI was through the transparent co-production of knowledge using inclusive and participatory approaches (Kupper & Schuijer 2018a).

How was the public engagement carried out?

The project was led by Sociedade Portuguesa de Inovação and funded by the EC. NANO2ALL consisted of a three-phase dialogue approach. The first dialogue phase consisted of a set of national citizen dialogues in six countries (France, Israel, Italy, Poland, Spain and Sweden). The second phase consisted of a set of national multi stakeholder dialogues in the same six countries. The third phase consisted of the organization of a final European stakeholder dialogue event in Brussels. This resulted in a total of 13 dialogue events (Kupper & Schuijer 2018b).[32,33] The output of the citizen dialogues fed into the multi-stakeholder dialogues, and the output of the multi-stakeholder dialogues fed into the final European stakeholder dialogue.

Part of the multi-stakeholder dialogue consisted of using the JRC's SES, a foresight gaming system developed for the application of futures thinking to policy-making (Bontoux et al. 2020).[34] The SES uses a game where actors from three stakeholder groups (businesses, policy makers and civil society organisations) try to achieve long-term objectives whilst being observed by the public in two scenarios (Bontoux et al. 2016). Participants receive a limited amount of resources, define their objectives to reach the horizon of the scenario, take actions

[32] The citizen dialogues were conducted in April-June, 2017 and multi-stakeholder dialogues in October 2017-February 2018.
[33] These two dialogues fed in to the NANO2ALL European dialogue event that was held on April 9th, 2018 in Brussels with 29 stakeholders with nano scientists, policy-makers, industry, civil society organisations, and intermediaries such as RRI experts, media representatives, social scientists, ethicists, and stakeholders from earlier dialogues.
[34] The dialogue participants were recruited by science centres and included the following types of actors: policy-makers, civil society organisations, business and industry representatives, nanoscientists, citizen dialogue representatives, and actors who do not have a formal stance on nanotechnologies, such as a journalist or artist (Kupper & Schuijer 2018a).

in turn to reach their desired objective, play 'real life cards' to explore further interactions, and get judged and scored by the 'public voice' (Bontoux et al. 2020). Players of the game, which included private stakeholders and members of the public, took on the role of policy-maker, civil society organisation, researcher, and business (Bontoux et al. 2020).[35]

The SES team created a gaming logic in the NANO2ALL project around how technophilic or technophobic a society is, and how centralised or decentralised governance is (Bontoux et al. 2020) (CS04-01). In the first half of the game, various futures of a nano-application field were explored using SES in two parallel sessions. Participants worked through a scenario in three steps in scenarios that unfolded over a 15-year time period. In the second half of the game, backcasting exercises[36] were performed in subgroups and pairs to identify actions that connect desirable futures identified in the first half to the present (Kupper & Schuijer 2016).

How effective was the public engagement?

The effectiveness of the public engagement technique was formally assessed by asking participants to provide feedback and to complete a short survey (Kupper & Schuijer 2018a; Kupper & Schuijer 2018b). Participants found the exercise to be 'fun' and 'engaging' and reported both a high level of comfort to express their opinion, and that they gained an awareness of the impact of nanotechnology, which changed their perspectives (Kupper & Schuijer 2018a) (CS04-02).[37] Two facilitators said participants appreciated the realism of the conversations (CS04-01) and that they gained an experience of the complex dynamics of the RRI system (CS04-02). One interviewee noted that the public engagement technique opened up thinking in the science centres on how to use public engagement. For instance, Bialystok University of Technology has used the SES for teaching science and technology students around how to engage with the public (CS04-02). The JRC reported that the participants were more interested in the mental exercise and reflection, rather than a specific documented outcome of the session (Bontoux et al. 2020). Many of the suggestions from stakeholders in the multi-stakeholder event reinforced current thinking about themes that are important to the democratisation of RRI (Kupper & Schuijer 2018b).

The citizen and multi-stakeholder dialogues fed into the NANO2ALL European dialogue that provided directions and recommendations for the EC and other important actors in the nanotechnology research and innovation ecosystem

[35] The NANO2ALL game asked participants to take on different roles than their own to think about different family perspectives.
[36] Backcasting is the process of starting from a desirable future and looking back to today to identify the strategic steps that are necessary to achieve a specific future (Bibri 2018).
[37] Participants gave a rating of 4.6, 4.2, and 4.2 respectively on a 5-point scale for these aspects.

(Kupper & Schuijer 2018b) (CS04-01)[38]. The recommendations suggested that creating genuine interest in RRI amongst researchers and policymakers, rather than enforcement by top-down regulation, was a more preferable way to open up the nanotechnology research and innovation system. The recommendations were sent to the EC in April 2018 to be drafted into an internal EC policy note on nanotechnology governance (Kupper & Schuijer 2018b). The dialogues also contributed to the development of public roadmaps on the commercialisation of nanotechnology (Garcia et al. 2019; NANO2ALL, 2021b),[39,40] and to the NANO2ALL ethics panel findings on public understanding, attitudes and fears of nanotech research (NANO2ALL 2019b). The dialogues also contributed to a series of flyers for different stakeholders,[41] webinars for application fields (NANO2ALL, 2021a), conferences and debates (NANO2ALL 2017; NANO2ALL 2018; NANO2ALL 2018; NANO2ALL 2019).[42] This might help inform nanotechnology policy and practice in the future, although no evidence has been found on the uptake of recommendations in practice.

What 'lessons' can be learnt from this example?

Based on the JRC's experience with using the SES for the NANO2ALL project, several key lessons emerge (Bontoux et al. 2020; Kupper & Schuijer 2018a; Kupper & Schuijer 2018b) (CS04-01):

The SES tool is versatile and creates a safe and dynamic space: It has been employed in different contexts, languages, and for different stakeholders.[43] It facilitates constructive engagement with stakeholder groups who might not otherwise engage with complex issues (Bontoux et al. 2020) (CS04-01). The tool has been used to explore diverse topics and issues (CS04-01). The ability to change the scenarios in one setting also expands these possibilities. The scale of the question asked will also determine the scale of the discussion of the question in the scenario (Bontoux et al. 2020).

Ensure that different stakeholder perspectives are represented in the game: Participants take up unknown roles and gain an emotional connection to the role in

[38] This included nanoscientists, policy-makers, industry, civil society organizations, media representatives, RRI experts, social scientists and ethicists.
[39] The public dialogues outline actions to be undertaken by EU and national decision-makers to foster RRI. It also fed into working groups on nanotechnology (Garcia et al. 2019).
[40] Including safety, communication, industrialisation, networking, regulation, research and technology, skills and education, standardisation, technology transfer and innovation financing, critical raw materials and societal aspects.
[41] Including policy, industry, media, CSOs, general public and academia.
[42] Such as the such as the International Congress "Nanotechnology in Everyday Life" and the ESCITE annual conference, the B.Debate, and a keynote presentation on RRI during an Info Session organised by INCOBRA at PUCRS in Porto Alegre, Brazil.
[43] The game has been used with people from diverse backgrounds including age (12-67), gender, geographical and professional background (Bontoux et al. 2020).

the game. It helps participants think strategically about the long-term. It is, however, important to ensure that different stakeholder voices are considered in the game, such as industry and the public (Kupper & Schuijer 2018a; Kupper & Schuijer 2018b) (CS04-02). It is also important to consider how to include the public voice in the game, as there are many publics rather than 'one public' that can represent different stakeholder perspectives (CS04-02). These roles have to be sufficiently independent to facilitate independent decision-making (Bontoux et al. 2020).

The success of the game depends on the moderation quality and creativity (Bontoux, Sweeney et al. 2020): although one interviewee said that it is easy to train people to be game masters (CS04-01).

Make the game shorter and ensure that there is a reflection session at the end: The time span of a game can be an investment for dialogue participants and a challenge for facilitators when convening the session (Kupper & Schuijer 2018a; Kupper & Schuijer 2018b).This can have an impact on the identification of actions to enhance social interactions around particular technologies and can also limit the time spent on reflection. One facilitator felt that these reflections are an important part of the game that should be included (CS04-02).

Some challenges can arise when conducting the game in different contexts: Challenges include the need to train multiple moderators, translating the game scenarios and cultural differences (Bontoux et al. 2020) (CS04-02).

A.5. Case study 5 (CS05): Determining public perception on the use of virtual reality in healthcare through social listening

Case study title	Determining public perception on the use of virtual reality in healthcare through 'social listening'		
Concise summary of the case study	VR provides an immersive environment that enables users to have an altered experience of reality. It is increasingly used across the healthcare sector to support patients during treatment. Yet, the public perception on its use remains under-studied. Here, the research team used a method called 'social listening' in order to collect and analyse Facebook comments in response to a video on the use of VR in healthcare. Analysis of these comments showed that the public was generally excited about the use of VR within a healthcare setting, but also identified several potential concerns of its use. These concerns highlight potential future barriers of this kind of research and provide insight into how this area should progress.		
Technology area	**Sector / organisation**	**Public engagement techniques**	**Country and timescale**
VR	Healthcare	Social listening	United States, 2016
What is the technological innovation?			
This public engagement exercise focused on the use of VR technology in healthcare. VR provides an immersive environment that enables users to have altered experiences of reality (Li et al. 2011; Malloy & Milling 2010). It is being used increasingly across the healthcare sector to help patients control pain, treat anxiety disorders, support physical rehabilitation and distract patients during treatment (Garrett et al. 2014; Hoffman et al. 2000; Hoffman et al. 2001; Li et al. 2011; Malloy & Milling 2010; Morris et al. 2010). A review of randomised control trials demonstrated that VR is generally effective and well tolerated by patients across a range of clinical settings (Dascal et al. 2017).			
What was the purpose of the public engagement?			

The purpose of this public engagement technique was to better understand public opinion about the use of VR in healthcare (Keller et al. 2017). Despite increasing awareness of VR and its potential benefits, there remains a lack of research on the factors determining public acceptance of VR in clinical settings. To better explore this, the research team set out to examine public perception of VR in healthcare including the understanding of VR technology itself, concerns around its use and possible areas for its use and future applications (Keller et al. 2017). Ultimately, this aimed to build a picture of the potential facilitators and barriers to implementation of VR in healthcare and understand how the public would perceive this VR technology if they were to find it within a healthcare setting (CS05-01).

How was the public engagement carried out?

Public engagement was carried out using a method called 'social listening' (CS05-01). This method allows researchers to explore unfiltered views on topics, such as those discussed on social media and online forums (Stewart & Arnold 2018). The research team, based at the Cedars-Sinai Medical Center, used 'social listening' to gather public perception on a video that had been posted onto the social media site Facebook (CS05-01). The video, produced by NBC News, depicted the use of VR in healthcare, and was repackaged by a news aggregator that then posted the video onto Facebook (Keller et al. 2017). This video subsequently went viral and therefore attracted a lot of online attention and prompted comments from Facebook users (CS05-01). The research team saw this as an opportunity to gather invaluable information on how the public felt about VR (CS05-01). Therefore, after the video was posted online, the research team downloaded the comments from the video and uploaded them to their computer-assisted software, which enabled subsequent text-mining and content analysis of the comments (CS05-01). Posts were categorised into sentiment categories (positive, negative, neutral), and into major or minor themes. Major themes included high-level aspects, such as interest in VR technology; desire for personal use; as well as health care uses including pain or lack of mobility. Minor themes offered a more granular categorisation on the major themes, including defining pain into further categories such as dentistry, chronic pain, burns (Keller et al. 2017). Some comments could not be analysed as it was impossible to determine which high-order category they fit into, and therefore were ignored. In addition, the research team determined the self-identified gender from the Facebook users page and performed sentiment analysis of the language to analyse whether perception of VR differed with gender (Keller et al. 2017).

How effective was the public engagement?

Social listening enabled the collection of a 'snapshot' of data on public reaction to the use of VR in healthcare (CS05-01). The research team were able to analyse 1614 comments from the Facebook video in total, which were downloaded

approximately two weeks after the initial video had been posted (CS05-01). From their analysis, the research team identified 1197 (74.16%) as expressing a positive perception, 251 (15.55%) as expressing a negative perception or concern, and 560 (34.70%) expressing comments categorised as neutral (Keller et al. 2017).

The engagement highlighted specific concerns and potential barriers to the use of VR in healthcare, which included the threat that VR may pose to patient health (e.g. concerns around motion sickness or radiation), as well as more general concerns around the cost of such technology as well as increasing societal reliance on technology (Keller et al. 2017).

The study demonstrated the readiness of the public to engage with VR (CS05-01); and the technique offered crowd-sourced avenues for future study in this area (Keller et al. 2017). These included the use of VR technology for pain reduction; to combat a lack of mobility, and to positively influence mental health treatment (Keller et al. 2017).

The study provided insight into the potential barriers regarding the adoption of VR which may be relevant for future work (CS05-01). In this connection, participants raised concerns around the cost of such treatment, and the possibility of cross-infection and contamination from VR equipment (CS05-01). This informed how the research team undertook further work on VR within a clinical setting. For example, in a study on the use of VR for patients with chronic back pain, the research team used this prior knowledge of patient concerns to alleviate patient fears prior to their engagement with VR (CS05-01).

The engagement technique enabled views to be captured from participants across a demographic and geographic spectrum (Keller et al. 2017). There were, however, some limitations to this study including that the video was posted in English, thus limiting participation from non-English speakers, as well as those that had a Facebook account (Keller et al. 2017).

What 'lessons' can be learnt from this example?

Social listening can be a potentially cost-effective way to engage with a large participant sample: this technique enabled the research team to analyse a large number of social media comments in response to the video (CS05-01). Future studies may wish to use social listening to rapidly capture a broad 'snapshot' of public opinion.

Social listening can provide a way to capture participant views from groups that may not generally engage: because views were captured from existing comments, this enabled unsolicited views to be captured that were not influenced by the presence of a researcher, as well as enabling engagement with groups who

may not have participated in a formalised engagement technique such as a survey (Keller et al. 2017).

Social listening may have limited utility if the rationale behind participant's views needs to be understood: although the engagement technique provided valuable data, there was limited participant information that could be captured using this method, reducing the extent to which contributing social factors could be analysed (CS05-01). Future studies that wish to use social listening could combine this technique with follow-up focussed participant discussion with a subset of the participants (CS05-01). This would enable the rapid analysis of a large sample of comments whilst allowing for follow-up discussion on specific participant views.

A.6. Case study 6 (CS06): Using the vTaiwan platform to carry out a public debate on the regulation of Uber in Taiwan

Case study title	Using the vTaiwan platform to carry out a public debate on the regulation of Uber in Taiwan		
Concise summary of the case study	vTaiwan is a deliberative digital platform. It facilitates constructive debate and helps identify areas of consensus on specific issues amongst citizens, stakeholders, and government. The aims are to increase engagement, scrutiny and transparency in decision-making. In this example, vTaiwan was used in the regulation of the UberX service from the ride-hailing app Uber. vTaiwan uses a dedicated AI-facilitated social media tool, Pol.is, which allows users to draft ways in which a problem may be addressed, as well as to respond to other users' solutions by agreeing or disagreeing with them. The application of the vTaiwan process to the regulation of UberX demonstrated impacts through its ability to diffuse a potential dispute between Uber drivers and traditional taxi drivers around whether Uber was an app or taxi service in Taiwan. By engaging citizens and stakeholders it reached constructive outputs regarding legal requirements for both traditional taxis and Uber cars, and these outputs subsequently became law. The effectiveness of the vTaiwan process in this case study has been highlighted in a number of published articles.		
Technology area	**Sector / organisation**	**Public engagement techniques**	**Country and timescale**
Ride-hailing / car-pooling app	Transport	Discussion and deliberation via social media, and then face-to-face meetings to discuss specific proposals.	Taiwan, July-August 2015
What is the technological innovation?			
Uber is a ride-hailing company. Uber provides a mobile app that can be used to submit a trip request, which is sent to Uber drivers in the vicinity of the user and alerts them of the user's location. A driver with capacity will then accept this request, collect the user, and drive them to the destination requested through the app. UberX is one of the services provided by Uber Inc. UberX cars can			

accommodate parties of up to 4 people, with one person in the front seat and 3 in the back (Uber 2021).

What was the purpose of the public engagement?

When UberX started in Taiwan in 2014, it was popular but also caused problems with traditional taxi drivers. Uber registered as a technology company rather than a transport company on the basis that it is an app rather than a taxi service. This gave Uber several competitive advantages over existing taxi drivers in areas such as insurance, fares and taxes. The Taiwanese Ministry of Transport and Communications, however, still considered Uber a transport company and said it had to obey taxi laws (Hsiao et al. 2018). When Uber refused, it faced penalties under the Highway Act (Hsiao et al. 2018). vTaiwan facilitated a transparent debate between citizens and stakeholders, such as the Association of Taxi Drivers in Taipei, Taiwan Taxi and Uber (Tang 2016) over a period of a few months about what constitutes fair competition regulation (King 2019).

How was the public engagement carried out?

The vTaiwan engagement process is centred around a dedicated AI-facilitated social media tool, Pol.is, which allows users to draft ways in which a problem may be addressed, as well as to respond to other people's solutions by agreeing or disagreeing with them (CS06-02). By drawing a map that clusters users based on their opinions in real time, Pol.is is able show axes of consensus and disagreement. vTaiwan's key to success is in focusing on areas of consensus amongst citizens and stakeholders, and gamifying the process of finding commonalities (The Alternative 2019).

The engagement process was carried out in four stages: proposal, opinion, reflection and legislation (Simon et al. 2017; CS06-01). The decision to transition from one stage in the vTaiwan process to the next is not pre-determined; it is decided through consensus by the vTaiwan community. vTaiwan argue that this facilitates meaningful deliberation when all stakeholders are prepared to collaborate and iterate on solutions.

The Proposal Stage took two weeks. The Ministry of Transportation and Communications, Ministry of Economic Affairs, and the Ministry of Finance wanted to regulate UberX's operations in Taiwan. With consensus from the vTaiwan community, this topic was selected for open consultation.

The Opinion Stage took a month, from 15 July to 15 August 2015. It involved gathering relevant facts and research, simplifying complex legalese to define the scope of the topic in plain language, drafting default statements to begin the engagement process, and then allowing vTaiwan users to vote on statements

through Pol.is. Users had the option to 'agree', 'disagree', or 'pass' when given a statement, or had the option to contribute their own idea with a limit of 140 characters. To prevent trolling and to focus on consensus, users could not directly reply to other users' ideas (Hsiao et al. 2018). The Pol.is URL link was distributed through Facebook adverts and through stakeholder networks so that affected groups such as Uber drivers and taxi drivers could engage in this process. One of the key innovations of the Pol.is platform is the visual expression of users' views through real-time maps that cluster opinions into groups. In the opinion stage, the Pol.is algorithm initially identified four distinct groups: taxi drivers, UberX drivers, taxi-passengers and UberX passengers. The views of these groups coalesced into anti-Uber and pro-Uber groups, clearly seen in two statements that generated consensus (CS06-02). A third statement that generated 95% consensus amongst all participants was: 'The government should leverage this opportunity to challenge the taxi industry to improve their management and quality control system, so that drivers and riders would enjoy the same quality service as UberX's (Tang 2016). By the end of the Opinion Stage, 1,737 participants had taken part, 196 opinions had been entered into Pol.is and 47,539 votes were cast (Simon et al. 2017). In order for the Pol.is platform to give visual expression to user's views, there must be at least 20 statements on the specific issue being debated.

The Reflection Stage was a two-hour in-person consultation with academics and industry experts, citizens who were active users from the Pol.is platform stage of the consultation, as well as representatives from the Association of Taxi Drivers in Taipei, Taiwan Taxi, Uber and relevant government ministries. This consultation took place on 27 August 2015 and was live-streamed. A total of 1,845 people participated through the live cast of the event (Tang 2016). The outcome of the reflection stage was an agreement that Uber needed to comply with legal requirements of insurance and driver training, whilst taxi services agreed to broaden services in response to the market demand for ride-hailing apps (Hsiao et al. 2018).

The Legislation Stage took place on 23 May 2016, when the consensus reached through the Pol.is platform and Reflection Stage was enacted through an amendment of the regulation on automobile transportation management.

How effective was the public engagement?

The vTaiwan engagement process to carry out the regulation of Uber was effective in three ways.

Firstly, this process of engagement and deliberation reduced tensions between Uber drivers and traditional taxi drivers (King 2019); stakeholders displayed a strong willingness to engage in the process (Tang 2016).

Secondly, there were several constructive proposals that emerged from this process relating to competition in the taxi industry, which subsequently became law. In particular, taxis no longer needed to be painted yellow; carpooling taxis were free to operate on the basis that they do not undercut the fares of current taxis; carpooling apps must display car and driver identification, estimated fare and customer rating; and per-ride taxation must be reported to the Ministry of Finance (King 2019).

Thirdly, the vTaiwan process meant that Uber changed its business model in Taiwan to become a legal ride-hailing company (Hsiao et al. 2018).

What 'lessons' can be learnt from this example?

