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# Evaluation of the Industrial Strategy Challenge Fund

Evaluation framework report

RAND Europe and Frontier Economics

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## Executive summary

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Established in 2016, the Industrial Strategy Challenge Fund (ISCF) is a key part of the UK government's efforts to leverage research and innovation (R&I) to support the UK Industrial Strategy. Delivered by UK Research and Innovation (UKRI), the ISCF aims to support the development of solutions to major industrial and societal challenges facing the UK, including the four 'Grand Challenges'. With a total government funding commitment of £2.6 billion, combined with £3 billion in matched private sector funding, the ISCF seeks to achieve these aims through the delivery of a mission-oriented R&I funding programme. Under the ISCF, funding has been distributed through the establishment of 24 individual 'Challenges', each focussing on a pressing societal or industrial issue.

In November 2020, RAND Europe and Frontier Economics were commissioned by UKRI to undertake an evaluation of the ISCF. The aims of this evaluation are threefold: (i) to build an evidence base with which to inform ongoing and future improvements to the ISCF; (ii) to demonstrate what the ISCF has delivered to taxpayers; and (iii) to understand the impact of mission-oriented and Challenge-focused R&I support. This Fund-level evaluation of the ISCF seeks to build upon and complement the ongoing evaluations of individual ISCF Challenges. The evaluation will be conducted over four years, between 2020 and 2024.

The purpose of this report is to present a detailed framework for the evaluation of the ISCF. The report presents an evaluation framework that is grounded in a theory-based approach using contribution analysis, the foundation for which is an ISCF Theory of Change (ToC). The ToC identifies key 'inputs', 'activities', 'outputs', 'outcomes' and 'impacts' of the ISCF. These elements are then clustered into a series of evaluation themes that provide the basis of our evaluation framework. For each evaluation theme, the framework identifies evaluation questions, indicators and data sources. The evaluation themes, covering both the process and impact themes, are summarised below.

### Process evaluation themes

The process evaluation will examine how the ISCF has been implemented in relation to the following themes:

- **Strategy:** This theme considers how the ISCF is structured and designed, and the strategic governance and oversight processes in place
- **Delivery:** This theme considers how the ISCF is delivered in terms of funding and managing the portfolio of R&I

- **Wider engagement:** This theme considers the outward-looking aspects of the ISCF, particularly in terms of how it engages with wider stakeholders and the wider landscape to ensure its ongoing relevance and effective operation
- **Cross cutting:** This theme considers the cross-cutting issues that are important for all the ISCF processes, including diversity and equal opportunities, barriers and facilitators, and lessons learned

### Impact evaluation themes

The impact evaluation will assess to what extent the ISCF has contributed to the following themes:

- **Creating knowledge and innovation pathways:** This theme considers the contribution of the ISCF to the development of new knowledge addressing the Challenges and promoting the advancement and adoption of new innovations
- **Capacity and investment:** This theme considers the extent to which the ISCF has helped increase capacity and investment in R&I in the UK, including the leveraging of capacity and investment towards addressing the Challenge areas.
- **Connected innovation ecosystem:** This theme considers the extent to which the ISCF has helped to foster multidisciplinary, interdisciplinary, multi-sectoral and multi-stakeholder collaboration and networks around the Challenges
- **Societal impact:** This theme considers the extent to which the ISCF has delivered substantial long-term impacts for society, focusing on benefits to health and wellbeing, the environment and sustainability, and infrastructure and services. It also considers the contribution of the ISCF to wider societal impacts, including unanticipated impacts
- **Economic impact:** This theme considers the extent to which the ISCF has delivered substantive, long-term impacts for the economy, including the growth of UK businesses (including in international markets), national and regional economic growth, and increased productivity
- **Value for money:** This theme considers the extent to which the benefits that can be attributed to the ISCF constitute value when compared to the costs of the Fund

To collect data against our evaluation themes, we will draw upon a wide range of data sources. These include the review of Challenge-level evaluation findings, the review of UKRI data, the review of external data sources, and our own mixed-methods primary research. Primary research methods to be employed include key informant interviews, case studies, workshops, econometric analysis, network analysis and value for money (VfM) analysis. Research for this evaluation will be implemented through four overarching phases: evaluation framework development (phase 1, culminating in this report); baseline measurement (phase 2); review of Challenge-level evaluation findings (phase 3); and analysis and reporting (phase 4).

This evaluation framework presented in this report draws upon learnings from a rapid evidence assessment (REA) on the evaluation of mission-oriented R&I. This REA, undertaken as part of our framework development, has highlighted general challenges and requirements for the evaluation of mission-oriented R&I, as well as specific research methodologies, which we incorporate into our own approach. Other activities that have informed the development of this evaluation framework include a review of key Fund-

and Challenge-level documentation, a ToC workshop and wider stakeholder engagement focused on data scoping.

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# Abbreviations

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AI	Artificial Intelligence
BEIS	Department for Business, Energy and Industrial Strategy
EDI	Equality, diversity and inclusion
GC	Grand Challenge
ISC	Industrial Strategy Council
ISCF	Industrial Strategy Challenge Fund
ITT	Invitation to Tender
MIS	Mission-oriented innovation system
MOIP	Mission-oriented innovation policies
NAO	National Audit Office
ONS	Office of National Statistics
PIPA	Participatory Impact Pathways Analysis
PCF	Project Closeout Form
PESCA	Prospective & Adaptive Societal Challenges Assessment Approach
R&D	Research and development
R&I	Research and innovation
REA	Rapid evidence assessment
SVAR	Structural vector autoregression
ToC	Theory of Change
UKRI	UK Research and Innovation
VfM	Value for Money

# 1. Introduction

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In November 2020, RAND Europe and Frontier Economics were commissioned by UK Research and Innovation (UKRI) to undertake an evaluation of the Industrial Strategy Challenge Fund (ISCF). The aims of this evaluation, building on the ongoing evaluations of individual ISCF Challenges, are to build an evidence base with which to inform ongoing and future improvements to the ISCF; to demonstrate what the ISCF has delivered to taxpayers; and to understand the impact of mission-oriented and Challenge-focused R&I support. This report sets out the evaluation framework for this evaluation. The report has been prepared as part of phase 1 of the evaluation plan, as specified in the Invitation to Tender (ITT).

The report is structured as follows:

- The remainder of this introduction describes in more detail the objectives and structure of the ISCF, the aims and scope of the evaluation, and our approach to developing the evaluation framework
- Chapter 2 presents the findings of a rapid evidence assessment (REA) on the evaluation of mission-oriented R&I, undertaken to inform the evaluation framework development, and considers implications for the evaluation
- Chapter 3 outlines our overarching approach to this evaluation, including our approach to key challenges of evaluating mission-oriented R&I as highlighted by the REA
- Chapter 4 presents the ISCF Theory of Change (ToC), extrapolating key thematic strands that form the basis of our evaluation framework
- Chapter 5 presents the evaluation framework. Here, aspects of the ToC are operationalised into themes and evaluation questions on both process and impact. For each evaluation question, we identify key Challenge-level and Fund-level evaluation indicators. We also specify the data collection sources, including our own primary collection methods, that will be used to evaluate the ISCF.
- Chapter 6 sets out our plan for implementing the evaluation. Here, we outline an evaluation implementation plan (following this initial phase of evaluation framework development) consisting of three key phases: baselining, review of Challenge-level evaluation findings, and analysis and reporting. For each of these phases, the chapter provides detail on the key methodological steps we will take.
- Chapter 7 outlines the key deliverables for the evaluation

- Chapter 8 sets out our approach to communicating and working with key evaluation stakeholder groups. The chapter includes a stakeholder mapping table outlining all key stakeholders in the evaluation and the way in which we anticipate engaging with them, both as a potential information source and as an audience for the evaluation’s findings.
- Chapter 9 presents an analysis of the key risks to the evaluation and the steps we will take to mitigate these risks
- Finally, the annexes to the report present the following additional information: (i) the methodology for the REA on evaluation of mission-oriented R&I (Annex A); (ii) a list of papers reviewed by the REA (Annex B); (iii) a list of examples of mission-oriented R&I programmes based on the literature reviewed by the REA (Annex C); (iv) the initial logic model developed at the time of inception of the ISCF (Annex D); (v) a ‘strawman’ ToC developed for a workshop held as part of the ToC development (Annex E); (vi) notes from the ToC workshop (Annex F); (vii) a mapping of connections across the different elements of the ISCF ToC presented in this report (Annex G); (viii) a draft privacy notice and topic guide for key informant interviews to be conducted as part of the evaluation (Annex H); (ix) an indicative matrix to be used for the long-listing of potential evaluation case studies (Annex I); (x) an overview of different potential theory based evaluation methods that have been considered for this evaluation (Annex J); (xi) an initial assessment of the strength of evidence for each impact evaluation question (Annex K); and (xii) an initial scoping of wider databases for potential inclusion in the evaluation methodology (Annex A).

## 1.1. UK Industrial Strategy and the ISCF

In 2016, the UK government adopted its new Industrial Strategy: ‘Building a Britain fit for the future’ (Department for Business 2017). Establishing key goals of helping businesses to create ‘better, higher-paying jobs in every part of the United Kingdom’, and ensuring that all citizens ‘can embrace and benefit from the opportunity of technological change’, the Industrial Strategy seeks to meet these goals by combining horizontal policies (i.e. the Five Foundations that impact all sectors of the economy), sectoral policies (i.e. the Sector Deals that promote partnerships between government and industry), and a mission-based element (i.e. the four overarching Grand Challenges). The Grand Challenges – Artificial Intelligence (AI) and Data; Ageing Society; Clean Growth; and Future of Mobility – have been designed in response to the global forces shaping the rapidly evolving future. These Grand Challenges were developed with the University College London Commission for mission-oriented innovation and industrial policy, which made a series of recommendations including the need for cross-sectoral solutions, and to capture value from emerging technology and market opportunity (UCL 2016).