Gamification can help engage users: By getting users to 'agree', 'disagree' or 'pass' on randomly selected proposals from other vTaiwan users, the Pol.is platform introduces an element of gamification. The ultimate aim is to come up with the proposal that can generate the most 'likes' from a diverse group of stakeholders who have different opinions on the subject being debated (CS06-02). Taiwan's Digital Minister, Audrey Tang, said that the goal of vTaiwan is to gamify the system so that there is instant gratification and a tangible reward by contributing an opinion (Storey 2018).

Focusing on consensus is constructive: vTaiwan focuses on constructive engagement by removing potential obstacles to reaching a consensus. In order to prevent trolling and to encourage constructive dialogue, users cannot directly respond to other users' proposals – they can only vote on them (CS06-02).

Real-time data analysis can be a powerful tool to understand engagement: The ability of the Pol.is platform to give visual expression to the views being raised through the process in real-time means that areas of consensus and disagreement are easier to understand. Moreover, the use of open-source software, in particular the Pol.is platform, enables vTaiwan to support participation on a large scale; the platform can support up to 100,000 comments (CS06-01).

A multi-stage process can help ensure a broad range of opinions are considered: The vTaiwan process ensures that citizens' voices are heard in the Opinion Stage, whilst also bringing citizens, stakeholders, and experts together to focus on working out details in the Reflection Stage. Although the Legislation Stage depends on the will of the government to implement findings, reaching a consensus between citizens and stakeholders through this process demonstrates that the outputs are likely to be desirable and suitable to all parties involved (Hsiao et al. 2018).

A.7. Case study 7 (CS07): Engaging expert and citizen perspectives on AI using a workshop and online platform

Case study title	Engaging expert and citizen perspectives on AI		
Concise summary of the case study	This case study explores a two-stage public engagement process on AI, conducted under the auspices of the Human Brain Project (HBP) and overseen by the Danish Board of Technology (DBT). In the first stage of the public engagement, an expert workshop was organised. The workshop brought together cross-disciplinary experts to consider the ethical, economic, legal political and social impacts of AI using a '360' approach. In the second stage, findings from the expert workshop were used to inform an EU-wide 'citizen consultation' on AI using an online platform. The case study highlights the potential for linked approaches to public engagement drawing on both expert stakeholders and the broader public, as well as the utility of online platforms as mechanisms for engaging public perspectives. The extent, however, to which these recommendations will be taken into account by the EC is not clear as of December 2020.		
Technology area	**Sector / organisation**	**Public engagement techniques**	**Country and timescale**
Artificial Intelligence	Danish Board of Technology	Expert workshop and citizen consultation	EU-wide, March 2019 – September 2020
What is the technological innovation?			
The AI 360 Workshop and subsequent citizen engagement responded to the increasing proliferation of AI throughout European society. In both cases, AI was considered in the broadest possible terms, with no fixed definition applied. The adoption of a broad, flexible definition of AI was intended to facilitate a comprehensive, '360-degree evaluation' of AI, rather than focussing on more specific areas such as the future of work (CS07-01).			
What was the purpose of the public engagement?			
Against the backdrop of the expanding applications of AI, the AI 360 Workshop and citizen consultation sought to engage European stakeholders in conversation			

about the benefits, opportunities, risks and challenges such developments might bring (Bitsch & Bang 2020; Bitsch et al. 2020). As activities organised under the auspices of the HBP, a flagship EU-funded research project exploring possibilities for simulating the human brain, both engagements were intended to provide the basis for 'societal input' into that project, including recommendations for how the HBP could be proactive in addressing public perspectives on AI (CS07-01).

In the case of the AI 360 Workshop, the specific purpose was to convene expert discussion in order to identify the key opportunities, challenges and potential solutions relating to the expanding application of AI (Bitsch & Bang 2020; Bitsch et al. 2020). The purpose of the citizen consultation was to understand the views of AI held by the public at large (Bitsch & Bang 2020; Bitsch et al. 2020). By seeking general public perspectives on AI, the citizen consultation sought to 'democratically qualify' debates on AI typically dominated by expert opinion (Bitsch & Bang 2020; Bitsch et al. 2020). Another stated purpose of the consultation was to establish greater public dialogue with a view to building 'public trust' in AI-related technologies (Bitsch & Bang 2020; Bitsch et al. 2020).[44]

How was the public engagement carried out?

In seeking to identify the key 'hotspots' relating to AI, the Workshop employed a '360 approach' (Bitsch & Bang 2020; Bitsch et al. 2020). Drawing inspiration from methods used by a 2013 EU-funded project on Decision Support on Security Investment (DESSI), this 360 approach involved the systematic and structured analysis of AI across five 'dimensions', thereby facilitating a holistic view of the technology and its potential impact (Bitsch & Bang 2020; Bitsch et al. 2020). The five dimensions used for the Workshop were 'political implications', 'rights and ethics', 'legal framework', 'economy' and 'societal implications' (Bitsch & Bang 2020; Bitsch et al. 2020).[45] In the first stage of the Workshop, experts were divided along the five dimensions according to their subject matter expertise, thereby enabling an assessment of each dimension by experts with strong connections to those areas (Bitsch & Bang 2020; Bitsch et al. 2020). In the second stage, participants were reorganised to create mixed, multidisciplinary panels for each dimension (Bitsch & Bang 2020; Bitsch et al. 2020).[46] In the third stage, mixed panels considered potential solutions to the issues and challenges identified during

[44] The absence of such a dialogue, according to the organizers, would potentially contribute to a public 'tech-lash against AI', thereby curtailing the positive potential impacts of this technology could have for society (Bitsch et al. 2020).
[45] For each dimension, a set of more detailed criteria were developed for participants' consideration Bitsch et al. 2020).
[46] Within these panels, experts rated the technology against the detailed dimension criteria using a scale of 1-5. Rating was performed both before and after the panel discussion, with the results presented in real-time on central screen (Bitsch et al. 2020).

the first two stages (Bitsch & Bang 2020; Bitsch et al. 2020).[47] A total of 28 experts participated in the Workshop.

To perform the citizen consultation, the DBT used an adapted form of its online dialogue tool GlobalSay.[48] Citizens were invited to volunteer to host micro citizen summits of between 5-8 participants facilitated by the online platform EngageSuite. The platform guided participants through a series of debates, including presentations, short videos and opportunities for deliberation. The content of the platform drew directly on the challenges and potential solutions identified by the AI 360 Workshop (Bitsch & Bang 2020; Bitsch et al. 2020). At the end of each round of debate, participants were asked to provide answers to a set of questions, with multiple choice answers to facilitate quantitative analysis (Bitsch & Bang 2020; Bitsch et al. 2020). To engage citizens in the consultation, the DBT adopted a two-pronged approach. Firstly, in 13 European countries, a local implementing partner agreed to recruit 10 local summit hosts (Bitsch & Bang 2020; Bitsch et al. 2020). Secondly, by publicising the consultation as widely as possible online and through social media, the DBT attempted to encourage broader participation from a self-selecting audience interested in the topic of AI and its future impact (Bitsch & Bang 2020; Bitsch et al. 2020). Overall, the consultation saw 157 summits take place across 13 countries, reaching a total of 928 participants (Bitsch & Bang 2020; Bitsch et al. 2020).

How effective was the public engagement?

As noted above, though forming part of a linked, two-step process, the AI 360 Workshop and the citizen consultation had distinct aims. In the case of the Workshop, the aims centred around engaging experts in debate around key challenges and solutions relating to AI; in the case of the citizen consultation, the aims focussed on qualifying these expert insights against broader public views.

While both forms of engagement were broadly effective in meeting their aims, both also demonstrated key shortcomings. The AI 360 Workshop demonstrated the value of an all-round, multidisciplinary approach as a method of expert stakeholder engagement. According to interviewees, however, it also lacked sufficient involvement from technical/engineering experts (most of the participants being from law, ethics, philosophy, political science and economics) (CS07-02, CS07-03).[49] The lack of deep technical knowledge within the Workshop meant that some discussions were 'surrealistic' rather than focused on concrete possibilities (CS07-

[47] Across these three stages were numerous presentations, discussions and feedback opportunities (Bitsch et al. 2020).
[48] The adapted version of the GlobalSay platform was referred to as EuropeSay.
[49] According to one interviewee, this was possibly because the organisers focussed more on engaging 'social science' expertise on AI, with the result that technical experts were comparatively under-represented (though not wholly absent) at the workshop (CS07-03).

03). On the citizen consultation side, the consultation demonstrated the effectiveness of online platforms as mechanisms for obtaining public views (CS07-01). According to one interviewee, the total number of participants in the consultation (928) was more than the anticipated number at the start of the process (CS07-01). At the same time, the consultation also faced difficulties garnering more widespread public engagement through 'viral' dissemination, with most of the consultation's participants engaged through in-country partners (CS07-01).

Together, the AI 360 Workshop and citizen consultations have led to two key outputs. First, in line with the initial aims of the process, the two engagements have provided the basis for an 'Opinion' submitted to the HBP (Aicardi et al. 2020) (CS07-01). The Opinion seeks to connect issues raised by the engagements to the work of the HBP and is currently being considered as part of internal discussions within the project (CS07-01). Second, the two engagements have also been used to inform a DBT commentary on a European Commission (EC) White Paper, which provides the basis for new EU guidelines on AI (Bitsch 2020). The DBT commentary included seven key recommendations for the EU guidelines based directly on inputs gained by the 360 Workshop and the citizen consultation (Bitsch 2020).50 According to one interviewee, however, it is not clear to what extent these recommendations will be taken into account by the Commission (CS07-01).

While the DBT's citizen engagement may have contributed to building public trust in AI in a small way, according to one interviewee, societal-level public trust in AI will require widespread proliferation of such engagement techniques, ideally involving those (such as technology developers and policy makers) with the power and influence to shape the course of the technology's future development (CS07-01).

What 'lessons' can be learnt from this example?

Linked, two-step approaches can be used to engage both expert opinion and broader public views: In the context of the HBP, the DBT established a two-step public engagement process focusing first on expert consultation and subsequently

[50] The seven recommendations were as follows: (1) undertake work to uncover and address the full range of potentially abusive uses of AI, including societal, political, security, intelligence, and military domains; (2) make obligatory regulation for all AI; (3) reconsider the distinction between high and low risk AI; (4) encourage public authorities to carry out a comprehensive investigation of their local challenges before implementing AI solutions; (5) build trust by supplementing balanced information with involving citizens in deliberation, agenda setting, prioritization and decision making; (6) encourage national and European deliberation and action on the role of digital spaces of interaction, news and debate central to the functioning of our democracies, human rights and well-being of European citizens; and (7) human oversight should be complimented by human insight and explainability (Bitsch & Bang 2020).

on citizen consultations to ‘democratically qualify’ expert views (CS07-01, CS07-02, CS07-03).

When engaging experts and citizens in discussion on the potential future impact of technologies, an all-round (360) approach can be beneficial: Both the 360 Workshop and the citizen consultation considered the implications of AI across multiple different dimensions, thereby permitting a more holistic understanding of opportunities, challenges and potential solutions than if focussing on one area (CS07-01).

Online platforms present a viable tool for conducting citizen consultations to engage public views: At the same time, however, generating truly widespread engagement with such platforms can be a challenge (Bitsch 2020) (CS07-01). It is also important to recognise that those engaging in online platforms may represent a fairly narrow self-selecting segment of the population at large.

One public engagement process is not sufficient to build public trust in a technology at a societal level: While single citizen engagement exercises may contribute to building public trust in a technology, to build public trust at a societal level, there is a need for systematic public engagement processes involving actors and organisations across a technology’s ecosystem (CS07-01).

A.8. Case study 8 (CS08): Engaging the public on facial analysis and automated decision-making through the use of BioMetric Mirror – an interactive application

Case study title	Engaging the public on facial analysis and automated decision-making through the use of BioMetric Mirror – an interactive application.		
Concise summary of the case study	Facial analysis applications are increasingly being used to inform decision-making processes, and concerns have been raised regarding the transparency and ethics of these technologies. Here, the research team developed an interactive application 'BioMirror' that performed facial analysis on the public, and subsequently provided inferences about the participants' demographic and psychometric characteristics. Through this application, the public were able to engage with this technology in an experiential way, which prompted discussion and reflection on not only the potential for this type of technology, but also on the ethical challenges that must be considered if this were to become more prevalent in society.		
Technology area	**Sector / organisation**	**Public engagement techniques**	**Country and timescale**
Facial recognition and automated decision-making	Multiple Sectors (Surveillance)	Interactive facial analysis application	Australia, 2018-19
What is the technological innovation?			
This public engagement exercise focused on facial analysis and automated decision-making processes. Facial analysis applications are increasingly being used to inform decision-making processes which may influence an individual's access to health care, real estate, financial services and the judicial system (Helbing et al. 2019). This technology enables personal characteristics, such as gender, age, race or emotional state, to be inferred from photographs or videos (McStay 2016; Müller et al. 2009).			
What was the purpose of the public engagement?			

To explore public opinion on the ethics of facial analysis and automated decision-making, researchers created BioMetric Mirror; an interactive application which enabled members of the public to have their face photographed, and analysed by a machine-learning installation which provided inferences on their demographic and psychometric characteristics (Wouters et al. 2019). Concerns have been raised around the use of facial analysis technology within automated decision-making, and a lack of transparency on the application of these technologies has limited the opportunity for public discussion and critique of these processes (Abdul et al. 2018; Datta et al. 2016; Ekstrand et al. 2018). This application aimed to explore public opinion of this technology, probing understanding around how these technologies work in practice, as well as ethical concerns around their use (Wouters et al. 2019). The technology was built using pre-existing facial analysis information from the 10k US Adult Faces Database – a database containing thousands of photographs along with subjective ratings on perceived demographic, psychological and social attributes crowd-sourced from the public (Bainbridge et al. 2013). The research team wanted to enable the public to experience facial analysis technology in an experiential way (CS08-01, CS08-02). Furthermore, the study aimed to probe ethical questions around the use of this type of technology. The algorithms used within the facial analysis installation were inherently sub-optimal, something which the research team used to demonstrate the potential limitations of automated decision-making when attempting to assign demographic or psychometric characteristics (CS08-01, CS08-02).

How was the public engagement carried out?

BioMetric Mirror was installed via large public displays within a public University space in Melbourne, Australia for 50 consecutive days (Wouters et al. 2019). Users interacted with this application via gestures captured by sensors. Once users had consented by raising their hand, their photograph was taken, and analysed using the BioMetric Mirror facial analysis installation. The user was then shown the psychometric analysis of their photograph determined by the installation, along with a value and confidence interval, which indicated the degree of certainty attached to this decision (Wouters et al. 2019). Following this, the user was presented with possible speculative scenarios using the results of their analysis (Wouters et al. 2019). For example, the application questioned how the user would feel about their data being shared with law enforcement or a recruitment agency, probing the individual to consider how they would feel about these decisions (see Figure 1 for examples of user interface (Wouters et al. 2019). Finally, semi-structured interviews were carried out with a subset of the users to enable discussion around how accurate they thought the technology was as well as ethical implications of the technology itself (Wouters et al. 2019).

How effective was the public engagement?

The use of an interactive application succeeded in engaging the public on the issue of facial analysis technology and automated decision-making. In total, 798 interactions took place with BioMetric Mirror across the 50 days of its installation, and 40 individuals were interviewed (Wouters et al. 2019). BioMetric Mirror enabled reflection on complex and potentially harmful ethical questions, providing a space for further discourse on facial analysis technology (Wouters et al. 2019).

The use of speculative scenarios within the application provided participants with the opportunity to reflect on the broader implications of these technologies (Wouters et al. 2019). Follow-up interviews with participants after the application highlighted their concerns. One user declared concern that analysis determining them as aggressive may be passed onto an immigration officer, whilst another considered the negative impacts of this type of data use within the judicial system (Wouters et al. 2019). The study also highlighted areas of general concern. For example, that the processing and storing of facial analysis data may result in the storage of a flawed readout of a user for an indeterminate time (Wouters et al. 2019).

The research team reflected that BioMetric Mirror had provided a thought-provoking and entertaining application which enabled engagement from the public on complex ethical issues around facial analysis technology (CS08-01, CS08-02). The application was able to provide participants with a space to explore psychometric analysis and profiling in a fun and informative way (CS08-01, CS08-02). The research team found that users generally perceived psychometric analysis as an enjoyable activity (Wouters et al. 2019). Participants, however. Were also able to consider the fallibility of psychometric profiling due to the inherent errors within the analytical algorithms that the application used (Wouters et al. 2019).

BioMetric Mirror was effective at engaging the public both nationally and internationally. The research team calculated that 155 news articles on BioMetric Mirror were published through online media outlets across 20 countries reaching an estimated 204 million readers (Wouters et al. 2019).

The technique resulted in further reflection and engagement on social media. A total of 2,588 messages were published on social media either responding to the study, or featuring associated hashtags (Wouters et al. 2019). In addition, the research team observed a twitter thread that speculated how the withdrawal gesture from the application (i.e. covering the participants eyes) could be translated into real-life scenarios, and become a standardised way for withdrawing consent from facial recognition and analysis (Henry 2018).

The study provided insight into further avenues for consideration in this area. For example, the study typically found that participants underestimated the extent to which facial analysis technologies are currently used, and misunderstood the

objectiveness of algorithms that rely on subjective crowd-sourced data (Wouters et al. 2019).

What 'lessons' can be learnt from this example?

The use of an interactive application enabled the research team to demonstrate the potential for this type of technology in the field: This enabled participants to engage with realistic application scenarios (Wouters et al. 2019). In addition, it gave participants the chance to consider this type of technology before it is fully integrated in society and engage with discussion and debate whilst the technology is still under development (CS08-01, CS08-02).

Choosing a provocative subject stimulates public engagement: The provocative nature of the interactive application stimulated public discussion on the ethics and use of this technology (CS08-01, CS08-02). The research team ensured that this was balanced with adequate information to enable participant wellbeing (Wouters et al. 2019). Future studies may wish to consider research questions that could stimulate and encourage public debate.

The creation of a tool that could be exhibited in differing locations enabled ongoing engagement in this area: Although the formal study is complete, BioMetric Mirror continues to be exhibited in both art and science exhibitions globally, continuing to stimulate conversation around the use of this technology and the potential ethical concerns (CS08-01, CS08-02). Future engagement activities may wish to consider an application-like tool that can support engagement with the public across different locations and contexts.

A.9. Case study 9 (CS09): Citizen and Multi-Actor Consultation on Horizon 2020 (CIMULACT) to formulate science and technology policy research agenda in the European Union

Case study title	Citizen and Multi-Actor Consultation on Horizon 2020 (CIMULACT) to formulate science and technology policy research agenda in the European Union		
Concise summary of the case study	The CIMULACT project focussed on advances in Responsible Research and Innovation (RRI) in terms of enhanced cooperation with science and society to promote scientific excellence, and social responsibility and awareness. CIMULACT carried out citizen and multi-actor consultations to contribute to research agenda formulation for science and technology policy in the European Union. The project was well-received by participants. It had an impact on the research agenda in Horizon 2020, as the project results were used in the formulation of H2020 WP 2018-2020. The project was also acknowledged in the Interim Evaluation of Horizon 2020 and was chosen as a good practice case for citizen engagement in agenda setting in open science at the OECD.		
Technology area	**Sector / organisation**	**Public engagement techniques**	**Country and timescale**
Science, Technology and Innovation	Science, Technology and Innovation	Workshops, consultations, and a conference	30 European countries, 2015 – 2018
What is the technological innovation?			
The Citizen and Multi-Actor Consultation on Horizon 2020 (CIMULACT) project focussed on Science, Technology, and Innovation (STI) as one of the ways for the EU to create jobs and improve the quality of life in Europe (CIMULACT 2021d; Hebakova et al. 2018). It specifically focussed on advances in RRI, related to enhanced cooperation with science and society to combine scientific excellence and social awareness and responsibility (CIMULACT 2021b; Hebakova et al. 2018). The definition of RRI in this project follows von Schomberg's (2011) definition, namely creating a space where different actors become mutually			

responsive to each other, and aimed for agenda setting based on societal needs (CIMULACT 2021b).

What was the purpose of the public engagement?

The aim of CIMULACT was to improve citizen engagement in the research agenda formulation process in Europe by providing inputs to the Horizon 2020 Work Programme 2018-2020 (H2020 WP 2018-2020) and the preparation of Framework Programme 9 (FP9)[51] (Hebakova, et al. 2018). The main objective of the project was to engage citizens and stakeholders in the co-creation of European research agendas 'based on real, validated and shared visions, needs and demands' (CIMULACT 2021d) (CS09-02, CS09-01). CIMULACT aimed to contribute to the development of RRI in STI by creating and improving the dialogue between citizens, stakeholders, scientists, and policy makers (CS09-02). The goal was to create scenarios of desirable and sustainable futures to create recommendations and suggestions for research and innovation topics and policies (CIMULACT 2021d; Hebakova et al. 2018).

How was the public engagement carried out?