The ISCF represents a cornerstone of the UK government’s efforts to leverage R&I to support the Industrial Strategy and to tackle the Grand Challenges. Established in 2016 and delivered by UKRI since 2018, the ISCF aims to support the development of solutions to major industrial and societal challenges facing the UK, including the Grand Challenges, through the delivery of a mission-oriented R&I funding programme. The ISCF has a total commitment of £2.6 billion in government funding, funded through the National Productivity Investment Fund (NPIF), combined with an additional £3 billion in matched private sector

funding. Under the ISCF's mission-oriented approach, funding has been distributed through the creation of individual 'Challenges' – formed to identify key societal and industrial 'Challenges' facing the UK. These Challenges have been selected for their alignment to at least one of the four Industrial Strategy Grand Challenges and, where possible, to relevant Sector Deals. The selection of Challenges has also considered industries and technologies with potentially large global markets, and areas where the UK has both the scientific and business capability to become a world leader. Following the establishment of each Challenge, public and private organisations have been invited to bid collaboratively for projects that have the potential to contribute to addressing the Challenge. Thus far, 24 ISCF Challenges<sup>1</sup> have been established, with 1,613 projects supported. A full list of the ISCF Challenges is presented in Table 1 below.

Across all Challenges, the ISCF has five objectives. These are to:

- Increase UK businesses' investment in R&D and improve R&D capability and capacity
- Increase multidisciplinary and interdisciplinary research around the Challenge areas
- Increase business-academic engagement on activities relating to the Challenge areas
- Increase collaboration between younger, smaller companies and larger, more established companies within the value chain
- Increase overseas investment in R&D within the UK

By meeting these objectives, each ISCF Challenge aims to contribute to the advancement of knowledge, technological solutions, capacities and capabilities specific to the Challenge area. Moreover, by encouraging new forms of collaboration between public and private actors, the ISCF also seeks to create the potential for greater impacts than a traditional sectoral approach.

In practice, individual ISCF Challenges have been delivered through an eclectic mix of funding mechanisms and instruments, with the specific mechanisms used depending on the requirements of the Challenge. Ways in which ISCF funds have been allocated include funding for demonstrator projects; funding for the development of R&I infrastructure; funding for early-stage collaborative R&D; and funding for discovery-driven research. A key feature of the ISCF's mission-oriented approach is the 'Challenge Director' approach. A lead expert within the specific Challenge area, the role of the Challenge Director is to ensure coordination across the various organisations and initiatives participating in the Challenge and successful delivery against Challenge objectives.

The ISCF Challenges have been established through three funding waves: wave 1 (£1.09bn), wave 2 (£744m) and wave 3 (£851m), with wave 1 divided into two distinct sub-waves; wave 1a (£283m) and wave 1b (£726m). In wave 1a, £283 million was allocated as fast start R&I grants which, unlike funding across

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<sup>1</sup> While we refer to the 24 ISCF 'Challenges', the ISCF portfolio in fact consists of 21 Challenges plus three programmes. The three programmes (Self Driving Vehicles, National Satellite Test Facility and Next Generation Aero Materials) do not follow the same model as the 21 Challenges, do not have a Challenge Director and are monitored and evaluated differently. The implications of this for our evaluation are discussed below and in later chapters of this report.

all other waves, did not use a challenge-led approach. The Creative Industries Clusters Programme (CICP), also established under wave 1a, is a non-Challenge programme but closely aligned to the Audience of the Future Challenge. Alongside 1a investments, there are also three wave 1b programmes – Self Driving Vehicles, National Satellite Test Facility and Next Generation Aero Materials – that have not been established through the Challenge approach.<sup>2</sup>

Since 2016, the ISCF has adapted to a changing policy landscape. While the Grand Challenges remain, the UK government has sought to adapt the ISCF to contribute to its ‘levelling up’ agenda, addressing regional disparities in economic and social outcomes, and to also contribute to its aim of achieving net zero carbon emissions by 2050. In February 2021, the UK Government announced the termination of the 2016 Industrial Strategy and its replacement by a new post-Covid-19 ‘Plan for Growth’ agenda. Together with the launch of a new UK Innovation Strategy in the summer 2021, these changes will alter the strategic framework surrounding the ISCF and, potentially, what it is expected to deliver. It is also not clear what further adaptations will be made to the ISCF following the National Audit Office (NAO) report on UKRI’s management of the ISCF, published in March 2021 (Davies 2021).

**Table 1: The ISCF Challenges<sup>3</sup>**

Challenge name	Funding wave	Budget (£)	Number of projects supported
Robotics and Artificial Intelligence in Extreme Environment (RAI)	1b	112m	101
Medicines Manufacturing (MM)	1b	207m	187
Faraday Battery (FBC)	1b	318m	77
Self Driving Vehicles* (SDV)	1b	26m	3
National Satellite Test Facility*	1b	109m	1
Next Generation Aero Materials*	1b	26m	5
Data to Early Diagnosis and Precision Medicine (D2ED)	2	223m	37
Next Generation Services (NGS)	2	20m	50
Quantum Technologies	2	20m	4
Healthy Ageing (HA)	2	98m	31
Prospering from the Energy Revolution (PFER)	2	108m	73
Transforming Construction (TC)	2	173m	67
Transforming Food Production (TFP)	2	90m	90
Audience of the Future (AoTF)	2	39m	75
Accelerating Detection of Disease (ADD)	3	79m	1
Commercialising Quantum Technologies	3	153m	43
Digital Security by Design (DSD)	3	70m	15
Manufacturing Made Smarter (MMS)	3	147m	19
Industrial Decarbonisation (IDC)	3	170m	13

<sup>2</sup> According to the recently published NAO report on the ISCF, these were established separately due to UKRI predecessors needing to spend money quickly and provide funding to investment ready programmes (Davies 2021).

<sup>3</sup> This list does not include the Creative Industries Clusters Programme established under wave 1a.

Transforming Foundation Industries (TFI)	3	66m	17
Smart Sustainable Plastic Packaging (SSPP)	3	60m	29
Low Cost Nuclear (LCN)	3	235m	1
Driving the Electric Revolution (DER)	3	80m	41
Future Flight (FFC)	3	125m	37

Source: UKRI/National Audit Office

\* Programmes not established through challenge-led approach

## 1.2. Aims of the evaluation

The aim of this evaluation is to build an evidence base with which to judge the success and overall impact of the ISCF in order to:

- Inform ongoing and future improvements to the ISCF to maximise the value of public funding
- Demonstrate return on investment (ROI) to taxpayers
- Build the evidence base on the impact of mission-oriented and Challenge-focused R&I support as part of UKRI’s wider efforts to understand ‘what works’ in R&I policy and delivery

Alongside this evaluation, UKRI is also commissioning evaluations of each of the individual ISCF Challenges.<sup>4</sup> The Challenges are each being evaluated by independent evaluators, with interim and final evaluation reports for each Challenge to be delivered over the course of our Fund-level evaluation, as shown by Table 2.

**Table 2: Timeframes for Challenge-level evaluation reports<sup>5</sup>**

Challenge	2020	2021	2022	2023	2024
Robotics and Artificial Intelligence in Extreme Environments					
Medicines Manufacturing					
Faraday Battery					
Self Driving Vehicles					
National Satellite Test Facility					
Next Generation Aero Materials					
Data to Early Diagnostics & Precision Medicine					
Next Generation Services					
Quantum Technologies					
Healthy Ageing					
Prospering from the Energy Revolution					
Transforming Construction					

<sup>4</sup> This is not the case for the wave 1a investments, with the exception of the Creative Industries Clusters Programme, or the non-challenge aspects of wave 1b.

<sup>5</sup> The Creative Industries Clusters Programme will also submit its interim report in November 2021 and its final report in June 2024.

Transforming Food Production			Interim report		Final report	
Audience of the Future	Interim report			Final report		
Accelerating Detection of Disease						
Commercialising Quantum Technologies						
Digital Security by Design			Interim report			
Manufacturing Made Smarter						
Industrial Decarbonisation						
Transforming Foundation Industries			Interim report		Final report	
Smart Sustainable Plastic Packaging						
Low cost Nuclear						
Driving the Electric Revolution			Interim report		Final report	
Future Flight						
Interim report						
Final report						

Source: UKRI

This evaluation seeks to both supplement and complement these ongoing Challenge-level evaluations by focusing on what the Fund as a whole has delivered. As highlighted throughout this report, this Fund-level evaluation will draw upon data from these Challenge-level evaluations, with this data being used to build an evidence base regarding both the impact and process of the ISCF. While drawing upon the findings and data collected in the Challenge-level evaluations, this evaluation will also seek to collect new data in order to understand the overall impact of the ISCF, and to consider the contribution of the challenge-led approach.

The aims of this evaluation are distinct from, but complementary to, the aims of the recently published NAO report, *UK Research and Innovation's Management of the Industrial Strategy Fund*, the scope of which was to provide an assessment of whether UKRI's management of the ISCF has optimised value for money (Davies 2021). One significant conclusion of the NAO report was the difficulty of measuring the impact of the ISCF as a whole. Understanding this Fund-level impact is a key aim of the present evaluation.

### 1.3. Scope of the evaluation

The scope of this evaluation is ISCF waves 1–3, inclusive. While the primary focus of the evaluation is the challenge-led aspects of the ISCF, the evaluation will also consider the impact of the ISCF programmes that have not been established through a challenge-led approach. The latter includes the investments made under wave 1a of the ISCF, issued through standard UKRI research and innovation grants, as well as three programmes established under wave 1b: Self Driving Vehicles, National Satellite Test Facility and Next Generation Aero Materials. While included within the general scope of the evaluation, these programmes will primarily be used to compare against the broader challenge-led approach of the ISCF. Moreover, the extent of this comparison will also depend on the availability of evidence regarding the wave 1a investments and wave 1b non-Challenge programmes. More information on the planned approach to incorporating the non-Challenge aspects is provided in Chapter 6 of this report.

## 1.4. Evaluation framework: aims and approach

The evaluation is structured across four phases, the first of which is the development of an evaluation framework. The purpose of this first phase is to set out a detailed evaluation approach, including data collection and analysis methods, in order to provide the basis for robust impact and process evaluation to be conducted over the subsequent stages. The output of this phase is this evaluation framework report. Below, we outline the key activities undertaken by the evaluation team to inform the development of this evaluation framework report.

- **Kick-off meetings:** On 24<sup>th</sup> November 2020 and 1<sup>st</sup> December 2020, the evaluation team hosted evaluation kick-off meetings with the core UKRI ISCF evaluation team and the ISCF evaluation working group respectively. The kick-off meetings were used to confirm the objectives, scope and expected outcomes of the evaluation, the plan and timescale for implementation (i.e. the four evaluation phases), the processes for sharing relevant documentation and for approving key deliverables, and the expected communication channels between key evaluation stakeholders. The kick-off meetings were also used to consider the optimal approach to the ToC workshop to be held with the evaluation working group on 18<sup>th</sup> January 2021 (as described below).
- **Literature review:** To inform the development of the evaluation framework, the evaluation team undertook a REA of the literature on evaluation of mission-oriented R&I. The REA used a systematic search strategy to identify key relevant academic and grey literature. The key findings of this assessment (as presented in Chapter 2 of this report) were used to inform both the evaluation framework and the planned methodological approach.
- **Documentation review:** Alongside our REA of the broader literature on evaluation of mission-oriented R&I, the evaluation team also conducted a review of key documentation from the ISCF programme as provided by UKRI. Documents reviewed included:
  - **Challenge-level evaluation framework reports:** The evaluation team reviewed evaluation framework reports for 10 Challenges, as provided by UKRI.<sup>6</sup> Review of these reports focused on the following information: the components of the ToC/logic models developed for each Challenge; the indicators/metrics that will be used to evaluate the Challenge; and the data sources and associated methodological approaches that will be used to collect Challenge-level data. The review was used to inform our approach to the development of the ISCF ToC, while also identifying the relevant Challenge-level data that can be drawn upon when implementing the evaluation framework.
  - **Challenge-level benefits maps and benefits realisation plans:** The evaluation team reviewed benefits maps and benefits realisation plans for 16 Challenges, as provided by

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<sup>6</sup> The Challenges for which we reviewed Challenge-level evaluation framework reports are as follows: Medicines Manufacturing, Digital Security by Design, Robotics and Artificial Intelligence in Extreme Environments, Next Generation Services, Faraday Battery, Future Flight, Audience of the Future, Prospering from the Energy Revolution; Creative Industries Clusters Programme and Smart Sustainable Plastic Packaging.

UKRI, together with the overarching ISCF benefits register.<sup>7</sup> Review of these documents focused on both understanding the range of benefits identified across the Challenges and identifying the indicators/metrics (as associated data sources) that will be used to measure progress against the benefits. As with the review of Challenge-level evaluation framework reports, the review was used to inform our approach to the development of the ISCF ToC, while also identifying the relevant Challenge-level data that can be drawn upon when implementing the evaluation framework.

- **ISCF portfolio performance and monitoring reports:** The evaluation team reviewed the ISCF portfolio-level performance and monitoring reports, as provided by UKRI. Review of these documents focused on identifying the types of Challenge-level data being collated at the Fund-level that can be drawn upon when implementing the evaluation framework.
- **Theory of Change workshop:** On 18<sup>th</sup> January 2021, the evaluation team hosted a ToC workshop with members of the ISCF evaluation working group. The aim of this workshop was to discuss refinements to the ISCF ToC with a view to producing a revised ToC which, in turn, could be used to inform the development of the evaluation framework. The ToC workshop was structured around consideration of a draft ‘strawman ToC’ developed by the evaluation team in advance of the workshop. The strawman ToC drew on the evaluation team’s then-ongoing review of Challenge-level evaluation framework reports and benefits maps described above. A summary of key takeaways from the ToC workshop is presented in Annex F. Insights from the workshop were used to refine the draft ToC, with a new draft subsequently shared with UKRI for further feedback. The output of this process of iterative refinement is presented in the form of the finalised ISCF ToC presented in Chapter 4.
- **Wider stakeholder engagement:** During February and March 2021, the evaluation team undertook additional engagements to inform the scoping of the econometric and network analyses for the evaluation. These interviews focused on determining what types of data were held on the types of organisations supported by the Challenges, to understand which approaches may be feasible in principle. Interviews were held with central data teams in the ISCF programme and a small number of individual Challenge leads.

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<sup>7</sup> The Challenges for which we reviewed benefits realisation plans are as follows: Smart Sustainable Plastic Packaging, Medicines Manufacturing, Accelerating Detection of Disease, Quantum Technologies, Robotics and Artificial Intelligence in Extreme Environments; Transforming Food Production, Transforming Construction, Next Generation Services, Prospering from the Energy Revolution, Healthy Ageing, Data to Early Diagnosis, Transforming Foundation Industries, Industrial Decarbonisation, Future Flight, Audience of the Future and Low Cost Nuclear.

## 2. Rapid evidence assessment on the evaluation of mission-oriented R&I: key findings and insights for the evaluation framework

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### 2.1. Overview

This chapter presents the findings of a REA on the evaluation of mission-oriented R&I. The REA was undertaken as part of the development of the evaluation framework for the ISCF and aims to provide a robust evidence base to inform and provide key learnings for the evaluation framework. The evidence assessment was conducted using a systematic approach and consisted of a structured review of academic and grey literature. Unlike a full systematic review – which aims to search the entire evidence base comprehensively – the scope and coverage of the rapid evidence assessment was restricted through search and screening criteria to focus on the most relevant literature, and to ensure that the amount of literature to review was manageable within the scope, resources and timeline available for the work (the methods and approach to the REA are summarised in detail in Annex A). The REA first summarises evidence on the concept of mission-oriented R&I, and then goes on to provide evidence on the evaluation of mission-oriented R&I programmes, focusing both on existing evaluations of programmes as well as conceptual considerations of requirements and Challenges. The evidence assessment has highlighted general principles and challenges, as well as specific methodologies, for the evaluation of mission-oriented R&I. Throughout this chapter, we have highlighted the implications of these findings for our evaluation. The way in which our evaluation approach draws on these findings is explained in Chapter 3 and elaborated on throughout the subsequent chapters of this report.

### 2.2. Mission-oriented R&I

#### 2.2.1. There has been a rise of interest in mission-oriented R&I in recent years

In recent years, there has been a rise in interest in mission-oriented R&I programmes. Mission-oriented R&I, also known as ‘grand-challenges’ research, challenge-oriented science, moon-shot science or mission-oriented innovation policies (MOIP), can be defined as interventions carried out, often cross-disciplinarily, on a large scale, with a clear, well-defined mission to be achieved (Fisher, Chicot et al. 2018; Casadevall and Fang 2016; Lalli, Ruysen et al. 2018; Geels 2019). The concept of mission-oriented R&I has been used in attempts to tackle some of the world’s greatest societal problems, such as climate change and an increasing aging population (Mazzucato 2018).

The concept of mission-oriented programmes is not a recent phenomenon and can be dated as far back as the 1940s and 1950s.<sup>8</sup> The Manhattan Programme, a research and engineering project during the Second World War that aimed to develop the world's first nuclear weapon (Casadevall and Fang 2016). On its own terms, the programme was a success, leading to the creation of two nuclear bombs and in the process making a major contribution to the end of the Second World War (Alexander 2008).<sup>9</sup> In the 1960s, President John F. Kennedy launched the Apollo 'man on the moon' project with the aim of getting a man on the moon and back to Earth by the end of the decade. On 20<sup>th</sup> July 1969, Neil Armstrong set foot on the moon (Mazzucato 2018).

Although these mission programmes were innovative in their time and are still influential to this day, there is now a shift in the focus on mission-oriented R&I. Replacing the emphasis of earlier mission-oriented programmes on supporting military, defence, nuclear and aerospace programmes, this new wave of mission-oriented R&I is both more global in outlook and more oriented towards societal impacts (Amanatidou, Cunningham et al. 2014, Boon and Edler 2015, Mazzucato 2018, Gibson, Stutchbury et al. 2019). Whereas 20<sup>th</sup> century science policies were dominated by references to 'problems', this is increasingly being substituted by a focus on grand societal challenges (Kaldewey 2018). A key feature of these 'grand challenges' is that they cannot be tackled by technological solutions alone (Amanatidou, Cunningham et al. 2014). Addressing grand challenges therefore requires broader changes in human perceptions and behaviour, as well as societal norms and values, and social innovations that promote non-technological solutions (Amanatidou, Cunningham et al. 2014).