CIMULACT was a three-year project carried out by 29 consortium partners and funded by the European Commission (EC) (Hebakova et al. 2018).[52] It involved workshops, consultations, partner meetings, and a conference with citizens and experts from 30 European countries. The CIMULACT project translated initial citizens' visions of the future into research topics using six consequent steps consisting of seven activities, focussing on both verbal and non-verbal communication (CIMULACT 2021c; Hebakova, et al. 2018) (CS09-02):

- National citizen vision workshops (NCVs): From November 2015 to January 2016 NCVs were held in the 30 participating countries with more than 1000 citizens to formulate 179 visions for a sustainable and desirable future in Europe.

[51] Horizon 2020 was the ninth framework programme of the EU and builds on Horizon 2020, which came to an end on 31 December 2020 (Karakas 2019).

[52] This included Teknologirådet – Danish Board of Technology, Fraunhofer Gesellschaft zur Forderung der Angewandten Forschung Ev, Oesterreichische Akademie der Wissenschaften, Missions Publiques, Strategic Design Scenarios Sprl, Technologicke Centrum Akademie ved Ceske Republiky, Asociatia Institutul de Prospectiva, Applied Research and Communications Fund, Greendependent Intezet Nonprofit Kozhasznu Korlatolt Felelossegu Tarsasag, Politecnico di Milano, The Association for Science and Discovery Centres, Fundacio Catalana per a la Recerca i la Innovacio, Akademien der Wissenschaften Schweiz Verein, Helsingin Yliopisto, Teknologiradet – The Norwegian Board Of Technology, Instytut Technologii Eksploatacji-Panstwowy, Instytut Badawczy, Asociacija Ziniu Ekonomixos Forumas, Sia Baltijas Konsultacijas, University College Cork, Wageningen Economic Research, Mediatedomain Lda, Universita Ta Malta, Slovenska Akademia Vied, Slovenian Business & Research Association, Rtd Talos Limited, 4motion Asbl, Odraz - Odrzivi Razvoj Zajednice, Statens Geotekniska Institut and Atlantis Symvouleftiki Anonymi Etaireia Atlantis Consulting

- Clustering workshop: In February 2016, the 179 visions were clustered according to social needs in a workshop with the consortium partners, 11 external experts and "creative thinkers".[53]
- Co-creation workshop: In Milan in April 2016, 100 citizens, experts and consortium partners co-created 48 research programme scenarios, or suggestions for research programmes that can address the underlying social needs identified in the previous stages of the project (CIMULACT 2016), based on the social needs from the clustering workshop.
- National Research and Policy Workshops (NPRS): 977 participants were introduced to eight research programme scenarios before or during the workshop and enriched at least four of these scenarios.[54]
- Online Research and Policy Consultations (ORPC): In parallel to the NPRS, the scenarios were discussed in a cross-European open consultation or survey with 3456 participants to validate and prioritise the scenarios.
- Core partner meeting: In November 2016, the core partners compiled the results and prepared them for the EC.[55]
- Pan-European conference: In December 2016, a pan-European conference was held to finalise the research topics suggestions with the CIMULACT partners, experts, advisors and project officers at the European Commission.[56]

How effective was the public engagement?

The process resulted in several deliverables aimed at European and national research policy making. These included 179 citizens' visions[57] and 48 research programme scenarios, and 23 research topics (Hebakova et al. 2018). CIMULACT carried out an impact assessment that compared the 23 citizen-based reports with the topics in the H2020 WP 2018-2020 and had interviews and an online survey

[53] The 26 social needs that were identified in the clustering workshop were merged in 12 domains of social needs: (1) equality; (2) unity and cohesion; (3) citizenship awareness and participation; (4) holistic health; (5) sustainable food; (6) life long process; (7) strength-based education and experiential learning; (8) harmony with nature; (9) personal developments; (10) green habitats; (11) sustainable economy; and (12) sustainable energy.
[54] The methods in these workshops differed as project partners either developed their own methodology or chose one from a set of three suggested methods.
[55] The results of the meeting consisted of the challenge, scope and expected impact of the 48 suggestions of research topics.
[56] 46 CIMULACT partners, 11 experts, 2 advisors, and 16 project officers from the EC worked together to revise the research topics based on the results from the NRPS and ORPs held from August until October 2016. This resulted in 23 research topics and 40 policy recommendations. The tics represented citizens' desirable future and their expectations, desires and concerns for Europe.
[57] The CIMLUACT project followed the CIVISTI project's definition of visions as "*a picture or an imagination of a desirable future. A vision can be based upon hopes and dreams—but also upon concerns and fears in relation to problems or imagined threats, which we do not want to become future reality. The time span of the vision is 30–40 years from now*" (Sotoudeh & Peissl 2008).

with research policy officers at Commission services (DGs) on the use of CIMULACT outcomes in an impact evaluation (Hebakova et al. 2018).[58]

The impact evaluation found that project results were used in the formulation of the H2020 WP 2018-2020, as there was an overlap between 15 of the 23 CIMULACT research topics and 22 topics from the WP (Hebakova et al. 2018). Survey and interview respondents also appreciated the approach adopted by CIMULACT and found it relevant (Hebakova et al. 2018). They agreed that citizens are competent enough to suggest directions for research and that their views can help distinguish between political pressure and real citizen needs. Interviewees appreciated the coverage of issues, their novelty, and compatibility with other sources (Hebakova et al. 2018). Two facilitators said that citizens appreciated that they could have an impact on agenda setting and to trace their inputs at every stage of the process (CS09-01, CS09-02), which was reflected in their willingness to return to consultations (CS09-01). The CIMULACT research topics also added new and unique perspectives, especially on societal aspects, in expert oriented foresight studies.[59] Policy officers at the European Commission who engaged with the project found that CIMULACT was a helpful instrument for citizen engagement, the methodology produced trustworthy outputs and a genuine consultation process. CIMULACT consortium partners noted that they gained new experiences in co-creation, adopted the project methods, improved their methodological knowledge, recruitment approaches, networking and facilitation skills (Hebakova et al. 2018).

Moreover, the work of CIMULACT was acknowledged in the Interim Evaluation of Horizon 2020 stating that the CIMULACT project provided concrete input to the Europe research and innovation agenda and improved the engagement of citizens (European Commission 2017). The project also fed into H2020 WP 2018-2020 and was acknowledged in the framework programme introduction (European Commission 2020; Hebakova et al. 2018). The CIMULACT project also had an impact on other work, as OECD chose CIMULACT as a good practice case for citizen engagement in agenda setting in open science (OECD 2017).[60]

What 'lessons' can be learnt from this example?

CIMULACT summarised several key lessons for the process in their impact evaluation report (Hebakova et al. 2018):

[58] The online survey was distributed to 215 policy officers. Two interviews were conducted with policy officers by phone and there were two face-to-face meetings with three policy officers in Brussels.
[59] 10 out 16 studies included one or more references to research topics identified in CIMULACT. Here, foresight was defined as a "*structured dialogue on long-term futures*" (CIMULACT 2021a).
[60] In addition, the project produced an inspiration catalogue on methods for consulting citizens and stakeholders (Dagorne & Gudowsky 2018), and a deliverable on the merits of citizen-focussed consultations compared to traditional foresight methods, which can provide methodological insights for other actors (Rosa et al. 2018).

Focus on dissemination among, and close collaboration with, policy makers and relevant EC policy officers: Dissemination and awareness raising procedures should be set up jointly with the EC at the early stages of the project (Hebakova et al. 2018).

Target dissemination efforts: The project paid particular attention to dissemination and promotion to increase the impact of the project.[61] A more detailed overview of the target groups and more user-oriented material could have increased their impact (Hebakova et al. 2018).

Recognise the challenge of conducting workshops across different countries: There were some challenges with time pressure, timelines for the online survey, and the number and diversity of consortium partners who conducted the workshops across Europe. One interviewee also said it is important to consider that the willingness to share and participate opinions will differ depending on the institutional history of the country (CS09-01).

Ensure that the public engagement process is flexible: Two interviewees noted that flexible public engagement processes allow citizen insights to emerge organically and to adapt the process to include citizen's perspectives at different stages in the process (CS09-01, CS09-02).

Establish strong data management systems: One interviewee noted that strong data management systems are necessary to capture and manage citizen perspectives (CS09-02).

Involve citizens at all stages of implementation and design: One interviewee argued that to facilitate innovations that are relevant to citizens, they should be involved at all stages of implementation and design. It would also be helpful to consider how to include citizen perspectives in more specific sectors and geographical locations (CS09-02).

[61] A total of 902 dissemination activities were carried out by consortium partners and 126 presentations were held at workshops and conferences.

A.10. Case study 10 (CS10): Rapid online deliberation to explore public attitudes to the use of COVID-19-related technologies

Case study title	Rapid online deliberation to explore public attitudes to the use of COVID-19-related technologies		
Concise summary of the case study	There appears to be a lack of public trust in some digital technologies developed to address different aspects of COVID-19, including contact tracing apps. To ensure public trust and buy-in of these technologies, it is important to determine under what circumstances the public considers technological solutions such as the COVID-19 contact tracing app to be appropriate. To this end, the Ada Lovelace Institute, together with collaborators, conducted a rapid online deliberation to explore the attitudes of members of the UK public to the use of digital COVID-19 technologies, including the NHS contact tracing app. The process was effective in enabling an informed dialogue with the public in a rapidly changing and uncertain environment. The process demonstrated that it is possible to gather public input in a short space of time and could potentially be applied to other future areas in which time is limited. Although it is too soon to indicate whether the engagement process has impacted on policy or regulation, the engagement exercise nonetheless identified four requirements that would help to ensure public trust and buy-in regarding future COVID-19 technologies (i.e. providing a transparent evidence base; offering independent review of the technology; clarifying data use, rights and responsibilities; and addressing the risks and needs of vulnerable groups). These requirements fed into a checklist aimed at government, policy makers and technology developers to help them with the future development, design and use of COVID-19 technologies.		
Technology area	**Sector / organisation**	**Public engagement techniques**	**Country and timescale**
Digital technologies developed to combat	Public Health	Deliberative dialogue using an online	United Kingdom, May-June 2020

COVID-19 (e.g. contact tracing app)		platform (Zoom and Engagement HQ)	

What is the technological innovation?

The technological innovation consisted of a range of COVID-19 technologies that governments across the world are developing to help with the surveillance, prevention and control of the COVID-19 pandemic. This includes symptom trackers, digital contact tracing apps, and public health identity systems, as well as broader data collection and data sharing infrastructures (such as the NHS DataStore). The discussion, however, centred on the UK's digital contact tracing app (being piloted in the Isle of Wight at the time).

What was the purpose of the public engagement?

There appears to be a lack of public trust in some digital technologies developed to address different aspects of COVID-19, including contact tracing apps, and their use of personal data (Gardner 2020). This is problematic because the efficacy of digital contact tracing apps relies on mass adoption (Ada Lovelace Institute 2020). This will require trust and buy-in from the public regarding the decisions made in relation to the app.

The aim of the public engagement was to determine under which circumstances the public considers technological solutions such as the COVID-19 contact tracing app to be appropriate (Ada Lovelace Institute 2020). This, in turn, intended to identify the requirements needed to make the UK Government contact tracing app trusted and justified in the public's view.

How was the public engagement carried out?

The public engagement consisted of a rapid online deliberative process with 28 members of the public (Ada Lovelace Institute et al. 2020). The process took place over a three-week period, in May and June 2020. It was conducted online using two online platforms, Zoom and Engagement HQ (Ada Lovelace Institute et al. 2020). The stakeholders involved included the project team representing four organisations (the Ada Lovelace Institute, Bang the Table, Involve and Traverse); 28 randomly selected members of the public from two urban and rural locations (Camden and Kent);[62] and five specialists from academia and the third sector who were experts in data and technology policy (Ada Lovelace Institute et al. 2020). Each engagement consisted of one 90-minute session per week. The process was

[62] The recruitment approach consisted of promoting the project with an advert using the team's local networks in Camden and Kent, through mutual aid groups and local community organisations. Potential participants completed a short demographics form to enable selection of the most diverse sample available.

deliberative, in that participants were first presented with information about the topic (e.g. digital contract tracing and the NHS app) from the expert speakers (who spoke for 10 minutes in each 90-minute session) and were then able to ask questions (using the Zoom chat function rather than verbally) for the remainder of the time. The closed platform Engagement HQ was also used for a limited time (the first two weeks) to enable participants to access materials (e.g. speaker slides and video recordings) and take part in activities (e.g. the ability to interact and have conversations with the other participants) (Ada Lovelace Institute et al. 2020). The whole process was designed to take place rapidly alongside the policy developing in real-time in response to COVID-19 during the lockdown.

How effective was the public engagement?

This was a pilot project that successfully demonstrated the feasibility of conducting a deliberative dialogue online on a rapidly evolving subject (as evidenced in the ability to produce considered findings from the public in a short space of time and outlined in the lessons below) (CS10-01; CS10-02). Going forwards, a key benchmark of change would be to determine whether policy makers adopt these approaches in the future.

Although it is too soon to indicate whether the engagement process has impacted on policy or regulation, the engagement exercise nonetheless identified four requirements that would help to ensure public trust and buy-in regarding future COVID-19 technologies. These were to: provide a transparent evidence base; offer independent review of the technology; clarify data use, rights and responsibilities; and address the risks and needs of vulnerable groups (Ada Lovelace Institute 2020). These findings fed into the development of a checklist (based around the four requirements outlined above) aimed at government, policy makers and technology developers to help them with the future development, design and use of COVID-19 technologies, including contact tracing apps, to ensure public trust and buy-in (Ada Lovelace Institute 2020).

The public engagement exercise has not been formally evaluated but the authors, together with feedback from a survey sent to participants, provide a number of key observations on the process (Ada Lovelace Institute et al. 2020). The engagement was deliberative, with good quality conversations able to take place despite the online format (Ada Lovelace Institute et al. 2020). Participants indicated that, overall, they were given sufficient time to contribute their views (Ada Lovelace Institute et al. 2020). The online process worked relatively well, using tools that were inexpensive to set up and easy to use, including two online platforms – Zoom and Engagement HQ. The deliberative exercise required experienced facilitators, which likely added to the cost.

Having both synchronous (everyone participating at the same time in, e.g. video chat) and asynchronous (interreacting in your own time in, e.g. an online forum) engagement worked particularly well according to one interviewee (CS10-02). Having the engagement take place over multiple sessions enabled participants to reflect and embed learning between sessions (CS10-02). There were mixed views regarding the different tools and methods that were used (e.g. some preferring the group discussion sessions, others preferring the chat function); however, overall participants reported that the variety of tools helped to support participant engagement and retention.

The information presented by the experts was clear and easy to understand. Some participants suggested that having the information and the topics in advance would have given them time to 'mull it over' and allowed them to engage better (Ada Lovelace Institute et al. 2020).

Limitations of the engagement process included:

- Working on a rapidly evolving policy area with a tight timeframe meant that there was no time to get policy makers on board (CS10-01; CS10-02). For an engagement process to have impact typically requires engagement and buy-in from policy makers (CS10-01; CS10-02).
- Communicating and gauging participants' understanding of the topic. The online nature of the engagement made it more challenging to check participants' understanding of the information received (Ada Lovelace Institute et al. 2020).
- The engagement was broadly inclusive but unlikely to be representative of the population in terms of demographics. Although the process included participants from both urban and rural areas (i.e. Camden and Kent), the sample was limited to 28 members of the public (Ada Lovelace Institute et al. 2020). In addition, although some participants enjoyed the online format, the tight timeframe meant that the process recruited individuals who were already comfortable online. Feedback from participants suggested they had mixed views about the online process, with some preferring it and others preferring face-to-face. Whereas the online format facilitated participation for some people due to the shorter time commitment compared to traditional deliberative processes, not everyone felt comfortable participating online and using online tools such as Zoom.

What 'lessons' can be learnt from this example?

Rapid online deliberation is a feasible public engagement technique: It is feasible to conduct informed public conversation online with a rapidly evolving policy context (CS10-01; CS10-02).

Rapid online deliberation works well with a clearly defined and articulated question: Working in a tight timeframe is perhaps less well suited to explore more complex or systemic questions (CS10-01). The fast-paced approach may not work so well if dealing for questions in which there is considerable difference of opinion, a need to build trust across the group when going into a deliberative process on a particular issue, and where coming to a consensus or a meaningful resolution may require several weeks and months, rather than days (CS10-02) (Ada Lovelace Institute et al. 2020).

Policy maker support and buy-in is important: The tight timeframes meant there was less time for policy makers to be involved. Going forwards, however, it is important to have clarity around the topic and policy maker buy-in and engagement, including how the work will feed into the decision-making process (CS10-01; CS10-02).

Online deliberation can be inclusive: Although it provides challenges around digital inclusion, it is also a means of including individuals that face-to-face methods exclude (CS10-01; CS10-02). It can be inclusive in ways that take into account time pressures on people's schedules.

Annex B: Overview of general public engagement techniques

Table 4 provides an overview of a selection of public engagement techniques that exist and have been used in contexts beyond technological innovation. Each public engagement technique has been categorised according to three high-level categories:[63] (1) Communicate, which is characterised by the delivery of information to the public to inform or educate (these techniques are one-way); (2) Consult, which is characterised by both the delivery of information to the public and the collection of input from the public to listen, gain knowledge and understanding (these techniques are one-way); and (3) Participate, which is characterised by collaboration and co-creation with the public (these techniques are two-way). This list is not intended to be an exhaustive guide. It is also important to note that the appropriate type of technique will depend on the objective of the exercise.

Table 4: Overview of general public engagement techniques

Public engagement technique	Description	High-level category			Source
		Communicate	Consult	Participate	
21st-Century Town Meeting	This approach brings together between 500-1000 people for discussion of local, regional or national issues. The participants are split into groups with 10-12 people in each and a networked computer is used to collect votes from participants during the event. Participants are also given individual keypad to vote on questions or themes. The data from the		X		(Involve 2018)

[63] As noted previously, these three categories broadly map onto IAP2 spectrum of public participation (IAP2 2018) that consists of the following categories: inform, consult, involve, collaborate, and empower. 'Communicate' and 'consult' roughly correspond to the IAP2 categories 'inform' and 'consult', respectively. The category 'participate' broadly includes the three IAP2 spectrum categories 'involve', 'collaborate' and 'empower'.