### 2.2.2. Complex societal challenges have resulted in funders turning to mission-oriented R&I

Funders have begun to turn towards mission-oriented R&I for several reasons. Most significantly, the embrace of mission-oriented approaches reflects recognition of the pressing and complex societal, environmental and economic challenges that society faces (Mazzucato 2018). These challenges, also referred to as 'wicked' challenges, require new and innovative approaches and solutions. These challenges are referred to as 'wicked' because of their complex, systemic, interconnected nature, which requires multidisciplinary insights (Amanatidou, Cunningham et al. 2014, Mazzucato 2018). According to Mazzucato (2018), for example, the 'wicked' challenge of global poverty cannot be solved without attention to the interconnections between nutrition, health, infrastructure and education, as well as redistributive tax policy.

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<sup>8</sup> In his analysis of mission-orientated policy designs, economist Henry Ergas (1987) introduced an initial definition of 'mission-orientated technology countries', as those actively involved in the search for international strategic leadership (Ergas 1987). At the time, defence accounted for a big proportion of government expenditure on R&D in these 'technology countries' (Kattel and Mazzucato 2018). There was a major theme of national sovereignty and technological leadership which provided the foundational objectives for mission-orientated programmes (European Commission & OECD 2020). According to the Schlenoff et al (2010), the term 'missions' shows strong links with military operations (European Commission & OECD 2020).

<sup>9</sup> The outcome of the Manhattan Programme resulted in repercussions in subsequent wars to follow, as there was a shift within R&D in the military and defence sector, and more nuclear atomic bombs were created by other countries (Alexander 2008).

Seen as a response to ‘wicked’ problems, mission-oriented research initiatives are ambitious, exploratory and ground-breaking in nature. They cross disciplines and target a concrete challenge with a large impact and a well-defined timeframe (Kattel and Mazzucato 2018). These initiatives typically have a clearly defined goal with qualified and or quantified targets, and progress can be monitored along pre-defined milestones (OECD 2020). Compared to more traditional approaches to R&I, the new wave of mission-oriented R&I is believed to offer directionality and intentionality (Kattel and Mazzucato 2018, Polt, Schuch et al. 2019). According to the literature, mission-oriented R&I programmes should possess a number of key characteristics, including (but not limited to):

- A clear direction (Mazzucato 2018)
- Ambitious but realistic R&I actions (Rodrik 2004)
- Cross-disciplinary and cross-sectoral innovation (Mazzucato 2018)
- Cross-actor innovation (both public and private actors) (Rodrik 2004, Mazzucato 2018)

They should also allow multiple bottom-up solutions, enabling bottom-up experimentation and learning so that the innovation process itself is nurtured through dynamic feedback loops and serendipity (Rodrik 2004, Amanatidou, Cunningham et al. 2014, Mazzucato 2018).

In contrast to more traditional R&I approaches, ‘new’ mission-oriented R&I has the potential to shape markets, public investment and policy frameworks (Amanatidou, Cunningham et al. 2014, Kattel and Mazzucato 2018). With the use of mission-oriented R&I, the market failure approach is not used as a theoretical foundation for public sector activities. While a traditional welfare economics driven market failure approach is good at identifying problems, such as areas with under-investment in R&D, it is less good at identifying areas with the highest potential social benefit (Nelson 1959, Kattel and Mazzucato 2018). In selecting ‘challenges’ or ‘wicked’ problems that will guide innovation across sectors and actors (public and private), mission-oriented programmes will potentially lead to an increase in investments across sectors and an opportunity to correct existing market failures, as well as shape and direct new markets (Mazzucato 2018).

### 2.2.3. There are several leading actors funding mission-oriented R&I programmes

The European Union (EU) is an important actor in the funding of mission-oriented R&I. Horizon Europe, the EU’s framework programme for R&I, is designed to generate new knowledge and technologies, promote scientific excellence, create social and environmental impact, and contribute to growth and jobs by speeding up the process through which research results are brought to market and innovations scaled-up (OECD 2020). One of the main new initiatives in the Horizon Europe programme is the mission-based approach and funding for specific missions (OECD 2020).<sup>10</sup> On a national level, the EU also contributes funds to

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<sup>10</sup> Horizon Europe has a budget of €97.6bn (European Commission & OECD 2020). The framework programme is designed around three pillars, similar to the three-pillar structure of Horizon 2020 (Fisher et al, 2018). The Open Science pillar (€25.8bn) supports researchers through fellowships and exchanges through the European Research

programmes that have the aim of targeting societal challenges. The Czech Republic, Lithuania, Malta, Poland, Romania and Slovakia have seen an increase in EU contribution to their R&D national expenditures in this way (Fisher, Chicot et al. 2018).<sup>11</sup> EU member states such as Denmark, France, Germany and Italy have a high share of government R&I budget set aside specifically to fund research on societal challenges (Fisher, Chicot et al. 2018).

While European countries have been active players in the rise of new mission-oriented programmes, it is also the case that European countries remain behind several other nations in innovative-based growth and R&D targeting (Veugelers, Cincera et al. 2015). Outside Europe, other major funding actors in mission-oriented R&I include the United States, and Asian countries such as China, Japan and South Korea. The United States has long been a trailblazer in R&I (e.g. Apollo 11 project, DARPA). However, within recent years, Asia has seen a rise in R&D spending, as well as private and public investments (Bonner 2019). Japan's R&D investment in 2018 was higher than the OECD average, equivalent to 3.3 per cent of GDP (Ward 2020). As part of this investment, Japan has established successful mission-oriented R&I programmes such as the Moonshot R&D programme launched by the Japanese cabinet office (see Table 3 below). This mission-oriented programme is cross-cutting across all disciplines and aims to promote high-risk, high impact R&D with the goal to solve issues such as global warming and the issue of an ageing population (Bonner 2019).

UK R&D investment was equivalent to 1.7 per cent of GDP in 2018, below the OECD average of 2.4 per cent (Ward 2020). By investing in innovative mission-oriented challenges through the ISCF, however, the UK government aims to enable rapid progression in R&I across grand challenges (UKRI 2020). The ISCF aims to provide solutions to the industrial and societal challenges that the UK faces by not only increasing UK businesses' investment in R&D, but by increasing overseas R&D investment in the UK, increasing multidisciplinary and interdisciplinary research around the challenge areas, and increasing business-academic engagement on innovation activities relating to the challenge areas (UKRI 2020). Aside from the ISCF, the UKRI has started to adopt a challenge approach with their role (alongside other partners) in delivering the Global Challenges Research Fund (GCRF). As part of the UK's official development assistance, the GCRF is a £1.5 billion Fund that supports cutting-edge research to address challenges faced by developing countries (UKRI 2020). The GCRF addresses the UN sustainable development goals and aims to maximise the impact of R&I to improve lives and opportunities in the developing world (UKRI 2020).

This REA has found evidence of a large number of mission-oriented programmes, at various stages of development, that may be characterised as mission-oriented. Selected examples of mission-oriented R&I

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Council and the Marie-Sklódowska-Curie actions (European Commission & OECD 2020). The global challenges pillar (€52.7bn) supports research relating to societal challenges, setting EU-wide missions with ambitious goals (European Commission & OECD 2020). Finally, the Open Innovation pillar (€13.5bn) aims to make Europe a front runner in market-creating innovation (European Commission & OECD 2020).

<sup>11</sup> According to Fisher et al (2015), this may have been due to the member states similarly increasing their budget allocation for grand challenges significantly. This may encourage other EU member states to invest more in mission-oriented R&I.

programmes, together with key features of those programmes, are presented in Table 3 below.<sup>12</sup> However, though we present these specific examples here, we have included evidence regarding the evaluation of mission-oriented R&I for all programmes (not just those included in this table) in the following sections (2.3 and 2.4). Therefore, these examples are just illustrative and do not indicate a restriction placed on our evidence base.

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<sup>12</sup> The examples presented in this table have been selected based on their potential relevance to UKRI (as reflected in discussions with UKRI stakeholders), while also focusing on those mission-oriented programmes for which the most information was available, based on the data extracted through the REA. A longer list of mission-oriented R&I programmes encountered in the literature can be found in Annex C of this report.

**Table 3: Selected examples of mission-oriented R&I programmes**

Name of mission-oriented programme	Funder	Geographical setting	Sector/discipline	Budget	Planned timetable	Source
NRC Challenge Programme	NRC National programme office  Collaborations with Canadian government  NRC Ideation Fund	Canada	Cross-cutting (includes AI, Internet of things, construction and aerospace)	\$150m over five years +  \$30m per year to fund multi-party R&D programmes. Additional \$15m granted to support Covid-19 research	Seven years for each programme: e.g. Aging in Place Challenge programme has a planned timeline from 20/21–2028	<a href="https://nrc.canada.ca/en/research-development/research-collaboration/programs/challenge-programs">https://nrc.canada.ca/en/research-development/research-collaboration/programs/challenge-programs</a>
ImPact Canada Initiative	Impact and Innovation Unit of the Privy Council Office  Collaborations with Canadian government	Canada	Cross-cutting (includes housing, energy and smart cities)	Up to 25 finalists will receive \$100,000 each to enter stage 2 development phase  E.g., \$300m (£1.7m) over five years to support Housing Supply Challenge	Approx. one year (Oct 23, 2020–Oct 2021)	<a href="https://impact.canada.ca/en/node/19">https://impact.canada.ca/en/node/19</a>
Moonshot R&D programme	Cabinet office	Japan	Cross-cutting (includes super-aging populations & global warming)	100bn Japanese Yen (£730m) in FY2018 as set-up, 15bn Japanese Yen for FY2019 onwards	2013–2050	<a href="https://www8.cao.go.jp/cstp/14stimat/moonshot/top.html">https://www8.cao.go.jp/cstp/14stimat/moonshot/top.html</a>

Name of mission-oriented programme	Funder	Geographical setting	Sector/discipline	Budget	Planned timetable	Source
Vinnova Challenge-Driven Innovation programme	CDI (Challenge-Driven Innovation)	Sweden	Sustainability, innovation	Projects within programmes are granted seed funding of equivalent £43k for Stage 1 (development) and £1.7m for Stage 3 (implementation)	2011–	<a href="https://www.vinnova.se/contentassets/6bf9b3642c2b492e8cc5e6a7c8bce955/cdi-program-description-171025.pdf">https://www.vinnova.se/contentassets/6bf9b3642c2b492e8cc5e6a7c8bce955/cdi-program-description-171025.pdf</a>
BRAIN (Brain Research through Advancing Innovative Neurotechnologies) Initiative	Private and public funders	USA	Health (neuroscience)	The <i>BRAIN 2025</i> report calls for an escalating budget to reach \$500m per year by FY2019, for a total 12-year budget of \$4.5bn	April 2013–2025	Fisher et al., (2017): Mission-Oriented R&I: Assessing the impact of a mission-oriented R&I approach
Solar energy in Chinese Five-Year Plans	Independent power producers  Public private partnerships	China	Energy	Information not available	2011–2020 13 <sup>th</sup> Five Year plan: 2016–2020	Fisher et al., (2017): Mission-Oriented R&I: Assessing the impact of a mission-oriented R&I approach

Source: RAND Europe analysis

## 2.3. Evaluation of mission-oriented R&I

This section presents evidence from a rapid review of the evidence on evaluation of mission-oriented R&I. The REA has highlighted general principles and challenges, as well as specific methodologies, for the evaluation of mission-oriented R&I. Throughout this section, we have used boxes to highlight key implications of these findings for our evaluation.

### 2.3.1. Although interest in mission-oriented R&I programmes is growing, the evidence on evaluation of mission-oriented R&I remains limited

Although there is growing interest in mission-oriented R&I programmes in policy circles, these currently remain understudied (Wesseling and Meijerhof 2020), and very few mission-oriented programmes have been systematically and rigorously evaluated (Fisher, Chicot et al. 2018). Some authors have argued that existing innovation systems and transitions frameworks, for example the Multi-Level Perspective on technological transitions<sup>13</sup> (Geels 2002) and the Technological Innovation System perspective<sup>14</sup> (Hekkert, Suurs et al. 2007), are not relevant to understand and assess the impact of mission-oriented R&I programmes (which cover multiple societal functions, e.g. achieving a 100 per cent circular economy, or focus on highly specific challenges, e.g. achieving long-term survival for the majority of cancer patients by 2030) (Ghazinoory, Nasri et al. 2020, Hekkert, Janssen et al. 2020). In addition, existing frameworks often focus on analysing a specific technological domain rather than progress in solving societal challenges, and a dedicated framework for assessing mission-oriented innovation policies has not yet been developed (Hekkert, Janssen et al. 2020). Therefore, there is a limited evidence base for what is required to successfully evaluate mission-oriented R&I programmes.

### 2.3.2. However, the literature does provide some evidence to draw on

Despite the lack of evaluations and applicable frameworks, the literature does provide some evidence on evaluations of mission-oriented R&I. Broadly, this evidence derives from two types of source:

1. There are some examples where mission-oriented programmes *have* been evaluated.

Our review identified nine programmes or initiatives that have been evaluated. The programmes cover multiple countries worldwide and a range of thematic areas (e.g. transport, food and agriculture, neuroscience, energy, climate change and maternal health). Table 4 provides an overview of existing evaluations of mission-oriented R&I programmes as encountered by our review.

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<sup>13</sup> Framework that describes long-term and large-scale technological developments and transitions, focusing on patterns and mechanisms in transition processes.

<sup>14</sup> Framework that focuses on understanding and mapping the *activities* that take place in innovation systems resulting in technological change.

Table 4: Overview of existing evaluations of mission-oriented R&amp;I programmes

Name of programme or initiative	Country of the initiative	Description	Main methods	Key source
University of Wollongong's Global Challenges Program	Australia	Reports on findings from a detailed feedback and evaluation process conducted at the start of 2017, four years into the programme's operation	<p>Online survey of 161 researchers who could potentially have applied for programme funding</p> <p>Focus groups of a random selection of 25 researchers who had been involved in projects previously funded by the programme</p>	(Gibson, Stutchbury et al. 2019)
Saving Brains, Grand Challenges Canada (GCC)	23 low- and middle-income countries	Participatory mixed-method impact and process evaluation of projects funded by Saving Brains, Grand Challenges Canada between 2011 and 2016	<p>Adopted a ToC based approach</p> <p>Mixed-methods approach: different quantitative data sources from the programme; literature review, stakeholder consultation and analysis of written portfolio documents</p>	(Milner, Bernal Salazar et al. 2019, Kohli-Lynch, Ponce Hardy et al. 2020)

Name of programme or initiative	Country of the initiative	Description	Main methods	Key source
Challenge Programme on Water and Food	Africa, Asia, Latin America	Describes the development and application of an evaluation framework, Participatory Impact Pathways Analysis (PIPA), to evaluate the Challenge Program on Water and Food (CPWF), a large and complex, five-year research-for-development (R4D) programme.	Developed and used PIPA that consists of a ToC based approach.  Impact pathways workshop with different stakeholders for each project Development of logic models and actor network maps to determine organisations necessary for impact to happen.	(Douthwaite, Alvarez et al. 2007, van Drooge and Deuten 2016)
Pilot Regional Energy Strategy (RES) programme	Netherlands	Comparative case study of regional energy strategies in the Netherlands in three regions that took part in the pilot RES programme from June 2016-October 2017: Friesland, Midden-Holland and West-Brabant. The aim was to identify lessons to implement mission-oriented innovation policy for mission formulation and execution.	Uses qualitative data generated through interviews, policy documents and mission evaluation reports.	(Geels 2019)

Name of programme or initiative	Country of the initiative	Description	Main methods	Key source
EU Human Brain Project Future and Emerging Technologies Flagship	EU	Panel of high-level experts undertook an interim evaluation of the Future and Emerging Technologies flagship programme, specifically the Graphene and Human Brain Projects.	Evidence was collected through technical reports of two scientific project reviews, written questionnaires and interviews, from a wide range of stakeholders.	(European Commission 2017)
EU Joint Programming Initiatives	EU	Evaluation of the progress made by Member (and Associated) States on Joint Programming in addressing Grand Societal Challenges.	<p>Evaluation was carried out by an Expert Group from five countries with assistance from European Commission staff.</p> <p>Work involved: Review of documentary evidence that had been produced to monitor and support the implementation of the JPIs; a survey of national policy stakeholders; follow on interviews</p>	(Hunter, Hernani et al. 2016)

Name of programme or initiative	Country of the initiative	Description	Main methods	Key source
Saving Lives at Birth	Africa Asia and Pacific Europe and Eurasia Latin America/Caribbean North America Middle East and North Africa	Developed a ToC and impact framework with prioritised metrics to map the contribution of Saving Lives at Birth towards overall goals, and to measure progress towards improved outcomes around the time of birth	A theory of change and impact framework was developed retrospectively, drawing on expertise across the partnership and stakeholders. Specific methods included:  Literature review Consultation of technical and policy experts; a series of workshops with partners, finalists and current innovators across all funding stages	(Lalli, Ruysen et al. 2018)
Dutch Green Deal: Maritime and Inland Shipping and Ports	Netherlands	Takes a case study approach and applies a 'Mission-oriented Innovation Systems' approach to assess the effectiveness of the Dutch Green Deal Maritime and Inland Shipping and Ports mission around sustainable shipping	Adopted a case study approach involving: interviews of the Dutch maritime and inland shipping sector; literature review on sustainable maritime transport solutions.	(Wesseling and Meijerhof 2020)

Name of programme or initiative	Country of the initiative	Description	Main methods	Key source
PAISS, PAISS 2 and Inova Energia	Brazil	Developed a mission-oriented analytical framework for renewable energy programmes and applies it to three mission-oriented programmes around renewable energy innovation policies	Conducted a literature review to identify and define key characteristics of mission-oriented policies and then apply this to three programmes in Brazil	(Mendonça, van Aduard de Macedo-Soares et al. 2018)

Source: RAND Europe analysis

1. Reflecting the relatively limited evidence on the evaluation of mission-oriented R&I, there has also been conceptual consideration of the potential challenges involved in evaluating such programmes, and what effective evaluation of mission-oriented R&I may require (Amanatidou, Cunningham et al. 2014, Joly and Matt 2017, van Drooge and Spaapen 2017).

In the sections below, evidence from these two sources is used to provide insight into the challenges and requirements of evaluating mission-oriented R&I, as well as evidence around methods and frameworks.