Public engagement technique	Description	High-level category			Source
		Communicate	Consult	Participate	
	voting exercises is sorted geographically and shared with stakeholders at the end of the event.				
Action Research/Planning	This approach aims at transformative action by involving the public in living conditions, everyday problems, and their environment, in order to change these conditions. It acknowledges diverse forms of knowledge, both scientific and citizen knowledge to politically empower people. They are normally structured in five phases: (1) a meeting with stakeholders and citizens to discuss issues; (2) topic and design workshops; (3) brainstorming session for the workshop ideas; (4) analysis of ideas; and (5) the agreed proposals are published in a final report.			x	(Engage2020 2014; Involve 2018; Ward 2009)
Appreciative inquiry	Questions are used to build a vision for the future, by focussing on past and potential future successes. The questions encourage between 5-15 participants and their networks to tell stories about their experience of what works. The process has four stages: (1) a		X		(Involve 2018)

Public engagement technique	Description	High-level category			Source
		Communicate	Consult	Participate	
	discovery stage: participants are asked 'what works?'; (2) a dream stage: participants are asked to imagine positive features identified in the discovery stage; (3) design stage: participants identify steps to realise the dreams identified in the previous stage; and (4) destiny stage: focusses on the implementation of previous ideas.				
Arts-based	Techniques to engage the public that span the visual arts, performing arts, games, art installations and other techniques.			X	(NCCPE 2019)
Briefing workshops	Working sessions that aim to establish a project agenda or brief. Users of a project are invited to attend a workshop that normally lasts 1.5 hours. The same workshop can be held with different stakeholder groups, is facilitated by a facilitator(s), and records are made of key points and issues.		X		(Engage2020 2014; Ward 2009)
Charrette/Design charrette/Enquiry by design	Intense and hands-on workshop/session that brings together diverse stakeholders to explore design options for certain issues. They often			X	(Engage2020 2014, Involve 2018; Tamarack Institute

Public engagement technique	Description	High-level category			Source
		Communicate	Consult	Participate	
	involve intensive workshops for stakeholders, such as policy makers, experts and public, to collaborate. An important component is integrating design activities at an early stage for research proposals and/or implementation plans.				2017; Ward 2009)
Citizen compass	Citizens, who are randomly selected, evaluate government work based on criteria that citizens have developed. They then propose measures for future government work. It offers a platform for citizens to teach politicians what the public thinks about political issues and provides recommendations for policy making.			X	(Engage2020 2014)
Citizen Advisory Groups/Committees	Involves 10-30 members of the public who form a committee to advise and inform decision making over a longer time period. They can take many different forms based on the requirements of the group.			X	(Involve 2018; Ward 2009)
Citizen science	Inclusion of the public in scientific research by collecting or analysing data and/or asking questions to			X	(Engage2020 2014)

Public engagement technique	Description	High-level category			Source
		Communicate	Consult	Participate	
	facilitate diverse contributions. It is often a hierarchical and organized process that are initiated and supervised by scientists.				
Citizens' jury	It usually involves 12-24 participants of a representative sample and last between 2-7 days. The opinions and insights of citizens are revealed, and a common decision is made. They are more applicable where a policy problem can be solved in diverse ways.		X		(Engage2020 2014; Involve 2018; Tamarack Institute 2017; Ward 2009)
Citizens' summits	Large-scale deliberative public meeting (with 200 to 5000 participants) to explore citizens' attitudes about political priorities and potential actions provided on a basis that is informed. The objective is to provide inspiration and advice for political decision making where large-scale decision-making happens by voting. It provides a clear indication of attitudes and implies some degree of commitment by policy makers.		X		(Engage2020 2014; Involve 2018; Tamarack Institute 2017)

Public engagement technique	Description	High-level category			Source
		Communicate	Consult	Participate	
Citizens' assembly	Citizen body that deliberates on an issue or issues with between 50-250 participants that often lasts over several weekends. The objective is to use a representative sample of the public who can learn about an issue, assess options and make recommendations independently of policy makers. It usually has three phases: learning, deliberation and decision making. It involves reporting phase with recommendations that is presented to policy makers or citizens through a referendum.			X	(Engage2020 2014; Involve 2018)
Citizens' hearing	The objective is to create discussions and inform citizens. It gathers 20-25 citizens in a one-day discussion and uses brainstorming, dialogue, prioritisation, reasoning and voting. Citizens independently formulate their own suggestions and ideas and present them to policy makers.		X		(Engage2020 2014)

Public engagement technique	Description	High-level category			Source
		Communicate	Consult	Participate	
Citizens' panel	Representative and consultative body for local residents used to assess their opinions and preferences. They can range between a few hundred or several thousand participants. When there are more than 1,000 participants sub-groups are often formed. The group is often renewed throughout the process so the population sample is representative.		X		(Engage2020 2014; Involve 2018; Ward 2009)
Citizen Visions of Science, Technology and Innovation (CIVISTI)	Based on the notion that the definition of relevant and forward-looking research and innovation agendas can be improved by consulting citizens (often 25) at the stage of development. It uses citizens' concern about societal development to develop research programme priorities. It does not develop real-world models, but asks citizens what a desired future should look like.			X	(Engage2020 2014)
Civic/Public dialogue	Structured format for public dialogues that aims to create understanding among diverse people. It can build broad consensus and commitment on issues that are complex and/or controversial. It is not			X	(Engage2020 2014; Involve 2018)

Public engagement technique	Description	High-level category			Source
		Communicate	Consult	Participate	
	one method, but constitutes a range of methods. The main types include: i) public inquiries, ii) open public consultations, and iii) selective participation.				
Community appraisal	Surveys of local needs and issues. Many include the following steps: (1) having a steering committee for oversight; (2) writing up a questionnaire for households; (3) responses are sorted and reported on; (4) distribute the report in the community; (5) actions are agreed with relevant bodies; and (6) developments are monitored and reported to the community.		X		(Involve 2018)
Community-based (participatory) research	Involves the community in all stages of the research process (from setting questions, framing, doing research, interpreting results, and communication) to enable better understanding and an improvement of a certain issue. It can be combined with actions to implement findings, which results in participatory action research. It involves co-learning and transfer of expertise by all research			X	(Engage2020 2014)

Public engagement technique	Description	High-level category			Source
		Communicate	Consult	Participate	
	partners, shared decision making, and collective ownership of processes and products involved in research.				
Community indicator projects	Communities develop a vision for a sustainable future and use indicators they have developed to track the progress towards that future.		X		(Tamarack Institute 2017)
Community mapping	Participatory process for the public to map social, ecological and economic assets, and historical events of their community. It involves an accessible and graphic way to learn about perceptions of a place and is often used for vision processes.			X	(Tamarack Institute 2017)
Consensus conference	Aim is to expand on and enrich debate on a topic that is socially controversial. A group of 10-30 randomly selected citizens give their perspectives on a specific technological problem or challenge area. They discuss, consult experts and create recommendations in a conference that is often three to four days long. It often takes place in two stages: (1) a meeting with experts and		X		(Involve 2018; Ward 2009)

Public engagement technique	Description	High-level category			Source
		Communicate	Consult	Participate	
	stakeholders to achieve consensus; and (2) a conference where the main findings are presented to the public.				
Consensus voting	Normally lasts from half a day to one day and is used to identify consensus using a balanced voting system. Everyone in the group can suggest a proposal, a list of issues is drawn up, they vote on their preferences, and votes are counted.		X		(Engage2020 2014; Involve 2018)
Conversation café	Informal dialogue where people are invited to discuss an issue in an informal setting. It normally has 10-12 participants and lasts between 10-12 hours. The process takes place in four rounds, namely: (1) Round 1: a talking object is passed around for participant discussion; (2) Round 2: participants use the talking object to expand on their comments; (3) Dialogue: open and spirited conversation is encouraged; and (4) Final Round: using the object, participants highlight what they found meaningful.		X		(Engage2020 2014; Involve 2018)

Public engagement technique	Description	High-level category			Source
		Communicate	Consult	Participate	
Co-production	Service providers and users work together to reach a collective outcome. It is an approach to service design and decision-making rather than a specific method of public engagement.			x	(Involve 2018)
Crowd wise (similar to consensus voting)	Community participation method that encourages consensus-based decisions. Consensus develop in stages using a combination of discussion and votes on a set of pre-defined options. The number of citizens differ to encourage consensus in diverse contexts. It is often used to set priorities, allocate budgets, or respond to consultations.			X	(Engage2020 2014; Involve 2018)
Crowdsourcing	Process to gather ideas, functions, services, or contacts from a large and undefined network of people. The principle of openness underpins the exercise and uses bottom-up process to find goals that are often top-down. This approach tends to happen online.			X	(Engage2020 2014; Involve 2018; Tamarack Institute 2017; Ward 2009)
Science week	Method to communicate science to a set, target audience. The aim is to create enthusiasm for	X			(Engage2020 2014)

Public engagement technique	Description	High-level category			Source
		Communicate	Consult	Participate	
	science, technology and health for children and youth, and to develop interest in science curricula in primary, secondary and upper secondary levels of the school system.				
Deep democracy (the Lewis method)	Advanced group facilitation method carried out over one to two days in intense dialogues to access and bring out knowledge that already exists within a group and to identify 'creative potential' that might result from conflict.		X		(Engage2020 2014)
Deliberative mapping	Technique that combines varied approaches and involves both experts (around 20 participants) and the public (around 40 participants) to rate diverse policy options against a set of criteria. The objective is to create a process that allows for more democratic, robust and accountable decision making that reflects publics values. The citizens and experts discuss issues separately and then together at a workshop.			X	(Engage2020 2014; Involve 2018)

Public engagement technique	Description	High-level category			Source
		Communicate	Consult	Participate	
Deliberative workshops/ Public Dialogue Workshops/ Deliberative Policy Workshops	Dialogue events with 10-12 participants that focus on in-depth and informed discussions of issues that are either complex or controversial. The aim is to collect social intelligence to inform policy, anticipate regulation, exchange perspectives, or raise awareness. They have also been used for research agenda development and to create objectives that reflect public views. They were developed out of focus groups and other in-depth and deliberative alternatives.		X		(Engage2020 2014; Involve 2018)
Deliberative online forum	Discussions in online and web-based forums between informed individuals about issues of concern that lead to consensus and collective decisions. It has three main elements: (1) communicative or a discussion space online; (2) major and minor discussion spaces defined by the likely impact that participants can have on a political outcome; and (3) political culture and ideology to reflect the socio-political context		x		(Engage2020 2014; Tamarack Institute 2017)

Public engagement technique	Description	High-level category			Source
		Communicate	Consult	Participate	
Deliberative polls	Technique that combines deliberation in small groups picked based on random scientific sampling to ensure public consultation on public policy and electoral issues with 100-600 participants.		X		(Engage2020 2014; Involve 2018; Ward 2009)
Democs card game/ Play Decide	Card-game and policy exploration tool for small groups of people to engage with policy issues that are complex. The aim is to inform participants about a topic, enable them to express their views, seek common ground with other participants, and provide their preferred policy options. It does not require speakers or experts as required information is provided on cards.			X	(Engage2020 2014; Involve 2018)
Dialogue	Covers different methods that has the goal to share opinions and develop relationships. It can involve a few people or several hundred and aims to involve all stakeholders who can have an impact on or are influenced by an outcome.			X	(Engage2020 2014; Involve 2018)
Digital Storytelling	Participants create stories of their life collected using images and that are shared using online devices. It has		X		(Engage2020 2014; Tamarack Institute

Public engagement technique	Description	High-level category			Source
		Communicate	Consult	Participate	
	seven elements: a point of view, dramatic question, emotional content, narrative voice, the soundtrack, economy and pacing.				2017; Ward 2009)
Distributed dialogue	Decentralised approach that aims to develop discussions that are ongoing and embedded on a topic. Some of the engagement is organised by participants or groups themselves. It engages research communities, stakeholders and the public for strategy and policy development. It often involves several dialogue events organised by researchers and interested parties, in different geographical areas and using diverse mediums, such deliberative engagement exercises in different regions, devolved activities, setting up an online forum, and working with existing networks.			X	(Engage2020 2014; Involve 2018)
E-conference/E-panel	Temporary online forum that uses technologies for engagement on a specific topic. It can be used for educational sessions, business meetings or other events. E-panels are used for councils and other			X	(Engage2020 2014; Involve 2018; Ward 2009)

Public engagement technique	Description	High-level category			Source
		Communicate	Consult	Participate	
	organisations for regular online consultations with a specific group of citizens.				
E-petitions	Online paper petitions that are used to illustrate support for an opinion to put pressure on government.		X		(Engage2020 2014; Involve 2018)
Experiential	Techniques that enable the public to experience a technology (either a test prototype in the real world, interactive applications, or using VR simulations).			X	(Wouters et al. 2019)
Feedback kiosk	Booths that are static and placed in any space for people to give electronic feedback on services. They often involve electronically-operated touch screen devices to collect feedback to improve public services.		X		(Engage2020 2014; Involve 2018)
Festival	Forum to engage the public and make use of diverse formats for public engagement, including talks, discussions, workshops, hands-on activities, performance.	X			(NCCPE 2020a)

Public engagement technique	Description	High-level category			Source
		Communicate	Consult	Participate	
Focus group	Guided discussion of a small group of the public to gather information on a particular topic. Qualitative technique to determine people's preferences or for them to evaluate strategies and concepts. Participants are selected based on certain characteristics and work in groups of 6-12 people for approximately two hours.		X		(Engage2020 2014; Involve 2018; Tamarack Institute 2017; Ward 2009)
Fishbowl conversation	Technique where the room set-up requires speakers to sit in the centre of the room or a 'fishbowl' where the other participants sit around them in a circle and listen to the conversation. The aim of the conversation is to increase participation and understanding of an issue.		X		(Involve 2018; Ward 2009)
Future Search	Aims to encourage participants to think about an issue in a new way. Participants come from diverse stakeholder groups and are asked to open up their perspectives on new ideas and actions that can gain widespread support. The conference aims to find a common basis that all participants can support and			X	(Engage2020 2014; Involve 2018; Ward 2009)

Public engagement technique	Description	High-level category			Source
		Communicate	Consult	Participate	
	normally lasts for three days with 25-99 participants.				
Future workshop	Technique to plan and form a vision of the future, and to set out and prioritise the steps required to achieve the vision. The workshops contribute to goal and problem definition and usually involves 1-25 participants. It has three phases: (1) critical analysis phase of the situation/technology; (2) visionary phase that builds on the first phase to create visions; and (3) an implementation phase to turn visions into actions.		X		(Engage2020 2014; Government Office for Science 2017; Involve 2018)
Graphic recording	Technique of capturing the ideas of participants on a large piece of paper using images, word, artworks, and colour. It is often used to record meetings and other events.		X		(Engage2020 2014; Involve 2018)
Hackathon	Design sprint-like events that can last between a few hours and a week where people use technology to either improve or build new software in a collaborative way. Sometimes they are undertaken to achieve a			X	(Engage2020 2014; Involve 2018; Tamarack Institute 2017)

Public engagement technique	Description	High-level category			Source
		Communicate	Consult	Participate	
	specific goal, but they can also be used to explore open-ended and innovative ideas led by citizens or the public.				
Interview	Structured conversation to gather information from the public on a particular topic. Explores views, normative positions, beliefs, experiences, and motivations of an individual participant. They provide an in-depth understanding of a certain topic. Three formats exist, namely: (1) structured interviews with a set of pre-determined questions; (2) semi-structured with several key questions, but that also allows the interviewer to diverge from the pre-determined questions to explore and elaborate on certain issues; and (3) unstructured that starts with an open quest and develops according to responses.		X		(Engage2020 2014; Tamarack Institute 2017; Ward 2009)
Local issues forum/Area forum	The aim of the technique is to provide a greater voice in local decisions to encourage public participation in local public policy making. It is an online or in-person public commons where the public or elected officials can: ask			X	(Engage2020 2014; Involve 2018)

Public engagement technique	Description	High-level category			Source
		Communicate	Consult	Participate	
	questions, make public announcements, network with other citizens, monitor local opinion and ask for public input.				
Mass experiment	Involves volunteering citizens in scientific research for data collection purposes in a scientific project. It is a useful method for data collection that requires a great number of individual contributions that are spatially dispersed.		X		(Engage2020 2014)
Most significant change (MSC)	Form of participatory evaluation and monitoring. Participants describe the changes that will be recorded and analyse the data. It occurs throughout the programme cycle and provides insight to help manage a programme, whilst providing data on impact and outcomes.		X		(Tamarack Institute 2017)
Mystery shopping	"Mystery shopping a way of auditing services through the involvement of trained user volunteers. Mystery shoppers have been described as 'under-cover' service users."				(Engage2020 2014; Involve 2018; Ward 2009)
Multi Criteria Decision Analysis (MCDA)	Tool applied in complex decision making processes to identify a single most		X		(Engage2020 2014)

Public engagement technique	Description	High-level category			Source
		Communicate	Consult	Participate	
	preferred option, rank options, short-list options, or to make a distinction between acceptable and unacceptable possibilities.				
Public consultation	Technique used to ask groups of people to discuss their opinion on issues. Unlimited numbers of participants can be sent information about the subject, download it online, and respond via email or comment on the website.		X		(Engage2020 2014; Involve 2018)
Online discussion	Takes place online and support users to have conversations with one or more people by typing messages. Can involve between one to over 500 hundred participants.		X		(Engage2020 2014; Involve 2020)
Open Space (Technology)	Technique for the organisation of participant event for an unlimited number of participants that lasts between one to five days. It has three parts: (1) introduction to the plenum; (2) the sessions; and (3) a final round with the whole plenum.		X		(Engage2020 2014; Involve 2018; Tamarack Institute 2017; Ward 2009)
Open House	Events that present initiative to a wider public and secure	X			(Tamarack Institute

Public engagement technique	Description	High-level category			Source
		Communicate	Consult	Participate	
	a reaction in an informal manner. They are more informal than a traditional exhibition and are less structured than workshops. The public can attend the event at any time at a set location for a specified time and it can last between a few hours to several weeks. Different options will be displayed using interactive displays.				2017; Ward 2009)
Opinion poll/survey	Quantitative survey that measures the opinion of a sample of people on a particular topic.		X		(Engage2020 2014; Involve 2018; Tamarack Institute 2017)
Participatory appraisal	Broad empowerment approach that aims to develop community knowledge and encourages grassroot actions. It often uses several visual methods so that participants can use other means to communicate.			X	(Engage2020 2014; Involve 2018)
Participatory budgeting	Umbrella term that encompasses the involvement of citizens to exercise power or influence over local budgets, investment priorities and economic spending. It can be			X	(Engage2020 2014; Involve 2018; Tamarack Institute 2017)

Public engagement technique	Description	High-level category			Source
		Communicate	Consult	Participate	
	run as a one-off or cyclical process.				
Participatory design	Includes various tools such as consultations, workshops, and design workbooks. Often carried out with citizens who are concerned about a specific issue. It starts with a consultation phased with individuals and community organisations, followed by an interactive design process, which includes field tests with users of technologies or devices under development.			X	(Engage2020 2014)
Participatory Geographic Information Systems	Social learning tool that uses visual representation for facilitation of the event. It is often used for organisations involved in participation and local stakeholders who are interested in local issues.			X	(Involve 2018)
Participatory sensing/ Volunteer sensing/ Citizen observatory	Techniques that involve volunteers for data collection for research. It is facilitated by ICT platforms and often involves handheld devices such as smartphones and is often used for citizen science.			x	(Engage2020 2014)
Participatory strategic planning	Consensus-building workshop method that aims to bring communities together to explain how they envision			X	(Involve 2018)

Public engagement technique	Description	High-level category			Source
		Communicate	Consult	Participate	
	the development of their community or organisation in the next years. The number of participants varies between five and 50 and the event takes place over two days. There are four stages to the process: (1) creating a vision for the future of the community/organisation; (2) discussing the potential threats that create barriers to reaching the vision; (3) agreeing methods to reach the visions and overcoming obstacles; and (4) implementation planning.				
Participatory video	Set of approaches that involve communities and groups to shape and create their own films.			X	(Engage2020 2014; Involve 2018)
Perspective workshop	SWOT-inspired workshop to explore myths, generate new perspectives, and create guidelines on a technology or technological development. It often has 36-48 participants and lasts for one and a half day and combines group and plenary sessions.		X		(Engage2020 2014)
Planning for real events	Focussed on the 3-D model of a local area, where participants discuss strengths and weakness, and suggest		X		(Engage2020 2014; Involve 2018)

Public engagement technique	Description	High-level category			Source
		Communicate	Consult	Participate	
	how they would like the community to develop.				
Pop-up democracy	Temporary and site-specific installations for local and civic participation. The goal is to create spaces and opportunities for local activism and participation in the community.			X	(Involve 2018)
Q methodology	Research tool used to gain insights into diverse perspectives and can used to select participants for further discussion about the relevant issues. It involves three main stages: (1) definition of the concourse: defining the sum of all statements about an issue; (2) interviews and perspective identification where the issues from the first stage are presented to participants and they are asking to rank the statements (Q-sort of the Q-set); and (3) analysis and conclusions: statistical analysis to find correlations between individual viewpoints.		X		(Engage2020 2014)
Reflexive Interactive Design	Stakeholders, consumers, NGOs and citizens define the most important characteristics of a sustainable production-			X	(Engage2020 2014)

Public engagement technique	Description	High-level category			Source
		Communicate	Consult	Participate	
	consumption system and then design a production system to meet these demands. Carried out in several stages: (1) interviews with numerous stakeholders in the sector; (2) collective system analysis in a workshop; and (3) design ateliers where interested participants work together for two days to identify the important characteristics of a sustainable production system and to design the production system.				
Scenario workshop/ Scenario testing	Instrument used for participatory planning using dialogue and participation with stakeholders, local citizens, experts and policy makers. The aims are to facilitate dialogue, exchange experience and knowledge about barriers and enablers, improve understanding of the issue, and facilitate consensus on the solutions proposed by the involved groups. It is often a two-day meeting with 25-30 stakeholders.			X	(Engage2020 2014; Tamarack Institute 2017)
Science café	Event organised in an informal information to create a dialogue with participants	X			(Engage2020 2014)

Public engagement technique	Description	High-level category			Source
		Communicate	Consult	Participate	
	from the public and academia. An expert presents a subject concisely and openly and then opens the floor for discussion. The moderator aims to facilitate sharing of a wide range of issues related to the discussed subject.				
Science/Forum Theatre	Techniques that use creative approaches to bring complex issues alive with audiences who would not take part in more traditional processes. It encourages audience interaction and explores different approaches to deal with an issue.	X			(Engage2020 2014; Involve 2018)
Sentiment analysis/mapping	Technique to gather and analyse data on public perceptions.		X		(Smart Mobility Living Lab 2020)
Serious gaming	Techniques that serve as tools to gain complex knowledge and stimulate real-life events and/or processes, and to provide the participant with a problem-solving environment for training. It can also be used to develop innovative products and services.			X	(Engage2020 2014)

Public engagement technique	Description	High-level category			Source
		Communicate	Consult	Participate	
Social listening	Technique to capture 'natural' unsolicited opinions using text mining or content analysis. Examples include analysis of comments on social media (e.g. Facebook and Twitter).		X		(Calabrese et al. 2019; Keller et al. 2017)
Social media discussion/Town Hall	Social media platforms are used to convene a group online on ideas, solutions, and questions related to a particular topic. The dialogues are often posted with a hashtag (#) to keep dialogues specific to an event.		X		(Tamarack Institute 2017)
Survey	Tool used to gather quantitative or qualitative information from a given population. Can be conducted face to face or online.		X		(Participedia 2021a)
User committee/ Citizens' panel	Technique that involves regular meetings between users and other or citizens and other stakeholders to formally monitor and direct the research and innovation process or changes to the local community.		X		(Engage2020 2014; Tamarack Institute 2017)
Video	Video designed to educate and inform the public on a particular topic.	X			(Middleton 2017)