### 2.3.3. Challenges of evaluating mission-oriented R&I

The complex nature of mission-oriented R&I poses new challenges related to evaluation (Amanatidou, Cunningham et al. 2014, Joly and Matt 2017). It has been acknowledged by some that mission-oriented R&I will require changes in evaluation practices (Biegelbauer, Hartmann et al. 2020). Evidence from evaluations of mission-oriented R&I programmes and conceptual consideration of challenges provide some insights on the challenges of evaluating mission-oriented R&I. Overall, evaluation challenges include dealing with or overcoming: multiple types of impact, long timeframes, and a broader set of stakeholders (Joly and Matt 2017).

#### Mission-oriented R&I initiatives have a broad remit and often deal with multiple types of impact

Mission-oriented R&I initiatives aim to solve complex, global problems that require achieving multiple types of impact, including scientific, technological, economic, but also societal impact (Amanatidou, Cunningham et al. 2014). This requires solutions that combine both science and technology, and social sciences and the humanities (Amanatidou, Cunningham et al. 2014). Therefore, mission-oriented R&I initiatives require a multidisciplinary research approach (i.e. combining socio-economic, scientific and technological research), multi-sector expertise (e.g. public, private, non-profit) and generate multiple types of impact (i.e. spanning from basic research through to innovation diffusion) (Joly and Matt 2017, Geels 2019). In addition to developing new solutions, missions also involve the phasing out of existing practices and technologies (Wesseling and Meijerhof 2020). This means that coordination of solution development and phase out becomes important, and contestation features prominently (in terms of problem framings, selection of solution pathways and phase-out of existing practices and technologies) (Wesseling and Meijerhof 2020).

Currently, there is fragmentation in scientific and technological disciplines, across different sectors (i.e. public, private, non-profit, etc.) and across different policy areas and governance levels (regional, national, international) (Amanatidou, Cunningham et al. 2014). This poses challenges around developing evaluation frameworks that encourage and reward transdisciplinary research, broader societal impacts and public engagement (van Drooge and Spaapen 2017). There are also challenges around developing a flexible enough evaluation framework and associated indicators to capture such broad scope. For example, the Saving Lives at Birth programme is diverse with a wide range of innovations and challenges to developing a ToC that captures the diversity across the portfolio (Lalli, Ruysen et al. 2018). Developing impact measures was also challenging because the programme features different types of grants and domains and multiple innovations at different stages of the innovation pathway (Lalli, Ruysen et al. 2018). To address these challenges, the authors indicate that a multifaceted approach was required to ensure that inputs into the design of an impact

framework and prioritised metrics were appropriate in view of the broad remit of the programme (Lalli, Ruysen et al. 2018).

Mission-oriented R&I initiatives frequently lead to spillovers into other disciplines. The emergence of spillovers means that a mission-oriented initiative may affect disciplines that it does not directly target (Deleidi and Mazzucato 2021). Crowding in, or increased (intersectoral) investment by private firms following government spending, is relatively high with government spending on mission-oriented R&D initiatives (Deleidi and Mazzucato 2021), and mission-oriented research grants are relatively successful in stimulating diversity in research topics (Shimada, Tsukada et al. 2017). For a comprehensive assessment, an estimate on framework must not only capture the outcomes of the mission-oriented research on its target disciplines, but also incorporate the outcomes on the disciplines that benefit from the associated spillovers.

The implication of this challenge for the evaluation of the ISCF is that we need a broad and flexible framework that is able to capture unexpected impacts, and which not only looks at the technology advancement but also social and behavioural aspects.

### Mission-oriented R&I initiatives generally take place over long timeframes

Mission-oriented R&I initiatives typically aim to address long-term challenges, such as climate change (Amanatidou, Cunningham et al. 2014). This requires addressing social, economic and technological impacts over long timeframes, and involves objectives which are not necessarily given at the outset but emerge along the impact pathway (Joly and Matt 2017). For example, the German *Energiewende* programme confronted significant changes, such as new technological breakthroughs and technological bottlenecks, which required an adaptation of the programme over time (Fisher, Chicot et al. 2018).

The long-term approach of mission-oriented R&I initiatives also raises difficulties in attributing impacts to specific policy measures, since broader societal impacts may be beyond the scope of a particular programme (Amanatidou, Cunningham et al. 2014). The long time-horizon also conflicts with the short-termism of policymaking cycles (Amanatidou, Cunningham et al. 2014, Mendonça, van Aduard de Macedo-Soares et al. 2018).

The implication of this challenge for the current evaluation of the ISCF is the timeframe for the evaluation, which is taking place whilst the Fund is still ongoing. This means that many of the longer-term impacts will not be realised within the evaluation timeframe, which means it will not be possible to report on these. A key mitigation strategy for this involves building in intermediate measures looking at outputs and outcomes, in addition to longer-term impacts, which will provide an indicator as to whether the Fund is on track to achieve long-term impact. In addition, this evaluation will involve considering and recommending an appropriate approach to a future, follow-on phase of evaluation. It will also be important to understand anticipated long-term impacts in order to take relevant actions, such as capturing baselines.

### Mission-oriented R&I initiatives involve a variety of stakeholders

Mission-oriented R&I initiatives aim to develop solutions across the innovation pathway (i.e. spanning from basic research through to innovation diffusion) and in particular aim to achieve societal goals. This means they need to engage and coordinate a broader set of stakeholders (e.g. policymakers, NGOs, industry, universities, regulators, and citizens/end-users) (Joly and Matt 2017, Mendonça, van Aduard de

Macedo-Soares et al. 2018, Geels 2019), whose interactions and networks evolve over time (Joly and Matt 2017), and who may have different views on what the problem is and how it should be approached (van Drooge and Deuten 2016). The longer timeframes of these programmes also impact on the role of public and private actors, with a much larger role ascribed to private sector actors (Fisher, Chicot et al. 2018).

The involvement of multiple stakeholders presents challenges for evaluation around taking into account the variety of interests and expectations (e.g. regarding the organisation of a programme and ideas regarding impact), which may be conflicting, and interactions between stakeholders, which might be difficult to assess (Joly and Matt 2017, Modic and Feldman 2017, van Drooge and Spaapen 2017). It has been suggested by some authors that this will require encouraging different stakeholders to take the time to ensure mutual learning and understanding between them (van Drooge and Spaapen 2017).

Mission-oriented R&I involves a broad range of stakeholders in different ways at various stages of the R&I pathway, which is different from traditional forms of research governance, where stakeholders are involved at a distance or not at all (van Drooge and Spaapen 2017). This presents challenges around providing possibilities for broad stakeholder engagement in the performance, governance and evaluation of programmes. Stakeholders should be involved from the beginning of a programme, and consequently are involved in the development of the agenda of the project, and in allocation and evaluation decisions (van Drooge and Spaapen 2017). The literature suggests that governance of mission-oriented R&I programmes should be conducted in a centralised manner, combining technical expertise, financial resources and decision-making autonomy in one agency (Mendonça, van Aduard de Macedo-Soares et al. 2018). For example, a review of three mission-oriented R&I programmes (PAISS, PAISS 2 and Inova Energia) in Brazil found that the number of institutions setting priorities, monitoring the process and evaluating performance delayed the process and made priority investments and project integration less effective than they could have been (Mendonça, van Aduard de Macedo-Soares et al. 2018). It has been suggested that a new form of governance is needed, that is tentative, dynamic and involves a learning process (van Drooge and Spaapen 2017).

The Implication of this challenge for the evaluation of the ISCF is the need for a participatory evaluation approach, given the diversity of actors and perspectives. This will mean involving a variety of stakeholders in the design and implementation of the evaluation to ensure criteria and metrics capture a wide variety of views. Wide stakeholder engagement should be planned early on as part of the inputs and activities through various means (e.g. workshops and meetings).

#### 2.3.4. Requirements for the evaluation mission-oriented R&I (general principles)

The literature highlights that effective evaluation of mission-oriented R&I will require finding ways to address and overcome the aforementioned challenges, and thus points to several general requirements of effective evaluation of mission-oriented R&I. Where relevant, key insights and considerations for our evaluation framework are drawn out under each section.

##### The purpose of the evaluation should be focused on learning

Given that mission-oriented R&I aims to achieve wider system-level transformations with multiple levels of impacts (i.e. individual behaviour but also societal structures and institutions), evaluation should explore impact pathways that are non-linear and often involve feedback and rebound mechanisms between

different levels (Fisher, Chicot et al. 2018). This will require the abandonment of the linear Bush model of science<sup>15</sup>, to recognise that basic research and scientific excellence alone is not enough to solve societal issues (van Drooge and Spaapen 2017). Therefore, commonly used practices for evaluation of scientific research (accountability, rankings and benchmarking, dedicated to scientific excellence) do not fit the goals of ‘transdisciplinary collaborations’ (van Drooge and Spaapen 2017). It has been suggested that rather than accountability, the primary function of evaluation of mission-oriented R&I should focus on mutual and system-level learning to enable a better understanding of the impact generating mechanisms (van Drooge and Spaapen 2017). This involves considering the various pathways involved in the translation of research results into impacts and recognising that systems transformation is a long and complex process with multiple causes and consequences (van Drooge and Spaapen 2017). This requires a bottom-up or stakeholder-oriented approach that stimulates mutual learning as well as the development of socially robust knowledge (van Drooge and Spaapen 2017).