Public engagement technique	Description	High-level category			Source
		Communicate	Consult	Participate	
	Provides information on a particular topic in a manner that is engaging and interesting.				
World Café	Technique that uses an informal I setting to engage groups within organisations and in the public space. It follows seven core design principles: (1) set the context; (2) create a hospitable space; (3) explore questions that matter; (4) encourage contributions from everyone; (5) connect and learn from diverse perspectives; (6) listen together for insights, patterns and deeper reflection; and (7) collect and share shared discoveries.		x		(Engage2020 2014; Involve 2018)
World-Wide Views	Deliberative technique that aims to engage citizens in debates about important and challenging issues to give advice to policy makers. Citizens at numerous sites (with 100 participants at each meeting) discuss the same policy-related questions for the same issue on a given day. Citizens are given material beforehand and during the event and then vote on predefined questions. The views are reported online			x	(Engage2020 2014; Involve 2018)

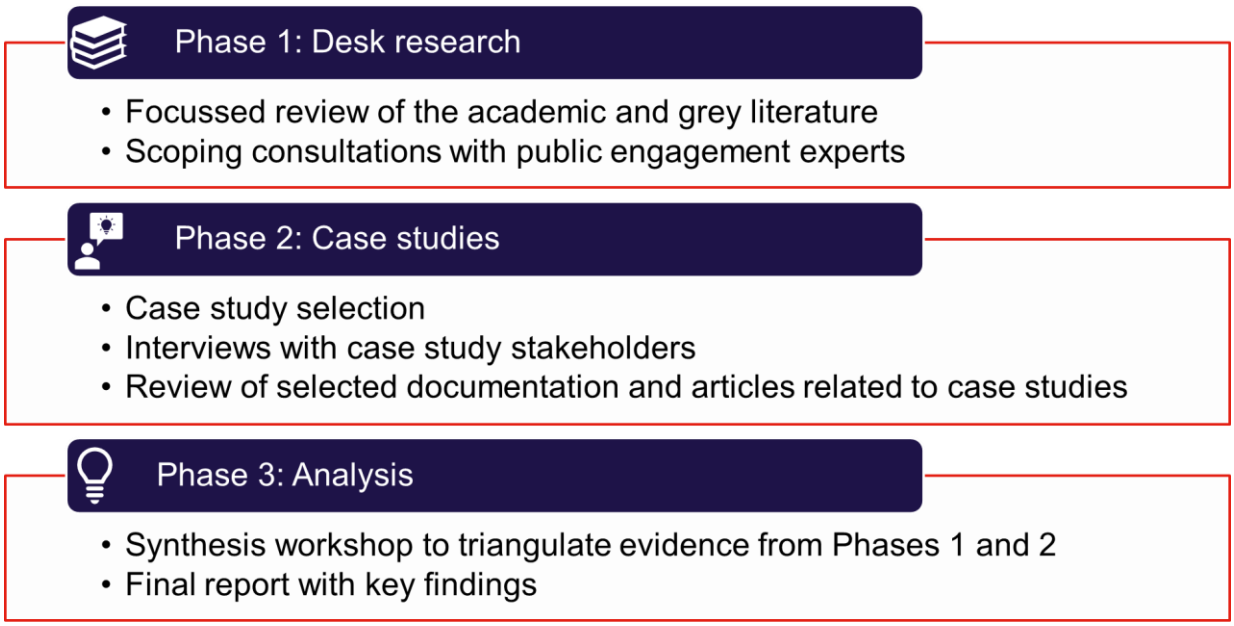
Public engagement technique	Description	High-level category			Source
		Communicate	Consult	Participate	
	for comparison and then analysed and presented to policy makers.				
Workshop	Intensive and structured meeting, which is led by a session leader and facilitator to work through an issue or develop solutions. An interactive workshop environment, effective group dynamics, visual aids and facilitated sessions aim to gather high quality information over a set time period in order to meet pre-determined goals.			x	(Engage2020 2014; Tamarack Institute 2017)
Written consultation	Way to gather outside opinions and diverse perspectives on an issue. They are created to engage with parties to gather intelligence, ideas and viewpoints on any type of issue.		x		(Engage2020 2014; Involve 2018)

Source: RAND Europe analysis

Annex C: Description of methodological approach

In this section, we provide a detailed description of the methodological approach we adopted in the study. The following figure provides an overview of the research approach.

Figure 1 Overview of methodology and approach



Source: RAND Europe

As the above figure shows, the study was conducted over three phases.

- **Phase 1** of the study included a focussed review of the literature which was complemented with consultations with public engagement experts, to refine the scope of the research questions. At the conclusion of phase 1, a long-list of case studies was identified
- **Phase 2** of the study focussed on the selection of ten case studies from the long-list identified at the end of phase 1. For the short-listed case studies, the study team reviewed additional documents relevant to the case studies and conducted interviews with stakeholders associated with each case study. The findings from the document review and the interviews were then incorporated as part of the case study write-ups.

- **Phase 3** of the study covered cross-analysis of the findings from the desk research in Phase 1 and the case studies in Phase 2. This cross-analysis was conducted via a virtual synthesis workshop by the core members of the study team. The resulting findings form the basis of the narrative presented in this report.

Each of these phases is discussed in more detail below.

C.1. Phase 1: Desk research

C.1.1. Focussed review of the academic and grey literature

We conducted a focussed review of the available academic and grey literature on public engagement techniques, technological innovation, and the effectiveness and impact of the techniques. As part of this review, we drew on some of the key principles of a systematic review to take a robust and replicable approach to searching and reviewing the literature. In order to ensure rapid turnaround of the findings, we adopted a pragmatic approach to the scope and coverage of literature, limiting study inclusion by using a range of criteria that were adjusted in response to the volume of literature identified, enabling them to be conducted within a more limited timeframe. The remaining sections set out our approach across four tasks:

- Conducting searches
- Screening
- Extraction
- Analysis

Conducting searches

We developed a search strategy with expert input from RAND Knowledge Services and BEIS/BRE. Our set of search terms and our search criteria are presented in **Table 5** and **Table 6**. The search was conducted in Scopus. The publication timeframe was restricted to 2016 onwards to capture literature from the past five years, and only high-quality academic publications (book chapters, articles, reviews and conference proceedings) published in English were considered. A total of 820 potentially relevant studies were identified for screening.

In addition to the formal searches, we conducted targeted searches of the grey literature. Searches were conducted in Google and Google Scholar using a similar search strategy and inclusion/exclusion criteria (**Table 6**) but also targeting key public engagement techniques/methods and/or a specific technological innovation to which the public engagement had been applied. An example of a targeted search

includes: ("public engagement" AND (technology OR technologies OR "technological innovation").

Beyond the formal searches, we also identified additional literature through ‘snowballing’. This is a process in which a small number of additional relevant studies are found through the quick review of the reference list of studies identified for inclusion at the end of the screening stage. From these, a total of 57 potentially relevant articles were identified for screening.

Table 5 Search terms used in the focussed literature review

	Search category	Search terms	Notes
1	Public engagement	(public OR citizen OR user OR lay OR community) w/2 (engagement OR science OR crowdsourc* OR involve* OR participation OR perception* OR opinion* OR dialogue* OR attitude* OR understanding OR awareness OR acceptability OR perspective*)	This set of search terms seeks to identify different forms of public engagement
AND			
2	Technological innovation	technolog* w/2 (new OR innovat* OR novel OR emerg* OR “cutting edge” OR “state-of-the-art” OR future)	This set of search terms seeks to identify technological innovations or new and emerging technologies
AND			
3	Regulation	governance OR regulat* OR polic* OR legislat* OR ethic* OR risk* OR trust* OR mistrust* OR distrust* OR skeptic* OR oversight	This set of search terms seeks to identify examples that consider some form of link between public engagement and impacts

	Search category	Search terms	Notes
			on regulation, governance or public trust

Screening

We screened articles by title and abstract for relevance against predefined inclusion and exclusion criteria (**Table 6**).

Table 6 Inclusion and exclusion criteria

Criterion	Include	Exclude	Rationale
Topic relevance	Studies addressing public engagement techniques or approaches in relation to technological innovation/emerging technologies, and any evidence of their impact or effectiveness	Studies addressing public engagement techniques or approaches in contexts outside of technological innovation (e.g. communication of research)	We propose to focus on the key aspects stipulated in the specification
Geographical location	All countries	N/A	We will not restrict the search to any particular countries to provide a global overview of public engagement techniques
Year of publication	2016 onwards	2015 or earlier (with some exceptions, e.g., any seminal studies referenced	We propose this time period (5 years) in order to optimise the identification of

Criterion	Include	Exclude	Rationale
		in multiple publications within the 5-year timeframe)	novel and innovative public engagement techniques across a spectrum of relevant technologies and limit spurious results (this is particularly relevant in the area of technological innovation where research and knowledge is advancing quickly)
Study type	Peer-reviewed journal publications, conference proceedings, grey literature with clear authorship	Documents without clear organisational authorship, theoretical work, letters, editorials, comments or opinion pieces, book reviews, sub-PhD level theses	The ‘study type’ selection criteria are intended to optimise the quality of sources in the literature search
Language	English	Other languages	It is expected that literature searches applying the English-language search terms will yield mostly English-language sources

The inclusion/exclusion criteria were applied in three stages:

- Criteria were applied on the titles. Those appearing to fit the criteria, or where there was uncertainty, were included.
- The abstracts of these titles were read, and inclusion criteria applied again. Those fitting the criteria or those where there was uncertainty were included. In these first two stages, we were overinclusive to avoid excluding potentially relevant studies.
- Reviewers retrieved full reports of studies passing the first round. Each criterion was then applied again at the full text level.

Following screening, a total of 42 studies were identified as meeting the inclusion criteria.

Extraction

In this stage, information was extracted from each included publication to facilitate cross-analysis against the key study questions and themes, and the quality of the studies included assessed to inform that analysis.

Following piloting, researchers independently recorded data about each selected paper meeting the inclusion criteria, including both general information on the publication and information on the elements of each study question it addressed. We captured information from each included study in a standard template in Excel covering the different elements of our conceptual framework and in line with the aims and objectives of this study:

General information about the evidence source

- Author, year and study title
- Brief summary
- Study type (e.g. experimental/randomised controlled trial, cohort/longitudinal, cross-sectional/factorial, meta-analysis, synthesis)
- Methodology (e.g. qualitative data collection, quantitative data collection, mixed methods)
- Publication type (e.g. journal article, review, book chapter)
- Coverage of study (temporal, geographic)

Evidence on public engagement techniques and applications in relation to new technologies and technological innovation

- Method of public engagement technique(s) used in the study

- The new technology or technological innovation that was the focus of the engagement
- The sector that the technology or technological innovation was being applied to
- The country in which the engagement process took place
- The stakeholder group(s) involved in the engagement
- How and when the public engagement technique was applied – information about the public engagement process and application

Evidence on the impact of public engagement techniques

- The impact or outcome of the public engagement

Evidence on the effectiveness of public engagement techniques and any learnings

- Was the effectiveness of the public engagement technique(s) (formally) assessed?
- Evidence of the effectiveness of the technique (how and why was it effective or not effective?)
- Evidence on the following criteria in relation to the public engagement technique, e.g. cost, burden, speed of deployment, inclusive representation
- Any key lessons learned from any (formal) assessment of effectiveness of the public engagement technique(s)
- Other comments

Analysis

The evidence was brought together using a framework synthesis approach based on the framework set out in our evidence extraction approach.

Each element of the framework was explored initially by a member of the study team to identify the key trends and issues emerging. The findings were then discussed with other members of the team and then further explored. Through an iterative process of analysis and discussion we were able to identify a set of key emerging findings that are set out in this document.

As part of the extraction and analysis of the focussed review of the literature, we collated a long-list of potential studies as per the study objectives. This list was further augmented based on the inputs received from the public engagement experts with whom we spoke as part of the scoping consultations.

C.1.2. Scoping consultations

We conducted seven scoping consultations with individuals involved in or with knowledge of public engagement around technology. The aim of this engagement process was to: (1) strengthen our baseline understanding of, and insights specific to, the public engagement techniques for technological innovation in the UK; (2) gather information related to the success/effectiveness of engagement initiatives; and (3) obtain examples of public engagement from these stakeholders that could feed into the case studies in Phase 2 of the study.

Interviews were conducted by telephone or e-mail. The interviews were semi-structured, thereby ensuring a similar set of questions were asked of all interviewees but allowing for emergent issues to be explored. The organisations we engaged with are as follows: Ada Lovelace Institute; Involve; Nesta; Royal Society; Society Inside; UKRI; and a UK-based Higher Education Institution (HEI). All consultations were conducted under the principles of informed consent in line with the requirements of the EU General Data Protection Regulation requirements and the Ethical Assurance for Social Research in Government principles

At the conclusion of Phase 1, an interim report providing the emerging findings from the focussed review of literature and scoping consultations was provided to BEIS/BRE for review.

C.2. Phase 2: Case studies

C.2.1. Case study selection

As indicated in the previous section, as part of Phase 1 of the study (focussed review and scoping consultations), a long-list of potential case studies was compiled based on the results of the focussed literature review and scoping consultations showcasing a spectrum of real-world public engagement techniques in relation to technological innovation. The examples spanned different technology areas, countries, sectors, organisations, time periods and public engagement techniques.

For each of these examples, we collated the following information to make the selection for the final case studies: technology area, sector, organisation(s), timescale, public engagement technique(s)/method(s), and any information related to the potential effectiveness (for non-UK examples, we also noted the country).

Initial recommendations from the long-list of potential case studies

The initial long-list contained 36 potential case studies. On the basis of these case studies, three core members of the study team participated in a virtual workshop to conduct a holistic assessment of the long-list with a view to arriving at an initial set of

recommended case studies to develop further. In this workshop, each of the case studies was examined for their fit with the study objectives, range of public engagement techniques used, technological innovations covered, evidence of effectiveness and the availability of stakeholders for an interview. In addition, the sectors impacted and the country/region in which the public engagement was carried out were also considered. Another criterion for short-listing case studies was the strength of evidence in the literature associated with each case study; some examples had more extensive and rigorous evidence associated with them than others.

Based on these factors, the core members of the study team assigned a possible recommendation of 'Yes', No', and 'May be' to each case study for further in-depth investigation. Out of the potential 36 case studies, 11 case studies were identified as 'Yes', 13 were marked as 'No', and 12 were highlighted as 'May be' for further consideration and discussion with BEIS/BRE.

Discussion and short-listing of the case studies with BEIS/BRE

On the basis of the initial long-list of case studies and potential recommendations for inclusion / exclusion, we had a detailed discussion with BEIS/BRE. As part of this discussion, the long-list of case studies was examined for various criteria, including novel public engagement techniques, country of origin, potential availability of the evidence, and the technological innovation covered by the public engagement techniques. At this stage, based on the evidence from the focussed literature review and scoping consultations we had identified two additional potential case studies as part of the long-list (which was now 38 case studies), which were also discussed. BEIS/BRE decided upon an initial short-list of 10 case studies on the basis of which we approached stakeholders associated with the case studies for interviews.

Due to unavailability of stakeholders for interviews, one of the case studies in the initial short-list was deemed unattainable and needed to be replaced. We proposed four potential alternatives from our initial long-list, including three further, previously unidentified case studies in the long-list (which was now 41 case studies). Annex A contains the final short-list of 10 case studies agreed with BEIS/BRE. The long-list of case studies is included in Annex D for reference.

C.2.2. Interviews with case study stakeholders

With the short-list of case studies finalised, we approached multiple stakeholders associated with each of the case studies for an interview. In order to ensure a balanced perspective on the effectiveness of the public engagement techniques used and impact achieved, where possible we targeted the organisers of the public engagement exercise along with participants and technology partners.

The interviews were conducted in a semi-structured format under the principles of informed consent as per the GDPR and the Ethical Assurance for Social Research in Government principles. To protect the anonymity of the interviewees, they have not been named in this report. Across the 10 case studies, we conducted 20 interviews with various stakeholders associated with the case studies.

We include below the indicative set of questions covered with the interviewees as part of the discussion. The interviewer adapted the questions in line with the interviewee's experience and expertise.

- What was the purpose of the public engagement?
- How was the public engagement carried out?
- How effective was the public engagement? (e.g. in terms of influencing regulation, alternatives to regulation, public trust, new business models)?
- What lessons can be learned from this example?
- Are there any key pieces of literature that we should include or focus on regarding this example (this can include academic literature or relevant reports from organisations)?

C.2.3. Review of selected documentation and articles related to case studies

In addition to the interviews, we also conducted highly targeted searches to identify documentations and articles relevant to each case study. These searches focussed on identifying reports and peer-reviewed articles discussing evaluation of the public engagement exercise and also any evidence of effectiveness of the public engagement technique employed. The searches and the review of the documentation was carried out in parallel with the stakeholder interviews. We also drew on the inputs of the stakeholders interviewed to identify relevant literature. The articles reviewed are cited as part of the case study descriptions included in Annex A.

The findings from the interviews with relevant stakeholders and the document review for the case studies were used to write case study descriptions. Along with the insights gathered as part of the focussed literature review, the case study descriptions were used for the synthesis workshop and the final report writing as part of Phase 3 of the study.

C.3. Phase 3: Analysis

C.3.1. Synthesis workshop to triangulate evidence from Phases 1 and 2

Core members of the study team participated in a virtual workshop aimed at effective synthesis of the evidence from Phases 1 and 2. The evidence from the focussed literature review, in terms of the different types of public engagement techniques, the discussion in the literature on the effectiveness of the techniques, and the suitability of the techniques depending on the objectives of the engagement exercise, was cross-analysed with the observations from the case studies on the use of the techniques in practice.

For each case study, we considered the public engagement technique used, the technology area, the geographical context, the duration of the exercise, effectiveness in terms of engaging general public (and sustaining the engagement), change in real-world practice, and potential impact (e.g. in terms of increased public trust or improved understanding of the technological innovation). The cross-analysis also considered potential gaps in the evidence, in particular some case studies appear to have employed multiple techniques and the extent to which the techniques worked effectively in conjunction with each other was also a crucial aspect of the discussion.

Guided by the evidence in the focussed review of the literature in Phase 1, the workshop covered possible typologies of the public engagement techniques and how these aligned with the focus of the study on public engagement in relation to technological innovation. Although implications of the techniques beyond technological innovation were considered, the workshop outcome was to cluster the evidence from Phase 1 and Phase 2 to identify key lessons learnt and inform the choices available to regulators and policy makers. The outcome of the workshop in terms of clustering of the evidence and potential gaps in it has been used to structure the narrative presented in the main text of this report.

C.3.2. Final report with key findings

As part of the final reporting, we collated the findings from Phase 1 and Phase 2 of the study on the basis of the three high-level research questions that guide this study. For each question, the insights from the literature review formed the baseline of the findings reported. We drew on the case studies for additional practical insight to understand the effectiveness of the techniques and context in which the technique is most likely to be useful.

The key findings have been grouped to enable quick discovery of the range of public engagement techniques employed for technological innovation, evidence of impact of the different engagement techniques, and any formal assessments on the effectiveness of the techniques. We have used message-led headings in the sub-

sections to communicate the findings in a succinct manner for a non-expert reader. Detailed case study descriptions have been included in the annex to enable a reader to understand specific use of the techniques in more depth if required.

C.4. Caveats of the analysis

The analysis presented here is subject to some caveats related to the approach, the scope of the literature and the analysis. Key limitations are outlined below and the findings from this study should be considered bearing these limitations in mind.

The study conducted a focussed review rather than a systematic review. This places limitations on the coverage of literature included in the study. There may be important studies that have not been included, either because they were not identified through our search strategy or because they fell outside of our inclusion criteria (e.g. by date). We note that the volume of literature in the field here has been a significant challenge and we have had to place additional limitations on the scope of our approach to make the study feasible within timeframes (e.g. by focusing on more recent literature). We are confident, however, based on the approach taken and our scoping consultation process, that our analysis provides a fair and relatively representative picture of the current state of the evidence.

Because of the complexity and richness of the literature, it is likely that there are a number of elements even within the studies included that have not been fully explored within the scope of this report. We have balanced length and complexity with comprehensiveness, aiming to provide an overall picture of the key emerging issues with a focus on the study questions identified for this work.

While we aimed to ensure that we captured as many relevant and interesting examples, the list of case studies was not intended to be definitive or exhaustive. Rather they served as concrete, illustrative examples of how public engagement techniques has been used in the context of technological innovation. The final set of case studies highlight a spectrum of public engagement techniques ranging from traditional techniques to more atypical techniques, in relation to technological innovation. In addition, the examples spanned different technology areas, sectors, organisations, and time periods.

Annex D: Long-list of case studies illustrating the use of public engagement techniques in the context of technological innovation

Title, year, and country/region	Technology/ innovation, and sector	Public engagement technique and brief description of the engagement
Public views of mitochondrial replacement therapy **Year:** 2012 **Country/region:** United Kingdom	Mitochondrial replacement therapy **Sector**: Medical	**Public engagement technique:** Deliberative: workshop **Brief description:** The Human Fertilisation and Embryology Authority used a multi-method approach, including workshops, a public survey, open meetings and focus groups to determine public acceptability of mitochondrial replacement therapy.
Public views of machine learning **Year:** 2017 **Country/region:** United Kingdom	Machine learning **Sector:** Technology/IT	**Public engagement technique:** Online survey, and deliberative methods: public dialogue and discussion groups, online community **Brief description:** The Royal Society conducted a public engagement exercise consisting of a quantitative survey, public dialogue and discussion events and an online community on machine learning to raise awareness, to understand views held by the public and identify key social, ethical, scientific and technical issues.
Public attitudes towards GM foods	GM foods **Sector:** Agriculture	**Public engagement technique:** Face-to-face survey

Title, year, and country/region	Technology/ innovation, and sector	Public engagement technique and brief description of the engagement
Year: 2019 **Country/region:** United Kingdom		**Brief description:** British social attitudes survey asked about attitudes towards GM foods (e.g. if the UK should grow GM food, if the advantages outweigh the risks).
Public attitudes towards nanotechnology **Year:** 2014 **Country/region:** United Kingdom	Nanotechnology **Sector:** Technology/IT	**Public engagement technique:** Face-to-face survey **Brief description:** Survey asked whether the advantages of nanotechnology outweighs the risks
Public attitudes towards AI (general use of AI) **Year:** 2019 **Country/region:** Global	AI **Sector:** Technology/IT	**Public engagement technique:** Online survey using online platform **Brief description:** Global survey on attitudes towards AI (e.g. concern about use of AI, whether AI should be banned). The survey was conducted in 27 countries via Global Advisor, the online survey platform of Ipsos.
Public attitudes towards AI (ethical use of AI) **Year:** 2019 **Country/region:** United Kingdom	AI **Sector:** Technology/IT	**Public engagement technique:** Deliberative i.e. citizens' jury **Brief description:** The RSA and Deep Mind convened a citizens' jury to deliberate on the ethical use of AI, and in particular, its use to help make decisions.
Public attitudes towards AI and associated technologies	AI **Sector:** Technology/IT	**Public engagement technique:** Deliberative: workshop **Brief description:**

Title, year, and country/region	Technology/ innovation, and sector	Public engagement technique and brief description of the engagement
Year: 2018 **Country/region:** United Kingdom		Involve and Nesta delivered a one-day workshop to explore how members of the public might approach some of the biggest questions around AI and associated technologies.
Public engagement, awareness-raising, communication and the testing of policies **Year:** 2016 **Country/region:** EU	Nanotechnology **Sector:** Medical	**Public engagement technique:** Serious game: scenarios **Brief description:** The Scenario Exploration System, designed by the European Commission, is a board game designed to get people thinking about the future, from different viewpoints (policy maker, citizen, business or civil society organisation).
Public perceptions of the use of virtual reality in healthcare **Year:** 2016 **Country/region:** USA	Virtual reality **Sector:** Medical	**Public engagement technique:** Social listening **Brief description:** Researchers from the Cedars-Sinai Medical Center in Los Angeles analysed over 2,400 comments on a video on Facebook about the use of VR in healthcare.
Public debate on the regulation of Uber in Taiwan **Year:** 2015 **Country/region:** Taiwan	Ride-hailing apps (Uber) **Sector:** Transport	**Public engagement technique:** Online deliberative and crowdsourcing platform: open source, online survey tool **Brief description:** The vTaiwan platform is based on pol.is, an open source, online survey tool designed to engage the public in large-scale deliberation. In 2015, the

Title, year, and country/region	Technology/ innovation, and sector	Public engagement technique and brief description of the engagement
		platform organised a debate on the regulation of Uber in Taiwan, attracting 1,737 participants.
Public debate about governing artificial intelligence **Year:** 2017 **Country/region:** Global	AI **Sector:** Technology/IT	**Public engagement technique:** Crowdsourcing **Brief description:** In 2017 the AI Initiative launched a 7-month online Global Civic Debate. The software it uses (Assembly) uses algorithms to structure and organise participant contributions.
Public perspectives on moral decisions made by AI **Year:** 2018 **Country/region:** USA	Driverless cars **Sector:** Transport	**Public engagement technique:** Serious game **Brief description:** MIT have developed Moral Machine, an online platform for gathering human perspectives on moral decisions made by machine intelligence, such a self-driving cars.
Public participation in climate policy **Year:** 2013 **Country/region:** United Kingdom	Decarbonising the economy **Sector:** Energy	**Public engagement technique:** Online experimental platform **Brief description:** The Department for Energy and Climate Change have developed an online tool that uses gamified and scenario based methods for the public to input on climate change policies.
Public attitudes towards genomic data sharing **Year:** Ongoing **Country/region:** United Kingdom	Genome editing **Sector:** Medical	**Public engagement technique:** Online survey with educational videos **Brief description:** The 'Your DNA, Your Say' project is a global online survey gathering public attitudes towards genomic data sharing.

Title, year, and country/region	Technology/ innovation, and sector	Public engagement technique and brief description of the engagement
Public dialogue on genome editing **Year:** 2016 **Country/region:** United Kingdom	Genome editing **Sector:** Medical	**Public engagement technique:** Deliberative: public dialogue **Brief description:** The Nuffield Council on Bioethics and Sciencewise organised a workshop with policy makers, funders and dialogue specialists on genome editing techniques.
Public awareness on synthetic biology technology **Year:** 2012 **Country/region:** Canada	Synthetic biology technology **Sector:** Medical	**Public engagement technique:** Deliberative: scientific café **Brief description:** The authors conducted five Science Cafés across Canada to gauge public awareness of synthetic biology technology and its potential applications.
Exploring determinants of solar power adoption **Year:** 2014 **Country/region:** Canada	Solar power **Sector:** Energy	**Public engagement technique:** Survey **Brief description:** National survey of 2065 Canadian residents to identify the determinants of technology adoption intention with the exemplary case of rooftop solar.
Public acceptance of, and attitudes towards, driverless vehicles **Year:** 2017 **Country/region:** United Kingdom	Autonomous vehicles **Sector:** Transport	**Public engagement technique:** Experiential: live trials **Brief description:** GATEway Project overseen by the Transport Research Laboratory and other partners to test prototype automated vehicles in a real-world environment.

Title, year, and country/region	Technology/ innovation, and sector	Public engagement technique and brief description of the engagement
GM Nation **Year:** 2002 **Country/region:** United Kingdom	GM crops **Sector:** Agriculture	**Public engagement technique:** Deliberative: public meetings & workshops **Brief description:** A public engagement process overseen by a government-appointed steering board to discuss genetic modification of food crops.
NanoJury UK **Year:** 2005 **Country/region:** United Kingdom	Nanotechnology **Sector:** Multiple	**Public engagement technique:** Deliberative: citizen's Jury **Brief description:** This 'citizen's jury' brought together twenty people, chosen to represent a broad cross section of society but also inclusive of a number of ethnicities and religions, to discuss issues surrounding nanotechnology.
Public consultation on preimplantation genetic diagnosis (PGD) **Year:** 2005 **Country/region:** United Kingdom	PGD for non-medical sex selection **Sector:** Medical	**Public engagement technique:** Public consultation **Brief description:** In 2005, the Human Fertilisation and Embryology Authority ran a consultation on options for the regulation of sex selection through preimplantation genetic diagnosis and other methods (such as sperm sorting).
Dialogue on online targeting **Year:** 2019 **Country/region:** United Kingdom	AI **Sector:** Technology/IT	**Public engagement technique:** Deliberative: workshop; Online survey **Brief description:** The Centre for Data Ethics and Innovation, with support from Sciencewise, ran a dialogue which explored public attitudes towards online targeting.
AI 360 **Year:** 2019 **Country/region:** Denmark	AI **Sector:** Technology/IT	**Public engagement technique:** Deliberative: workshop and citizen consultation **Brief description:** AI 360, an initiative within the Human Brain Project, was a new, two-stage experiment in public engagement. This innovated on the classic, deliberative dialogue model that

Title, year, and country/region	Technology/ innovation, and sector	Public engagement technique and brief description of the engagement
		DBT had previously applied to a variety of other topics in science and technology.
Consumer Attitudes towards Emerging Technologies **Year:** 2019 **Country/region:** United Kingdom	New food technologies **Sector:** Food	**Public engagement technique:** Deliberative: public dialogue **Brief description:** The Food Standards Agency conducted four public dialogue events to explore the views of members of the public towards four emerging technologies: GM foods, nanotechnology in foods, food from cloned animals and cultured meat.
Public dialogue on genomic medicine **Year:** 2018 **Country/region:** United Kingdom	Genome editing **Sector:** Medical	**Public engagement technique:** Deliberative: Public dialogue **Brief description:** Genomics England ran a public dialogue, with support from Sciencewise, to explore public attitudes to mainstreaming genomic medicine into the NHS.
Public dialogue on data science **Year:** 2015 **Country/region:** United Kingdom	Data science **Sector:** Government policymaking and service provision	**Public engagement technique:** Deliberative: workshops; Survey **Brief description:** The Government Data Science Partnership ran a public dialogue on data science ethics, including deliberative workshops, a survey and an online engagement tool/quiz, to inform a Data Science Ethical Framework.
EPSRC public dialogue on Quantum Technologies **Year:** 2017	Quantum technologies **Sector:** Not specified /multiple	**Public engagement technique:** Deliberative: workshop **Brief description:** Kantar Media carried out workshops to better understand how the public views and feels about the Quantum Technologies (QTs) currently being developed by researchers and their potential applications.

Title, year, and country/region	Technology/ innovation, and sector	Public engagement technique and brief description of the engagement
Country/region: United Kingdom		
Citizen deliberations on climate and energy **Year:** 2009 **Country/region:** Global	Climate change **Sector:** Sustainability /climate change	**Public engagement technique:** Deliberative: online platform **Brief description:** World Wide Views on Global Warming, held on September 26, 2009, was the first-ever globe encompassing democratic deliberation involving roughly 4000 citizens in 38 countries.
Views on the future of neural interfaces **Year:** 2019 **Country/region:** United Kingdom	Neural interfaces **Sector:** Not specified /multiple	**Public engagement technique:** Deliberative: public dialogue **Brief description:** The Royal Society ran a series of public dialogues looking at neural interfaces to inform the Society's thinking on the regulatory and ethical issues associated with the emerging field.
ByoLogyc: exploring future scenarios through immersive experience design **Year:** 2012-13 **Country/region:** Canada	Biotechnology **Sector:** Consumer Health	**Public engagement technique:** Experiential: immersive experience **Brief description:** ByoLogyc was an experiential futures project, which explored the possible impacts of biotechnology in the context of consumer health. The project developed a fictional company, fictional employees and live events that participants could engage with.
Public attitudes to facial recognition technology **Year:** 2019	Facial recognition technology **Sector:** Multiple (surveillance)	**Public engagement technique:** Survey **Brief description:** Ada Lovelace Institute commissioned YouGov to undertake the first survey of its kind to understand public attitudes in the UK to the emerging public and private

Title, year, and country/region	Technology/ innovation, and sector	Public engagement technique and brief description of the engagement
Country/region: United Kingdom		sector deployment of facial recognition technology.
Collaborative storytelling that explores the impact of climate change **Year:** N/A **Country/region:** Global	Climate change **Sector:** Sustainability /climate change	**Public engagement technique:** Crowdsourcing **Brief description:** The FutureCoast storytelling project developed by US games designer, Ken Eklund, in collaboration with the PoLAR Institute at Columbia University: an international online digital storytelling project which asks audiences to imagine and create voicemails from a range of possible climatically changed futures.
CAV public acceptability dialogue **Year:** 2018 **Country/region:** United Kingdom	Connected and autonomous vehicles **Sector:** Transport	**Public engagement technique:** Deliberative: public dialogue **Brief description:** The UK Government in partnership with Sciencewise, funded by UK Research and Innovation, commissioned Traverse to deliver a set of public dialogues on attitudes towards connected and automated vehicles (CAVs).
Exploring public attitudes towards gene editing **Year:** 2018 **Country/region:** United Kingdom	Gene editing **Sector:** Medical	**Public engagement technique:** Deliberative: workshops **Brief description:** Gene Gap was a project to explore people's attitudes towards gene editing. Five facilitated workshops were run with diverse communities across the UK.
BioMetric Mirror **Year:** 2018-19 **Country/region:** Australia	Facial analysis technology **Sector:** Multiple (surveillance)	**Public engagement technique:** Experiential: interactive application **Brief description:** Biometric Mirror, a case study that explored opinions about the ethics of an emerging technology. The interactive application

Title, year, and country/region	Technology/ innovation, and sector	Public engagement technique and brief description of the engagement
		distinguished demographic and psychometric information from people's facial photos and presented speculative scenarios with potential consequences based on their results.
Immersive environments in the context of an innovation process for smart cities **Year:** 2015-16 **Country/region:** France	Smart cities **Sector:** Urban governance	**Public engagement technique:** Experiential: immersive experience **Brief description:** Fab Living Lab Platform: immersive environment to engage different stakeholders. Citizens' workshops are hosted and supported by the LF2L platform. The LF2L innovation process was used in the context of Smart City policies.
Rapid online deliberation on COVID-19 technologies **Year:** 2020 **Country/region:** United Kingdom	COVID-19 contact tracing app **Sector:** Public health	**Public engagement technique:** Deliberative: online using Zoom **Brief description:** Traverse, Ada Lovelace Institute, Involve and Bang the Table trialled a new model of rapid, online deliberation that would enable citizens to feed into the development of policy for moving out of lockdown.
UK Citizens' Biometric Council: a Citizens' Assembly on the Use of Facial Recognition Technology **Year:** 2020	Biometrics **Sector:** Multiple (surveillance)	**Public engagement technique:** Deliberative: citizens' assembly **Brief description:** Following a national survey that found majority support for the regulation of facial recognition technology, the Ada Lovelace Institute has announced the establishment of a citizens' assembly to review the evidence around biometrics.

Title, year, and country/region	Technology/ innovation, and sector	Public engagement technique and brief description of the engagement
Country/region: United Kingdom		
Bioenergy Distributed Dialogue **Year:** 2012-14 **Country/region:** United Kingdom	Bioenergy **Sector:** Energy	**Public engagement technique:** Deliberative: distributed dialogue **Brief description:** BBSRC, on behalf of the UK Research Councils, undertook a public dialogue (distributed dialogue) to help ensure that contemporary public views, concerns and aspirations were taken into account by research funders and researchers in the area of bioenergy.
CIMULACT **Year:** 2015-16 **Country/region:** EU	Multiple **Sector:** S&T Policy	**Public engagement technique:** Deliberative: workshops **Brief description:** Led by the Danish Board of Technology, more than 1,000 citizens met during the winter 2015-2016 at national vision workshops where they expressed their dreams for a sustainable and desirable future.
Public Dialogue on Drones **Year:** 2015-16 **Country/region:** United Kingdom	Drones **Sector:** Transport	**Public engagement technique:** Deliberative: workshops **Brief description:** A public dialogue was commissioned by the Department for Transport and the Ministry of Defence with support from the Sciencewise programme. It explored the public's understanding of drones, attitudes towards current usage, and public expectations, aspirations and concerns about future usage.

References

Abdul, Ashraf, Jo Vermeulen, Danding Wang, Brian Lim, and Mohan Kankanhalli. 2018. 'Trends and Trajectories for Explainable, Accountable and Intelligible Systems: An HCI Research Agenda'. In *CHI '18: Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, 1–18.

Ada Lovelace Institute. 2019. *Beyond Face Value: Public Attitudes to Facial Recognition Technology*. London: Ada Lovelace Institute.

———. 2020. *Confidence in a Crisis? Building Public Trust in a Contact Tracing App*. London: Ada Lovelace Institute.

Ada Lovelace Institute, Traverse, Involve & Bang the Table. 2020. Deliberating rapidly and online about COVID-19 technologies. As of 6 January 2021: https://www.adalovelaceinstitute.org/event/deliberating-rapidly-and-online-about-covid-19-technologies/

Aicardi, Christine, Lise Bitsch, Saheli Datta Burton, Kathinka Evers, Michele Farisco, Tara Mahfoud, Nikolas Rose, Achim Rosemann, Arleen Salles, Bernd Stahl & Inga Ulnicane. 2020. 'Trust and Transparency in Artificial Intelligence (D12.–.4 - SGA2)'. sos-ch-dk-2.exo.io, 21 October. As of 6 January 2021: https://sos-ch-dk-2.exo.io/public-website-production/filer_public/95/15/9515ee61-bc63-43df-aad6-14a5649bc5d3/d1254_d794_d51_sga2_m24_accepted_200731.pdf

Allan, Sarah. 2016. '9 Steps to Getting Public Engagement Right'. involve.org.uk, 17 February 2016. As of 6 January 2021: https://www.involve.org.uk/resources/blog/opinion/9-steps-getting-public-engagement-right

Altamirano-Allende, C., & C. Selin. 2016. 'Seeing the City: Photography as a Place of Work'. *Journal of Environmental Studies and Sciences* 6 (3): 460–69.

Alvarez, W. M., M. Angel De Miguel, F. Garcia & C. Olaverri-Monreal. 2019. 'Response of Vulnerable Road Users to Visual Information from Autonomous Vehicles in Shared Spaces'. In *2019 IEEE Intelligent Transportation Systems Conference (ITSC), Auckland, New Zealand, 2019*, 3714–19.

Armstrong, H., C. Gorst & J. Rae. 2019. 'Renewing Regulation: "Anticipatory Regulation" in an Age of Disruption'. nesta.org.uk, 6 March 2019. As of 6 January 2021: https://www.nesta.org.uk/report/renewing-regulation-anticipatory-regulation-in-an-age-of-disruption/

Arnaldi, S. 2018. 'Retooling Techno-Moral Scenarios. A Revisited Technique for Exploring Alternative Regimes of Responsibility for Human Enhancement'. *NanoEthics* 12 (3): 283–300.

Arning, K., J. van Heek & M. Ziefle. 2018. ‘Acceptance Profiles for a Carbon-Derived Foam Mattress. Exploring and Segmenting Consumer Perceptions of a Carbon Capture and Utilization Product’. *Journal of Cleaner Production* 188: 171–84.

Awad, Edmond, Sohan Dsouza, Richard Kim, Jonathan Schulz, Joseph Henrich, Azim Shariff, Jean-François Bonnefon & Iyad Rahwan. 2018. ‘The Moral Machine Experiment’. *Nature* 563 (7729): 59–64.

Bainbridge, Wilma A., Phillip Isola & Aude Oliva. 2013. ‘The Intrinsic Memorability of Face Photographs’. *Journal of Experimental Psychology: General* 142 (4): 1323–34.

Balaram, B., T. Greenham & J. Leonard. 2018. *Artificial Intelligence: Real Public Engagement*. London: Royal Society for the encouragement of Arts, Manufacturers and Commerce.

Bandewar, S. V. S., F. Wambugu, E. Richardson & J. V. Lavery. 2017. ‘The Role of Community Engagement in the Adoption of New Agricultural Biotechnologies by Farmers: The Case of the Africa Harvest Tissue-Culture Banana in Kenya’. *BMC Biotechnology* 17 (1).

BBSRC (Biotechnology and Biological Sciences Research Council). 2005. ‘Nanotechnology Dialogue’. bbsrc.ukri.org, October 2005. As of 6 January 2021: https://bbsrc.ukri.org/engagement/dialogue/activities/activities-nanotechnology/

———. 2013. ‘Bioenergy Public Dialogue’. bbsrc.ukri.org, December 2013. As of 6 January 2021: https://bbsrc.ukri.org/engagement/dialogue/activities/bioenergy-dialogue/

BEIS (Department for Business, Energy & Industrial Strategy). 2019. ‘Regulation for the Fourth Industrial Revolution’. gov.uk, Research and analysis, 11 June 2019. As of 6 January 2021: https://www.gov.uk/government/publications/regulation-for-the-fourth-industrial-revolution

———. 2020. ‘Public Attitudes to Science’. gov.uk, Research and analysis, 17 July 2020. As of 6 January 2021: https://www.gov.uk/government/publications/public-attitudes-to-science-2019

Bellamy, R., & J. Lezaun. 2017. ‘Crafting a Public for Geoengineering’. *Public Understanding of Science* 26 (4): 402–17.

Bellamy, Rob, Jason Chilvers & Naomi E. Vaughan. 2016. ‘Deliberative Mapping of Options for Tackling Climate Change: Citizens and Specialists “Open up” Appraisal of Geoengineering’. *Public Understanding of Science* 25 (3): 269–86.

Bennett, D., & T. Radford. 2017. ‘Public Perceptions of Nanotechnologies: Lessons from Genetically Modified Foods’. In Nanotechnologies in Food: Edition 2, edited by Qasim Chaudhry, Laurence Castle, Richard Watkins, 60-80. London: Royal Society of Chemistry.

Bibri, S. E. 2018. ‘Backcasting in Futures Studies: A Synthesised Scholarly and Planning Approach to Strategic Smart Sustainable City Development’. *European Journal of Futures Research* 6 (13).