While our evaluation will focus on both accountability and learning, the literature stresses the importance of evaluations that focus on learning. The evaluation framework should be designed to enable learning from experience and the evolution of the programme. The framework should include activities to ensure that learning will take place, such as involving a wide range of stakeholders in programme and Challenge activities, including participatory workshops and meetings where stakeholders can develop a joint understanding and vision of the impact they are aiming for.

### A broader set of evaluation criteria and indicators need to be considered

In addition to developing technological solutions, mission-oriented R&I programmes aim to have broader societal impacts (van Drooge and Deuten 2016). Commonly used indicators that relate only to scientific aspects do not cover many of the aspects of a mission-oriented programme. For example, measuring societal impacts also highlights the importance of considering issues such as ‘behavioural additionality’ (e.g. assessing behavioural change) (Amanatidou, Cunningham et al. 2014). However, the full potential of the concept of behavioural additionality is rarely acknowledged or exploited in current evaluation practices (Amanatidou, Cunningham et al. 2014). Therefore, a range of indicators are needed, that together describe the complexities of mission-oriented R&I. Another possibility is to combine individual indicators into an overall indication of key outcomes, as has been done with the Innovation Union Scoreboard and Innovation Indicator (Frietsch, Rammer et al. 2015, Veugelers and Cincera 2015). An analysis of four case studies of mission-oriented programmes in Austria found that the programmes were missing appropriate indicators for outcomes, impact and societal targets (Biegelbauer, Hartmann et al. 2020).

In addition, it is important to consider both specific and spillover impacts (Mendonça, van Aduard de Macedo-Soares et al. 2018). Although mission-oriented programs usually have a specific target, historically they have frequently generated spillovers (Mendonça, van Aduard de Macedo-Soares et al. 2018). For

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<sup>15</sup> The Vannevar Bush report “Science – the endless frontier” published in 1945 presented a linear and unidirectional model of knowledge creation and application highlighting the importance of conducting unfettered basic research without looking at societal impact.

example, defence-backed technologies such as GPS, Internet, microprocessors and touch screens are spinoffs of mission-oriented initiatives (Mendonça, van Aduard de Macedo-Soares et al. 2018).

Our evaluation framework needs to consider multiple types of outcomes and impacts, with multiple qualitative and quantitative evaluation criteria and indicators. The framework should also capture elements related to encouraging interdisciplinary working, such as the formation of clusters, networks and collaborations across and within public and private sectors, and between disciplines, and multidisciplinary and interdisciplinary research around the Challenge areas. The framework also needs to account for the impact of both solution pathways and phase-out of existing practices and technologies (e.g. the phasing out of practices and technologies that are bad for the environment in environmentally focused Challenges). It will also be important to take into account the 'behavioural additionality', and not just ask questions of 'what?' and 'how much?' but also 'how?' and 'why?'.

### A flexible and adaptable framework should be developed

The changing nature of long-term and not clearly defined objectives of mission-oriented R&I means it is necessary to develop an evaluation framework with a high degree of flexibility and adaptability (Biegelbauer, Hartmann et al. 2020). This is important to allow the possibility to change course if there is a risk that the objective will not be achieved (Geels 2019) or new evidence becomes available (Biegelbauer, Hartmann et al. 2020). This requires defining intermediate goals to keep track of progress towards the mission objective, and to potentially scale back the initiative if the objective is not being met (Mendonça, van Aduard de Macedo-Soares et al. 2018, Geels 2019).

The evaluation framework should aim to identify and map indicators for short-, mid- and longer-term outcomes and impacts, and build in review points whereby suitability of indicators can be reviewed regularly, based on impacts that have materialised to date. This will enable the monitoring of programme performance and progress across multiple timeframes. This is particularly important given the evaluation is taking place while the ISCF is still ongoing, and is unlikely to be able to capture longer-term impacts.

### A participatory and distributed approach to evaluation should be adopted

Mission-oriented R&I involves a variety of societal stakeholders (e.g. funders, researchers and end-users) who are part of a joint process aimed at achieving societal impact. Therefore, evaluation should also be a joint effort between multiple stakeholders, to improve the collaborative understanding of the joint process and progress towards the common societal goal (van Drooge and Spaapen 2017). In addition, mission-oriented R&I initiatives have a greater focus on involving end-users and citizens in the research process (van Drooge and Spaapen 2017). This therefore entails a participatory and distributed approach to evaluation in which stakeholders are empowered and committed (Joly and Matt 2017).

Our evaluation framework should consider multiple avenues for wide stakeholder engagement to enable a participatory approach to evaluation (see Section 2.3.3).

### The uniqueness of each mission-oriented R&I programme should be recognised

It has been emphasised in the literature that each mission-oriented R&I programme is unique (Wesseling and Meijerhof 2020), and therefore evaluation should adapt to the specific characteristics of a particular mission. Different dimensions of missions include, for example: the level of ‘wickedness’ (differing degrees of complexity, uncertainty and contestation); the type of solutions focused on (i.e. technological or social); focus on development or diffusion of a solution; the number of possible ‘solution pathways’ within its scope; geographical scope (i.e. local, regional, national, supranational, global) and ensuing coordination problems; and governance structures (Wesseling and Meijerhof 2020). Therefore, these different dimensions are likely to bring about unique dynamics and challenges, which should be taken into account in any evaluation. For instance, one-size-fits-all indicators are no longer adequate, and so indicators (both quantitative as well as qualitative) are needed to suit each specific context and programme (van Drooge and Spaapen 2017).

The focus on recognising the uniqueness of each of the ISCF Challenges represents a key challenge for this evaluation. Our evaluation framework should be designed in a way that enables recognition of the specific impacts of each Challenge, while also retaining a Fund-level perspective. To strike this balance, the evaluation should explore the extent to which the Fund provides an enabling environment and pathways for all Challenges to progress regardless of their specific context.

#### 2.3.5. Frameworks that have been proposed for the evaluation of mission-oriented R&I

There is a lack of evaluation approaches suited for mission-oriented R&I and ‘transdisciplinary approaches’ more generally (van Drooge and Spaapen 2017, Fisher, Chicot et al. 2018). Traditional forms of research evaluation (with a focus on academic quality and output of academic staff in the scientific literature, goals of accountability for public funds (ex post) and underpinning of decisions about resource allocation (ex ante)) no longer suffice for mission-oriented R&I (although many principles from traditional research evaluation will still be relevant) (van Drooge and Spaapen 2017). The need to achieve impacts beyond the scientific, technological and economic spheres (e.g. topics such as sustainability, customer needs and structural and/or regional development might become more important) points to the importance of evaluation beyond the classical input/output and market-failure-based approaches (e.g. cost-benefit analysis) (Amanatidou, Cunningham et al. 2014). It has been suggested that evaluation should also integrate user research, social experiments and system-level reflection (Kattel and Mazzucato 2018). A range of evaluation approaches have been developed that address societal impact or relevance of scientific research (e.g. the Research Excellence Framework in the UK) but the evaluation of mission-oriented R&I requires more substantial changes (van Drooge and Spaapen 2017). Evidence from evaluations of mission-oriented R&I programmes and conceptual considerations proposes a selection of frameworks that could be used to evaluate mission-oriented R&I.

## Prospective & Adaptive Societal Challenges Assessment Approach

The Prospective & Adaptive Societal Challenges Assessment (PESCA) framework (Fisher, Chicot et al. 2018) is proposed specifically to evaluate mission-oriented R&I. It acknowledges that mission-oriented R&I initiatives produce effects and have impacts at different stages along so-called ‘impact pathways’ that are non-linear and often involve feedback and rebound mechanisms (from basic research to innovation and diffusion and system transformations) and at multiple levels (micro/individual behaviour, meso/organisation, and macro/systems). Acknowledging the complexity and uncertainty inherent in a long-term programme, this approach emphasises ex-ante (or concurrent) assessments (to be able to determine the intended and unintended impacts on society) and putting in place an iterative process of learning and adjustment. Given the long timeframes for mission-oriented R&I, there is a frequent need to re-visit the original targets and re-adjust the goals and instruments. To do this, PESCA suggests using a forward-looking, scenario-based approach, exploring scenarios at three different levels in order to cope with different types of future contingencies (i.e. context scenarios, system scenarios, policy and funding scenarios).

Several elements of the PESCA approach are relevant for the present evaluation. The approach considers different impact pathways, emphasises considering both intended and unintended impacts and has a strong focus on learning. Our evaluation will be conducted concurrently with the programme and takes an iterative approach, building evidence by ISCF wave, which allows scope for iterative learning and adjustment. In terms of method, the PESCA approach is strongly forward-looking (and involves the use of future scenarios); while our evaluation does not formally incorporate the use of scenarios, it builds in consideration of intended and unintended impacts

## Mission-oriented Innovation System approach

The Mission-oriented Innovation System (MIS) approach was specifically developed to study mission-oriented innovation systems (Fisher, Chicot et al. 2018). It is adapted from a structural-functional approach that is applied to ‘technological innovation systems’. Instead of focusing on a single technological solution, the MIS approach considers societal problems and corresponding sets of interrelated solutions, and aims to identify the systemic barriers that inhibit a well-performing mission-oriented innovation system (Wesseling and Meijerhof 2020). The authors define a mission-oriented innovation system as *‘the network of agents and set of institutions that contribute to the development and diffusion of innovative solutions with the aim to define, pursue and complete a societal mission’*. The MIS approach can be used ex-ante, ex-durante or ex-post to the policy process to help design or evaluate mission-oriented policy. The approach involves a series of five analytical steps: (1) problem-solutions diagnosis; (2) structural systems analysis; (3) system functions analysis; (4) systemic barriers analysis; and (5) contrasting planned policy instruments with the MIS barriers to identify mission-oriented policy recommendations. The authors suggest that the barriers identified can be used for several purposes, including to: (1) explore aspects of the innovation system that should be targeted by policymakers aiming to implement a set of mission-oriented policy instruments; (2) tentatively evaluate whether planned or recently implemented mission-oriented policy instruments effectively target these barriers; and (3) assess the impact that previous mission-oriented policy instruments have had on the development of the MIS.