Bitkina, O. V., H. Jeong, B. C. Lee, J. Park, J. Park & H. K. Kim. 2020. 'Perceived Trust in Artificial Intelligence Technologies: A Preliminary Study'. *Human Factors and Ergonomics In Manufacturing* 30 (4): 282–90.

Bitsch, Lise, & Nicklas Bang. 2020. 'Bringing Voices from Society to Bear on the EC White Paper On Artificial Intelligence - A European Approach to Excellence and Trust'. tekno.dk, Danish Board of Technology, 2020. As of 6 January 2021: https://tekno.dk/wp-content/uploads/2015/10/Feedback_EC_white_paper_AI_DBT-5.pdf

Bitsch, Lise, Nicklas Bang Bådum, Nathan Campion & Marie Louise Jørgensen. 2020. 'D12.3.1: Insight into Europeans' Informed and Considered Views on Artificial Intelligence – Results from EuropeSay on AI'. ec.europa.eu, Research & Innovation, Participant Portal, 2 October 2020. As of 6 January 2021: https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5d4318bcc&appId=PPGMS

Bontoux, L., J. A. Sweeney, D. Bengtsson & A. Rosa. 2016. 'The JRC Scenario Exploration System - From Study to Serious Game'. *Journal of Futures Studies* 20 (3): 93–108. https://jfsdigital.org/2016-2/vol-20-no-3-march-2016/r-e-p-o-r-t/the-jrc-scenario-exploration-system-from-study-to-serious-game/

Bontoux, L., J. A. Sweeney, A. B. Rosa, A. Bauer, D. Bengtsson, A. Bock, B. Caspar, M. Charter, E. Christophilopoulos, F. Kupper, C. Macharis, C. Matti, M. Matrisciano, J. Schuijer, A. Szczepanikova, T. van Criekinge & R. Watson. 2020. 'A Game for All Seasons: Lessons and Learnings from the JRC's Scenario Exploration System'. *World Economic Review* 12 (1): 81–103.

Boudet, H. S. 2019. 'Public Perceptions of and Responses to New Energy Technologies'. *Nature Energy* 4 (6): 446–55.

Brodie, E., E. Cowling, N. Nissen, A. E. Paine, V. Jochum & Warburton D. 2009. 'Understanding Participation: A Literature Review.' sp.gov.tr, Pathways through Participation, 2009. As of 6 January 2021: http://www.sp.gov.tr/upload/Sayfa/47/files/Pathways-literature-review-final-version.pdf

Buckley, J. A., P. B. Thompson & K. P. Whyte. 2017. 'Collingridge's Dilemma and the Early Ethical Assessment of Emerging Technology: The Case of Nanotechnology Enabled Biosensors'. *Technology in Society* 48: 54–63.

Burgess, J., J. Chilvers, J. Clark, R. Day, J. Hunt & S. King. 2004. *Citizens and Specialists Deliberate Options for Managing the UK's Intermediate and High Level Radioactive Waste: A Report of the Deliberative Mapping Trial, June–July 2004*. London: Department for Environment, Food and Rural Affairs.

Burgess, M. M., J. D. Mumford & J. V. Lavery. 2018. 'Public Engagement Pathways for Emerging GM Insect Technologies'. *BMC Proceedings* 12: Article 12.

Busby, Amy, Ali Digby & Emily Fu. 2020. ‘Quantum Technologies Public Dialogue’. epsrc.ukri.org, 2020. As of 6 January 2021: https://epsrc.ukri.org/newsevents/pubs/epsrc-quantum-technologies-public-dialogue-full-report/

Cabinet Office. 2018. ‘Consultation Principles: Guidance’. gov.uk, Guidance, 17 July 2012, updated 19 March 2018. As of 6 January 2021: https://www.gov.uk/government/publications/consultation-principles-guidance

Calabrese, C., J. Ding, B. Millam & G. A. Barnett. 2019. ‘The Uproar Over Gene-Edited Babies: A Semantic Network Analysis of CRISPR on Twitter’. *Environmental Communication* 14 (7): 954-70.

Cameron, David, & Kelly Maguire. 2017. ‘Public Views of Machine Learning’. royalsociety.org, Projects, 2017. As of 6 January 2021: https://royalsociety.org/~/media/policy/projects/machine-learning/digital-natives-16-10-2017.pdf?source=post_page

CDEI (Centre for Data Ethics and Innovation). 2020. ‘CDEI Review of Online Targeting’. gov.uk, Independent Report, 4 February 2020. As of 6 January: https://www.gov.uk/government/publications/cdei-review-of-online-targeting

Centre for Public Impact. 2019. ‘Building Consensus and Compromise on Uber in Taiwan’. centreforpublicimpact.org, 18 September 2019. As of 6 January 2021: https://www.centreforpublicimpact.org/case-study/building-consensus-compromise-uber-taiwan/

Chhetri, Netra, Rajiv Ghimire, Melissa Wagner & Meng Wang. 2020. ‘Global Citizen Deliberation: Case of World-Wide Views on Climate and Energy’. *Energy Policy* 147 (December): 111892.

CIMULACT. 2021a. ‘CIMULACT & Foresight’. cimulact.eu. As of 6 January 2021: http://www.cimulact.eu/approach/cimulact-foresight/

———. 2021b. ‘CIMULACT & RRI’. cimulact.eu. As of 6 January 2021: http://www.cimulact.eu/approach/cimulact-rri/

———. 2021c. ‘CIMULACT & Visualisation’. cimulact.eu. As of 6 January 2021: http://www.cimulact.eu/approach/cimulact-visualisation/

———. 2021d. ‘Objectives’. cimulact.eu. As of 6 January 2021: http://www.cimulact.eu/objectives/

Clift, J. 2019. ‘A Blueprint for Dynamic Oversight: How the UK can take a global lead in emerging science and technologies’. welcome.org, March 2019. As of 6 January 2021: https://wellcome.org/sites/default/files/blueprint-for-dynamic-oversight.pdf

Collier, D. 2016. ‘Public Dialogue on Drones in the UK: Evaluation Report’. sciencewise.org.uk, July 2016. As of 6 January 2021:
https://sciencewise.org.uk/wp-content/uploads/2018/07/Drones-evaluation-report.pdf

Dagorne, E., & N. Gudowsky. 2018. ‘Deliverable 5.1. Ispiration Catalogue for Consulting Different Groups’. teknologiradet.no, CIMULACT, Missions Publiques, 28 March 2018. As of 6 January 2021:
https://teknologiradet.no/wp-content/uploads/sites/105/2019/01/D5.1_Inspiration-Catalogue-for-consulting-different-groups-compressed.pdf

Dascal, Julieta, Mark Reid, Waguih William IsHak, Brennan Spiegel, Jennifer Recacho, Bradley Rosen & Itai Danovitch. 2017. ‘Virtual Reality and Medical Inpatients: A Systematic Review of Randomized, Controlled Trials’. *Innovations in Clinical Neuroscience* 14 (1–2): 14–21.

Datta, Anupam, Shayak Sen & Yair Zick. 2016. ‘Algorithmic Transparency via Quantitative Input Influence: Theory and Experiments with Learning Systems’. In *2016 IEEE Symposium on Security and Privacy (SP)*, San Jose, CA, 598–617.

Davies, G., J. Burgess, M. Eames, S. Mayer, S. Staley, and A. Stirling. 2003. *Deliberative Mapping: Appraising Options for Closing “the Kidney Gap”*. London: Wellcome Trust.

DeepMind. 2021a. ‘About’. deepmind.com. As of 6 January 2021:
https://deepmind.com/about

———. 2021b. ‘Exploring the Real-World Implications of AI’. deepmind.com. As of 6 January 2021:
https://deepmind.com/about/ethics-and-society

Degeling, C., S. M. Carter, A. M. Van Oijen, J. McAnulty, V. Sintchenko, A. Braunack-Mayer, T. Yarwood, J. Johnson & G. L. Gilbert. 2020. ‘Community Perspectives on the Benefits and Risks of Technologically Enhanced Communicable Disease Surveillance Systems: A Report on Four Community Juries’. *BMC Medical Ethics* 21 (1): Article number 31.

Drew, C. 2016. ‘Data Science Ethics in Government’. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* 374 (2083).

Dupont, L., J. Hubert, C. Guidat & M. Camargo. 2019. ‘Understanding User Representations, a New Development Path for Supporting Smart City Policy: Evaluation of the Electric Car Use in Lorraine Region’. *Technological Forecasting and Social Change* 142: 333–46.

Dupont, L., L. Morel & M. Pallot. 2016. ‘Exploring the Appropriateness of Different Immersive Environments in the Context of an Innovation Process for Smart-Cities’. In *2016 International Conference on Engineering, Technology and Innovation/IEEE International Technology Management Conference (ICE/ITMC)*, Trondheim, Norway, 2016, 1-9.

Eaton, Weston, Wynne Wright, Kyle Whyte, Stephen P. Gasteyer & Pat J. Gehrke. 2014. 'Engagement and Uncertainty: Emerging Technologies Challenge the Work of Engagement'. *Journal of Higher Education Outreach and Engagement* 18 (2): 151–78.

Ekstrand, Michael D., Rezvan Joshaghani & Hoda Mehrpouyan. 2018. 'Privacy for All: Ensuring Fair and Equitable Privacy Protections; Proceedings of the 1st Conference on Fairness, Accountability and Transparency'. *Proceedings of Machine Learning Research* 8: 35–47.

Engage2020. 2014. 'D3.2 Public Engagement Methods and Tools'. engage2020.eu, Media, October 2014. As of 6 January 2021: http://engage2020.eu/media/Fact-sheet-on-the-current-praxis-of-methods-tools-and-instruments.pdf

Engasser, F., & T. Saunders. 2018. 'How to Use Games to Involve the Public in Decisions about Research and Innovation Policy'. nesta.org.uk, 17 August 2018. As of 6 January 2021: https://www.nesta.org.uk/blog/how-use-games-involve-public-decisions-about-research-and-innovation-policy/

EU Science Hub. 2019. 'Scenario Exploration System (SES)'. ec.europa.eu, EU Science Hub, Research, 3 December 2019. As of 6 January 2021: https://ec.europa.eu/jrc/en/research/foresight/ses

European Commission. 2017. *Interim Evaluation of Horizon 2020*. Luxembourg: Publications Office of the European Union.

———. 2020. 'Horizon 2–20 - Work Programme 2018-2020'. Brussels, Belgium: Publications Office of the European Union.

Felt, Ulrike, Simone Schumann, Claudia G. Schwarz & Michael Strassnig. 2014. 'Technology of Imagination: A Card-Based Public Engagement Method for Debating Emerging Technologies'. *Qualitative Research* 14 (2): 233–51.

Fernández Medina, K., & R. Jenkins. 2017. 'GATEway: Public Perceptions of a Last-Mile Driverless Shuttle'. gateway-project.org.uk, GATEway Project, November 2017. As of 6 January 2021: https://gateway-project.org.uk/wp-content/uploads/2018/06/D3.7_TRL-Workshop-Findings-Report.pdf

Food Standards Agency. 2020. 'Consumer Attitudes towards Emerging Technologies'. food.gov.uk, Research projects, 21 April 2020. As of 6 January 2021: https://www.food.gov.uk/research/research-projects/consumer-attitudes-towards-emerging-technologies-0

Fung, Archon. 2006. 'Varieties of Participation in Complex Governance'. *Public Administration Review* 66: 66–75.

Garcia, R., P. Quiepo, O. Kammona & I. Malsch. 2019. 'D4.3 NANOFutures Working Group for Societal Engagement'. NANO2ALL, Societal Engagement on Responsible Nanotechnology. ec.europa.eu, Research, 26 February 2019. As of 6 January 2021: https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5c2ad4341&appId=PPGMS

Gardner, Allison. 2020. 'Contact-Tracing Apps: There's No Evidence They're Helping Stop COVID-19'. theconversation.com, 21 October 2020, 12:08 BST. As of 6 January 2021: https://theconversation.com/contact-tracing-apps-theres-no-evidence-theyre-helping-stop-covid-19-148397

Garrett, Bernie, Tarnia Taverner, Wendy Masinde, Diane Gromala, Chris Shaw & Michael Negraeff. 2014. 'A Rapid Evidence Assessment of Immersive Virtual Reality as an Adjunct Therapy in Acute Pain Management in Clinical Practice'. *The Clinical Journal of Pain* 30 (12): 1089–98.

Gunashekar, Salil, Sarah Parks, Joe Francombe, Camilla d'Angelo, Gemma-Claire Ali, Pamina Smith, Daniela Rodriguez-Rincon, Marlene Altenhofer & Gordon R. McInroy. 2019. Oversight of Emerging Science and Technology: Learning from Past and Present Efforts around the World. Santa Monica, Calif.: RAND Corporation. RR-2921-WT. As of 6 January 2021: https://www.rand.org/pubs/research_reports/RR2921.html

Harrow D, Gheerawo R. 2018. 'D3.6 Auto Valet Parking Trial Design for Acceptance and Adoption: GATEway Project Trial 2 RCA Workshop Report'. gateway-project.org.uk, 2018. As of 6 January 2021: https://gateway-project.org.uk/wp-content/uploads/2018/06/D5.3b_RCA_Trial-2-Auto-Valet-Parking.pdf

Hauthal, Eva, Dirk Burghardt, Carolyn Fish & Amy L. Griffin. 2020. 'Sentiment Analysis'. *International Encyclopedia of Human Geography (Second Edition)* 2020: 169-77.

Hebáková, L., T. Ratinger, L. Jansa & I. Vančurová. 2018. 'Deliverable 5.3 – Report on the Impact of the Project'. cimulact.eu, Publications, 31 May 2018. As of 6 January 2021: http://www.cimulact.eu/wp-content/uploads/2018/06/CIMULACT-D5.3.pdf

Helbing, Dirk, Bruno Frey, Gerd Gigerenzer, Ernst Hafen, Michael Hagner, Yvonne Hofstetter, Jeroen van den hoven, Roberto Zicari, and Andrej Zwitter. 2019. 'Will Democracy Survive Big Data and Artificial Intelligence?: Essays on the Dark and Light Sides of the Digital Revolution'. In Towards Digital Enlightenment, edited by Dirk Helbing, 73–98. Cham: Springer.

Hennen, L. 2013. 'Parliamentary Technology Assessment in Europe and the Role of Public Participation'. In Public Engagemetn and Emerging Technologies, edited by K. O'Doherty & Einsiedel. E, 27–44. Vancouver: UBC Press.

Henry, Christine. 2018. 'A speculative fiction thread. In response to @mediatecture's #biometricmirror and its deconsent mechanism. abc.net.au/triplej/progra… (by @jolauder.h/t @boingboing; feels like @doctorow you'd maybe appreciate this)'. twitter.com,

@christinelhenry (blog), 31 July 2018. As of 6 January 2021: https://twitter.com/christinelhenry/status/1024345651436507142

Hienuki, S., Y. Hirayama, T. Shibutani, J. Sakamoto, J. Nakayama & A. Miyake. 2019. 'How Knowledge about or Experience with Hydrogen Fueling Stations Improves Their Public Acceptance'. *Sustainability (Switzerland)* 11 (22): 63339.

Hoffman, H. G., J. N. Doctor, D. R. Patterson, G. J. Carrougher & T. A. Furness. 2000. 'Virtual Reality as an Adjunctive Pain Control during Burn Wound Care in Adolescent Patients'. *Pain* 85 (1–2): 305–9.

Hoffman, H. G., A. Garcia-Palacios, D. R. Patterson, M. Jensen, T. Furness & W. F. Ammons. 2001. 'The Effectiveness of Virtual Reality for Dental Pain Control: A Case Study'. *Cyberpsychology & Behavior: The Impact of the Internet, Multimedia and Virtual Reality on Behavior and Society* 4 (4): 527–35.

Horlick-Jones, Tom, John Walls, Gene Rowe, Nick Pidgeon, Wouter Poortinga & Tim O'Riordan. 2006. 'On Evaluating the GM Nation? Public Debate about the Commercialisation of Transgenic Crops in Britain'. *New Genetics and Society* 25 (3): 265–88.

Hsiao, Y., S. Lin, A. Tang, D. Narayanan, and C. Sarahe. 2018. 'VTaiwan: An Empirical Study of Open Consultation Process in Taiwan'. osf.io, SocArXiv Papers, 4 July 2018.

IAP2. 2018. 'IAP2 Spectrum of Public Participation'. cdn.ymaws.com, 2018. As of 6 January 2021: https://cdn.ymaws.com/www.iap2.org/resource/resmgr/pillars/Spectrum_8.5x11_Print.pdf

ICO (Information Commissioner's Office) & The Alan Turing Institute. 2021. 'Expaining Decisions Made with AI'. ico.org.uk. As of 6 January 2021: https://ico.org.uk/for-organisations/guide-to-data-protection/key-data-protection-themes/explaining-decisions-made-with-artificial-intelligence/

Institut Català de NanociènIia i Nanotecnologia. 2020. 'Nano2All Citizens Debate (Barcelona, June 2017)'. youtube.com, 11 May 2020. As of 6 January 2021: https://www.youtube.com/watch?v=iTAxdipw6WU

Involve. 2018. 'Methods'. involve.org.uk, 2018. As of 6 January 2021: https://www.involve.org.uk/resources/methods

Ipsos MORI. 2019. 'A Public Dialogue on Genomic Medicine: Time for a New Social Contract?'. ipsos.com, 25 April 2015. As of 6 January 2021: https://www.ipsos.com/ipsos-mori/en-uk/public-dialogue-genomic-medicine-time-new-social-contract-report

Karakas, C. 2019. 'Horizon Europe – Specific Programme Implementing the Framework Programme'. europarl.europa.eu, European Parliament Briefing Document, EU Legislation in Progress 2021-2027 MFF, May 2019. As of 6 January 2021:

https://www.europarl.europa.eu/RegData/etudes/BRIE/2018/628297/EPRS_BRI(2018)628297_EN.pdf

Keller, M. S., H. J. Park, M. E. Cunningham, J. E. Fouladian, M. Chen & B. M. R. Spiegel. 2017. 'Public Perceptions Regarding Use of Virtual Reality in Health Care: A Social Media Content Analysis Using Facebook'. *Journal of Medical Internet Research* 19 (12). doi:10.2196/jmir.7467

Kupper, F., & J. W. Schuijer. 2016. 'D3.1 Dialogue Methodology: Moderator Manual'. NANO2ALL, Societal Engagement on Responsible Nanotechnology. nano2all.eu, December 2016. As of 6 January 2021: http://www.nano2all.eu/wp-content/uploads/files/D3.1%20Dialogue%20methodology.pdf

———. 2018a. 'D3.3. Responsible Innovation Agendas at National Level'. NANO2ALL, Societal Engagement on Responsible Nanotechnology. nano2all.eu, 23 July 2018. As of 6 January 2021: http://www.nano2all.eu/wp-content/uploads/2018/12/NANO2ALL-685931-D3.3-Responsible-Innovation-Agenda-at-national-level.pdf

———. 2018b. 'D3.4. Responsible Innovation Agenda at European Level'. NANO2ALL, Societal Engagement on Responsible Nanotechnology. nano2all.eu, 10 July 2018. As of 6 January 2021: http://www.nano2all.eu/wp-content/uploads/files/NANO2ALL%20-%20685931%20-%20D3.4%20Responsible%20Innovation%20Agenda%20at%20European%20level-submitted.pdf

Lezaun, J., & L. Soneryd. 2007. 'Consulting Citizens: Technologies and Elicitation of the Mobility of Publics'. *Public Understanding of Science* 16: 279–207.

Li, Angela, Zorash Montaño, Vincent J. Chen & Jeffrey I. Gold. 2011. 'Virtual Reality and Pain Management: Current Trends and Future Directions'. *Pain Management* 1 (2): 147–57.

Malloy, Kevin M., & Leonard S. Milling. 2010. 'The Effectiveness of Virtual Reality Distraction for Pain Reduction: A Systematic Review'. *Clinical Psychology Review* 30 (8): 1011–18.

Martin King. 2019. 'Building Consensus and Compromise on Uber in Taiwan'. centreforpublicimpact.org, Tackling Challenges Together, Case Study, 18 September 2019. As of 6 January 2021: https://www.centreforpublicimpact.org/case-study/building-consensus-compromise-uber-taiwan/

McCambridge, Jim, John Witton & Diana R. Elbourne. 2014. 'Systematic Review of the Hawthorne Effect: New Concepts Are Needed to Study Research Participation Effects'. *Journal of Clinical Epidemiology* 67 (3): 267–77.

McCool, Skye. 2019. 'CAV Public Acceptability Dialogue, Engagement Report'. assets.publishing.service.gov.uk, Traverse report for the Department for Transport, 5 August

2019. As of 6 January 2021:
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/837958/cav-public-acceptability-dialogue-engagement-report.pdf

McStay, Andrew. 2016. 'Empathic Media and Advertising: Industry, Policy, Legal and Citizen Perspectives (the Case for Intimacy)'. *Big Data & Society* 3 (November).

MERGE Greenwich. 2018. 'Autonomous vehicle ride-sharing services: Will they make cities greener, more efficient and more accessible?' Merge Greenwich. static1.squarespace.com. As of 6 January:
https://static1.squarespace.com/static/5ae87244b105982d79d73cf5/t/5be2dc0d4ae2375f2749156b/1541594145674/MERGE+Greenwich+Final+Report.pdf

Miah, A. 2017. 'Nanoethics, Science Communication, and a Fourth Model for Public Engagement'. *NanoEthics* 11 (2): 139–52.

Middleton, Anna. 2017. 'Your DNA, Your Say'. *The New Bioethics: A Multidisciplinary Journal of Biotechnology and the Body* 23 (1): 74–80.

Mil, A. V, H. Hopkins & S. Kinsella. 2019. 'From Our Brain to the World: Views on the Future of Neural Interfaces'. semanticscholar.org. As of 6 January 2021:
https://www.semanticscholar.org/paper/From-our-brain-to-the-world%3A-views-on-the-future-of-Mil-Hopkins/53fd40b4e90cd0aeee2c1835825c0867605210b3

Morris, Linzette Deidré, Quinette Abegail Louw & Lynette Christine Crous. 2010. 'Feasibility and Potential Effect of a Low-Cost Virtual Reality System on Reducing Pain and Anxiety in Adult Burn Injury Patients during Physiotherapy in a Developing Country'. *Burns: Journal of the International Society for Burn Injuries* 36 (5): 659–64.

Müller, Jörg, Juliane Exeler, Markus Buzeck, and Antonio Krüger. 2009. 'ReflectiveSigns: Digital Signs That Adapt to Audience Attention'. In Pervasive Computing. Pervasive 2009. Lecture Notes in Computer Science, edited by H. Tokuda, M. Beigl, A. Friday, A. J. B. Brush & Y. Tobe, 17–24. Berlin: Springer.

NANO2ALL. 2017. 'Setting Priorities for New Euro-Brazilian Cooperation in Responsible Research and Innovation'. nano2all.eu, NANO2ALL, Societal Engagement on Responsible Nanotechnology, 30 October 2017. As of 6 January 2021:
http://www.nano2all.eu/2017/10/30/setting-priorities-for-new-euro-brazilian-cooperation-in-responsible-research-and-innovation/

———. 2018a. 'NANO2ALL at B.Debate'. nano2all.eu, 8 October 2018. As of 6 January 2021:
http://www.nano2all.eu/2018/10/08/nano2all-at-b-debate/

———. 2019a. 'D4.4 E-MRS Working Group "Outreach Societal Promotion"'. ec.europa.eu, NANO2ALL, Societal Engagement on Responsible Nanotechnology, 26 April 2019. As of 6 January 2021:

https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5c2475ea8&appId=PPGMS

———. 2019b. ‘D5.5 Report on the Public Understanding, Attitudes and Fears of Nanotechnology Research for the Nano2All Ethics Board’. ecsite.eu, NANO2ALL, Societal Engagement on Responsible Nanotechnology, 2019. As of 6 January 2021: https://www.ecsite.eu/sites/default/files/nano2all_report_on_the_public_understanding_attitudes_and_fears_of_nano.pdf

———. 201’c. ‘26 FEBRUARY: INTERNATIONAL CONGRESS “NANOTECHNOLOGY IN EVERYDAY LIFE”’. nano2all.eu, NANO2ALL, Societal Engagement on Responsible Research, 18 February 2019. As of 6 January 2021: http://www.nano2all.eu/2019/02/18/26-february-international-congress-nanotechnology-in-everyday-life/

———. 2021a. ‘Other NANO2ALL Results’. nano2all.eu, NANO2ALL, Societal Engagement on Responsible Nanotechnology. As of 6 January 2021: http://www.nano2all.eu/resources/other-nano2all-results/

———. 2021b. ‘Roadmap: For a More Inclusive Nanotechnology Development in Europe’. nano2all.eu, WP Content. As of 6 January 2021: http://www.nano2all.eu/wp-content/uploads/2019/05/roadmap_shortversion.pdf

NatCen. 2021. ‘British Social Attitudes 37’. bsa.natcen.ac.uk, NatCen Social Research. As of 6 January 2021: https://www.bsa.natcen.ac.uk

National Audit Office. 2014. ‘Using Alternatives to Regulation to Achieve Policy Objectives’. nao.org.uk, Report, 30 June 2014. As of 6 January 2021: https://www.nao.org.uk/report/using-alternatives-to-regulation-to-achieve-policy-objectives/

NCCPE (National Co-ordinating Centre for Public Engagement). 2018. ‘Genome Editing Resources’. publicengagement.ac.uk, 2018. As of 6 January 2021: https://www.publicengagement.ac.uk/sites/default/files/overview_of_resources_live_2.pdf

NCCPE (National Co-ordinating Centre for Public Engagement). 2019. ‘Science Research Engagement and the Arts’. publicengagement.ac.uk, 2019. As of 6 January 2021: https://www.publicengagement.ac.uk/sites/default/files/publication/science_research_engagement_and_the_arts.pdf

———. 2020a. ‘Festivals’. publicengagement.ac.uk, 2020. As of 6 January 2021: https://www.publicengagement.ac.uk/do-engagement/choose-method/festivals

———. 2020b. ‘What Is Public Engagement?’. publicengagement.ac.uk, 2020. As of 6 January 2021: https://www.publicengagement.ac.uk/about-engagement/what-public-engagement

———. 2020c. ‘Why Does Public Engagement Matter?’. publicengagement.ac.uk, 2020. As of 6 January 2021: https://www.publicengagement.ac.uk/about-engagement/why-does-public-engagement-matter

Navid, E. L., & E. F. Einsiedel. 2012. ‘Synthetic Biology in the Science Café: What Have We Learned about Public Engagement?’. *Journal of Science Communication* 11 (14).

Newson, A. J., S. De Lacey, D. K. Dowling, S. Murray, C. M. Sue, D. R. Thorburn, L. Gillam & C. Degeling. 2019. ‘Public Attitudes towards Novel Reproductive Technologies: A Citizens’ Jury on Mitochondrial Donation’. *Human Reproduction* 34 (4): 751–57.

OECD (Organisation for Economic Co-operation and Development). 2001. Measuring Productivity, OECD Manual: Measurement of Aggregate and Industry-Level Productivity Growth. oecd.org, 2021. As of 6 January 2021: http://www.oecd.org/sdd/productivity-stats/2352458.pdf

———. 2017. ‘Open Research Agenda Setting’. OECD Science, Technology and Innovation Policy Papers. OECD.

———. 2021. ‘Alternatives to Traditional Regulation’. oecd.org. As of 6 January 2021: https://www.oecd.org/gov/regulatory-policy/42245468.pdf

Participedia. 2021a. ‘Survey’. participedia.net. As of 6 January 2021: https://participedia.net/method/565

———. 2021b. ‘The UK Citizens’ Biometric Council: A Citizens’ Assembly on the Use of Facial Recognition Technology’. participedia.net. As of 6 January 2021: https://participedia.net/case/6086

Persaud, A., S. Desine, K. Blizinsky & V. L. Bonham. 2019. ‘A CRISPR Focus on Attitudes and Beliefs toward Somatic Genome Editing from Stakeholders within the Sickle Cell Disease Community’. *Genetics in Medicine* 21 (8): 1726–34.

Pfeiffer, J., A. Gabriel & M. Gandorfer. 2020. ‘Understanding the Public Attitudinal Acceptance of Digital Farming Technologies: A Nationwide Survey in Germany’. *Agriculture and Human Values, Journal of the Agriculture, Food, and Human Values Society* 2020.

Phillips, D., & Roberts E. 2016. ‘GATEway: Workshop Analysis’. GATEway Project. Royal College of Art.

Pint of Science. 2020. ‘Pint of Science’. pintofscience.co.uk, 2020. As of 6 January 2021: https://pintofscience.co.uk.

PytlikZillig, L. M., & A. J. Tomkins. 2011. ‘Public Engagement for Informing Science AndTechnology Policy: What Do We Know, What Do We Need to Know, and How Will We Get There?’ *Review of Policy Research* 28 (2): 197–217.

Ramos, J., J. A. Sweeney, K. Peach & S. Laurie. 2019. 'Our Futures: By the People, for the People'. nesta.org.uk, Reports, 11 November 2019. As of 6 January 2021: https://www.nesta.org.uk/report/our-futures-people-people/

Ramseyer, R., F. Cimmino, L. Emery, S. Grezes, V. Grezes, B. Nanchen, E. Simon & E. Fragniere. 2019. 'Using Phenomenology to Assess Risk Perception of a New Technology in Public Transportation the Case of the Autonomous Vehicles as Mobility as a Service (MaaS) in Switzerland'. In *2018 3rd International Conference on System Reliability and Safety (ICSRS)*, Barcelona, Spain, 2018, 289-293.

Rask, M., S. Maciukaite-Zviniene, L. Tauginiene, V. Dikcius, K. Matschoss, T. Aarrevaara & L. d'Andrea. 2012. *Innovative Public Engagement: A Conceptual Model of Public Engagement in Dynamic and Responsible Governance of Research and Innovation*. Brussels: PE2020, European Union. As of 6 January 2016: https://pe2020.eu/wp-content/uploads/2016/05/Innovative-Public-Engagement-FINAL-1.pdf

Rempel, E. S., Barnett, J., & Durrant, H. 2018. 'Public engagement with UK government data science: Propositions from a literature review of public engagement on new technologies'. *Government Information Quarterly* 35 (4): 569–578.

Rosa, A. B., N. Gudowsky, P. Warnke & N. Hauser. 2018. 'Deliverable 5.2 - Report on Comparison of Research Topics from CIMULACT with Those from Expert Oriented Foresight Studies'. cimulact.eu, 2018. As of 6 January 2021: http://www.cimulact.eu/wp-content/uploads/2018/04/D5.2_Report-on-comparison-expert-oriented-foresight-studies-compressed.pdf

Rotolo, Daniele, Diana Hicks & Ben R. Martin. 2015. 'What Is an Emerging Technology?' *Research Policy* 44 (10): 1827–43.

RSA. 2019. 'Democratising Decisions about Technology: A Toolkit'. thersa.org, 2019. As of 6 January 2021: https://www.thersa.org/globalassets/reports/2019/democratising-decisions-tech-report.pdf

Salisbury, J., & B. Nicholas. 2005. 'Review of Public Engagement in the Development and Oversight of Emerging Technologies ("Science and Society")'. researchgate.net, Publication, July 2005. As of 6 January 2021: https://www.researchgate.net/publication/228555382_Review_of_public_engagement_in_the_development_and_oversight_of_emerging_technologies_%27science_and_society%27

Sample, M., S. Sattler, S. Blain-Moraes, D. Rodríguez-Arias & E. Racine. 2020. 'Do Publics Share Experts' Concerns about Brain–Computer Interfaces? A Trinational Survey on the Ethics of Neural Technology'. *Science Technology and Human Values* 45 (6): 1242–70.

Saunders, T. 2018a. 'Seven Principles for Public Engagement in Research and Innovation Policymaking'. nesta.org, 30 August 2018. As of 6 January 2021: https://www.nesta.org.uk/report/seven-principles-public-engagement-research-and-innovation-policymaking/

———. 2018b. ‘Six Creative Ways to Engage the Public in Innovation Policy’. nesta.org, 28 February 2018. As of 6 January 2021: https://www.nesta.org.uk/blog/six-creative-ways-to-engage-the-public-in-innovation-policy/

Sciencewise. 2021a. ‘Case Study: Bioenergy Distributed Dialogue’. sciencewise.org.uk. As of 6 January 2021: https://sciencewise.org.uk/wp-content/uploads/2018/08/CS-BioenergyFinal.pdf

———. 2021b ‘Case Study: Drone Usage’. sciencewise.org.uk. As of 6 January 2021: https://sciencewise.org.uk/wp-content/uploads/2018/10/Drones-Case-Study-FINAL.pdf

———. 2021c. ‘Case Study: Genomic Medicine’. sciencewise.org.uk. As of 6 January 2021: https://sciencewise.org.uk/wp-content/uploads/2018/08/Genomics-England-Case-Study-FINAL.pdf

———. 2021d. ‘Case Study: Medical Frontiers: Debating Mitochondrial Replacement’. sciencewise.org.uk. As of 6 January 2021: https://sciencewise.org.uk/wp-content/uploads/2018/08/Mitochondrial-Replacement-Therapy-Case-Study-1.pdf

———. 2021e. ‘Our Impact’. sciencewise.org.uk. As of 6 January 2021: https://sciencewise.org.uk/projects-and-impacts/impacts/

Selin, C., K. Campbell Rawlings, K. de Ridder-Vignone, J. Sadowski, C. Altamirano-Allende, G. Gretchen, S. R. Davies & D. H. Guston. 2017. ‘Experiements in Engagement: Designing Public Engagement with Science and Technology for Capacity Building’. *Public Understanding of Science* 26 (6): 634–49.

Setälä, M., & Smith, G. 2018. ‘Mini-publics and deliberative democracy’. In The Oxford Handbook of Deliberative Democracy, edited by Andre Bächtiger, John S. Dryzek, Jane Mansbridge & Mark Warren, 300-314. Oxford: Oxford University Press.

Shabanpour, R., N. Golshani, A. Shamshiripour & A. K. Mohammadian. 2018. ‘Eliciting Preferences for Adoption of Fully Automated Vehicles Using Best-Worst Analysis’. *Transportation Research Part C: Emerging Technologies* 93: 463–78.

Sheikh, Sanah. 2013. ‘Medical Frontiers: Debating Mitochondria Replacement: Deliberative Public Workshops’. London: Office for Public Management. As of 6 January 2021: https://sciencewise.org.uk/wp-content/uploads/2018/08/Mito-Annex_II-public_deliberative_workshops.pdf

Simon, J., T. Bass, V. Boelman & G. Mulgan. 2017. ‘Digital Democracy: The Tools Transforming Political Engagement’. nesta.org.uk, 20 February 2017. As of 6 January 2021: https://www.nesta.org.uk/report/digital-democracy-the-tools-transforming-political-engagement/

Singh, A. 2019. ‘Patient AI: Towards a Human-Centered Culture of Technological Innovation in the NHS’. thersa.org, 30 October 2019. As of 6 January 2021: https://www.thersa.org/reports/patient-ai-innovation-nhs

Smart Mobility Living Lab. 2020a. ‘First UK AV Trial of Its Kind Gets Thumbs Up from London Participants’. smartmobility.london, 30 January 2020. As of 6 January 2021: https://smartmobility.london/news/first-uk-av-trial-of-its-kind-gets-thumbs-up-from-london-participants

Smart Mobility Living Lab. 2020b. ‘Greenwich Automated Transport Environment (GATEway)’. smartmobility.london, April 2020. As of 6 January 2021: https://smartmobility.london/trials-blog/gateway?rq=‘GATEway’

Smol’kin, A. A., P. A. Zhigareva, E. A. Makarova, A. A. Kiryukhina, E. A. Milova & D. A. Khaltourina. 2018. ‘Attitudes towards Aging Prevention: Results of a Focus-Group Study’. *Advances in Gerontology* 8 (1): 71–78.

Stewart, Margaret C., & Christa L. Arnold. 2018. ‘Defining Social Listening: Recognizing an Emerging Dimension of Listening’. *International Journal of Listening* 32 (2): 85–100.

Stilgoe, J. L., S. J. Lock & J. Wilsdon. 2014. ‘Why Should We Promote Public Engagement with Science?’ *Public Engagement in Science, Special Issue* 23 (1): 4–15.

Sutcliffe, H., R. Lindner & C. von Kameke. 2020. ‘Trust and Tech Governance: Towards a More Engaged, Collaborative, Communicative Approach’. rri-tools.eu, 2020. As of 6 January 2021: https://rri-tools.eu/-/trust-amp-amp-tech-governance-towards-a-more-engaged-collaborative-and-communicative-approach

Tang, Audrey. 2016. ‘Uber Responds to vTaiwan’s Coherent Blended Volition’. blog.pol.is, 23 May 2016. As of 6 January 2021: https://blog.pol.is/uber-responds-to-vtaiwans-coherent-blended-volition-3e9b75102b9b

The Alternative. 2019. ‘We Dream of a Consensus-Based Politics - but vTaiwan Is Using Digital Tech, as Well as Comfy Meals, to Make It Happen’. thealternative.org.uk, 24 October 2019. As of 6 January 2021: https://www.thealternative.org.uk/dailyalternative/2019/10/26/vtaiwan-shows-how-consensus-can-be-built

The RSA. 2019. ‘Democratising Decisions about Technology: A Toolkit’. thersa.org, 24 October 2019. As of 6 January 2019: https://www.thersa.org/reports/democratising-decisions-technology-toolkit

———. 2021. ‘Forum for Ethical AI’. thersa.org. As of 6 January 2021: https://www.thersa.org/projects/archive/economy/tech-and-society/forum-for-ethical-ai

Tong, Simon. 2017. ‘Bridging the Final Metres: Public Feedback on a Last Mile Driverless Delivery Service: A GATEway CAV Trial’. gateway-project.org.uk, 4 December 2017, GATEway Project, Published Project Report PPR851. As of 6 January 2021: https://gateway-project.org.uk/wp-content/uploads/2018/06/D5.3c_Trial-3-Public-Feedback-Survey-Report.pdf

Tournay, V., M. Jacomy, A. Necula, A. Leibing & A. Blasimme. 2020. ‘A New Web-Based Big Data Analytics for Dynamic Public Opinion Mapping in Digital Networks on Contested Biotechnology Fields’. *OMICS A Journal of Integrative Biology* 24 (1): 29–42.

TRLpublish. 2018a. ‘D1.3 GATEway Project: Final Report’. gateway-project.org.uk, GATEway Project, 8 June 2018. As of 6 January 2021: https://gateway-project.org.uk/d1-3-gateway-project-final-report/

TRLpublish. 2018b. ‘D3.6 Commonplace Sentiment Mapping’. gateway-project.org.uk, GATEway Project, 8 June 2018. As of 6 January 2021: https://gateway-project.org.uk/d3-6-commonplace-sentiment-mapping/

Uber. 2021. ‘UberX’. uber.com. As of 6 January 2021: https://www.uber.com/gb/en/ride/uberx/

UKERC (UK Energy Research Centre). 2021. ‘Societal Engagement Observatory’. ukerc.ac.uk. As of 6 January 2021: https://ukerc.ac.uk/research/see/

Venverloo, T., F. Duarte, T. Benson, Q. Bitran, A. D. Beldad, R. Alvarez & C. Ratti. 2020. ‘Evaluating the Human Experience of Autonomous Boats with Immersive Virtual Reality’. *Journal of Urban Technology*.

von Schomberg, R. 2011. *Towards Responsible Research and Innovation in the Information and Communication Technologies and Security Technology Fields*. Luxembourg: Publications Office of the European Union.

vTaiwan. 2021. ‘VTaiwan’. info.vtaiwan.tw. As of 6 January 2021: https://info.vtaiwan.tw

Watermeyer, R., & G. Rowe. 2013. ‘Evaluation of the Project: “Mitochondria Replacement Consultation”’. involve.org.uk, July 2013. As of 6 January 2021: https://www.involve.org.uk/sites/default/files/field/attachemnt/Mitochondria-evaluation-FINAL-2013.pdf

Hamlyn, Becky, Martin Shanahan, Hannah Lewis, Ellen O’Donoghue, Tim Hanson. 2015. ‘Factors Affecting Public Engagement by Researchers: A Study of Behalf of a Consortium of UK Public Research Funders’. welcome.org, December 2015. As of 6 January 2021: https://wellcome.org/sites/default/files/wtp060033_0.pdf

Welp, M., A. de la Vega-Leinert, S. Stoll-Kleemann & C. C. Jaeger. 2006. ‘Science-Based Stakeholder Dialogues: Theories and Tools’. *Global Environmental Change* 16 (2): 170–81.

Wilsdon, James, & Rebecca Willis. 2004. ‘See-through Science: Why Public Engagement Needs to Move Upstream’. Demos. researchgate.net, 2004. As of 6 January 2021: doi:10.13140/RG.2.1.3844.3681

Winickoff, D. E., L. Jamal & N. R. Anderson. 2016. ‘New Modes of Engagement for Big Data Research’. *Journal of Responsible Innovation* 3 (2): 169–77.

Wouters, N., R. Kelly, E. Velloso, K. Wolf, H. S. Ferdous, J. Newn, Z. Joukhadar & F. Vetere. 2019. ‘Biometric Mirror: Exploring Values and Attitudes towards Facial Analysis and Automated Decision-Making’. In *DIS '19: Proceedings of the 2019 on Designing Interactive Systems Conference*, 447–61.

Zhao, Y., C. Fautz, Hennen. L, K. R. Srinivas & Q. Li. 2015. ‘Public Engagement in the Governance of Science and Technology’. In *Science and Technology Governance and Ethics*, edited by Miltos Ladikas, Sachin Chaturvedi, Yandong Zhao & Dirk Stemerding, 39–51. Cham: Springer. As of 6 January 2021: https://link.springer.com/chapter/10.1007/978-3-319-14693-5_4