The MIS approach proposes several aspects that are relevant for the present evaluation. These include: exploring actors, institutions, networks that are involved in the mission formulation, governance, and solution development/diffusion, and identifying 'key innovation activities' (e.g. knowledge development, knowledge diffusion, etc.). One aspect of the MIS approach is the identification of systemic barriers that may inhibit a well-performing mission-oriented innovation system. While our evaluation does not follow the specific analytical steps of the MIS approach, we incorporate consideration of barriers to the impact of the ISCF (as well as facilitators) at different points of the evaluation.

### Participatory Impact Pathways Analysis

This Participatory Impact Pathways Analysis (PIPA) approach comes from the field of development research (van Drooge and Spaapen 2017). It is not specific to mission-oriented R&I and may be used to evaluate 'transdisciplinary collaborations' more generally (van Drooge and Spaapen 2017). PIPA has been applied in a number of different contexts, in particular to measure the impact of research projects in developing countries (van Drooge and Spaapen 2017). The central element in this approach is a ToC-based approach (van Drooge and Deuten 2016). PIPA is based on a series of participatory workshops in which all participants jointly develop a ToC (Joly and Matt 2017). In terms of specific methods, PIPA combines logic models and quantitative and qualitative indicators. The indicators are related to measuring the set aims and objectives for change and the different project steps (inputs, activities, outputs, outcomes, impacts). These indicators are used to monitor the collaborative process, and to inform the stakeholders about outcomes. The objective of the indicators is not to compare projects or measure scientific excellence, but to understand the collaboration dynamics and the societal changes achieved (Joly and Matt 2017). There is also a change of function of indicators – instead of focusing on past performance, indicators look forward to the short-, intermediate- and longer-term future (van Drooge and Spaapen 2017).

Many elements of the PIPA approach are relevant for the present evaluation: the involvement of stakeholders from the start of a project or programme; the joint development of a ToC and logic model; indicators that are forward looking, with a focus on collaboration; that monitor and assess steps in the process towards the final goal; and measure both scientific excellence and whether societal change is achieved. PIPA evaluation is about mutual learning between interested parties, rather than accountability to a funder, and has a strong emphasis on participation, bringing together multiple stakeholders throughout the evaluation pathway to ensure mutual learning. In terms of method, the PIPA consists of a theory-based evaluation approach that aligns with our overarching evaluation design.

#### 2.3.6. Specific methods for the evaluation of mission-oriented R&I

As highlighted in earlier sections, challenges of evaluating mission-oriented R&I include developing methods able to improve understanding of the impact-generating mechanisms and assessing a broader set of impacts (Joly and Matt 2017). It would be useful to ensure a mix of complementary approaches (combining qualitative and quantitative evaluation, achieving a multi-objective evaluation and evaluating impacts at various level of aggregation) (Joly and Matt 2017). This includes complementarity between econometric evaluation methods designed to assess the economic impact of research, and methods focused on assessing societal impact (which includes a wider set of impacts beyond the economic) (Joly and Matt

2017). Although new evaluation methods and practices have been developed over the last few years, the use of these methods for the evaluation of mission-oriented R&I is limited (van Drooge and Deuten 2016). Nonetheless, evidence from evaluations of mission-oriented R&I programmes and conceptual consideration of challenges suggests that a range of different methods, both qualitative and quantitative, have been used to evaluate mission-oriented R&I.

A range of different methods, both qualitative and quantitative, have been used to evaluate mission-oriented R&I

Both qualitative and quantitative methods have been used to evaluate mission-oriented R&I. Qualitative methods can be useful to understand the cause-and-effect mechanisms in an R&I programme. Quantitative methods have generally been applied to the assessment of the economic impacts of an R&I programme. Table 5 presents a summary of different evaluation methods used in mission-oriented R&I found in the literature.

**Table 5: Summary of different evaluation methods used in mission-oriented R&I found in the literature**

	Method	Example	Key sources
Qualitative	Interview	<p>Interviews with researchers were conducted as part of an evaluation of the University of Wollongong’s Global Challenges Program in Australia (Gibson, Stutchbury et al. 2019).</p> <p>Interviews were conducted with experts from research organisations, the Austrian Research Promotion Agency (FFG) and project coordinators as part of an assessment of four mission-oriented R&amp;I programmes in Austria (Biegelbauer, Hartmann et al. 2020).</p>	(Gibson, Stutchbury et al. 2019, Biegelbauer, Hartmann et al. 2020)
	Case study analysis	<p>Case study analysis has been used to illustrate examples of mission-oriented R&amp;I programmes in different countries. It should be noted that ‘case study’ may involve deploying one or more other methods listed in this table. An evaluation of the Saving Brains, Grand Challenges Canada portfolio used case studies that were developed using a mixed-methods approach incorporating quantitative data sources from the programme, a literature review, stakeholder consultation and analysis of written portfolio documents (Milner, Bernal Salazar et al. 2019).</p> <p>A comparative case study analysis based on interviews with the Dutch maritime and inland shipping sector, and a literature review on sustainable maritime transport solutions, was conducted on three pilot regional energy strategies in the Netherlands (Geels 2019). Case studies, based on a document and literature review and interviews with experts, of four mission-oriented R&amp;I programmes in Austria were conducted as part of a study into mission-oriented innovation policy in Austria (Biegelbauer, Hartmann et al. 2020).</p>	(Geels 2019, Milner, Bernal Salazar et al. 2019, Biegelbauer, Hartmann et al. 2020)
	Focus group	<p>Focus groups were conducted with a sample of 25 researchers who had been involved in projects previously funded by the University of Wollongong’s Global Challenges Program to better understand researchers’ experiences with the programme (Gibson, Stutchbury et al. 2019).</p>	(Gibson, Stutchbury et al. 2019)

	Method	Example	Key sources
	Desk research	Document and literature analysis (programme documents, policy papers, evaluation studies and social science literature) was conducted to generate an overview of specific mission-oriented programmes as part of four case studies into mission-oriented R&I programmes in Austria (Biegelbauer, Hartmann et al. 2020).	(Biegelbauer, Hartmann et al. 2020)
	Workshop	A workshop was conducted with experts from ministries and agencies to discuss outcomes from four mission-oriented R&I programmes in Austria (Biegelbauer, Hartmann et al. 2020).	(Biegelbauer, Hartmann et al. 2020)
	Survey	An online survey of researchers who could potentially have applied for programme funding was used to understand research's experiences of the programme as part of an evaluation of the University of Wollongong's Global Challenges Program (Gibson, Stutchbury et al. 2019).	(Gibson, Stutchbury et al. 2019)
Quantitative	Metrics	<p>A trend or before-and-after analysis of various metrics can provide an initial descriptive assessment of aggregate innovation outcomes (Frietsch, Rammer et al. 2015, Veugelers and Cincera 2015):</p> <ul style="list-style-type: none"> <li>• Innovation Union Scoreboard</li> <li>• Revealed Technological Advantages</li> <li>• Business R&amp;D expenditure</li> <li>• Innovation Indicator</li> <li>• Patent and publication efficiencies</li> </ul> <p>These approaches allow observation of changes over time, but do not on their own provide insights on whether those changes can be attributed to a given intervention or factor.</p>	(Frietsch, Rammer et al. 2015, Veugelers and Cincera 2015)
	Econometric methods	<p>Econometric methods are used to estimate the impact of research expenditure on productivity gains in order to compile cost-benefit ratios or rates of return on investment in public research (Joly and Matt 2017). These include control group, counter-factual, cost-benefit, econometric and input-output approaches. Further specific econometric methods are outlined in the rows below. These econometric methods each provide various approaches that aim to statistically attribute observed changes to specific factors or variables.</p>	(Joly and Matt 2017)

	Method	Example	Key sources
	Difference-in-differences	The impact of the Japanese mission-oriented CREST research programme on researchers' performance was measured with a difference-in-differences econometric approach. The number of publications and citations of selected CREST researchers was compared to those of comparable researchers who were not selected (Shimada, Tsukada et al. 2017).	(Shimada, Tsukada et al. 2017)
	Structural vector autoregression (SVAR) model	The effect of mission-oriented policies on GDP and private investment in R&D was measured with an SVAR model. This econometric approach estimates these impacts by capturing relationships between the different variables at an economy-wide level as they change over time (Deleidi and Mazzucato 2021).	(Deleidi and Mazzucato 2021)
	Data mining	A burst data mining-based technique called DETECTS was used to analyse patent and publication data. Patent- and publication-based 'bursting' helps to detect the emergence of technologies, i.e. whether there is significant increase in those applications (Modic and Feldman 2017).	(Modic and Feldman 2017)

Source: RAND Europe/Frontier Economics analysis

### Evaluations in the literature typically adopted mixed-method approaches

All evaluations in the literature reviewed adopted a mixed-methods approach (Hayter 2015, Lalli, Ruysen et al. 2018, Gibson, Stutchbury et al. 2019, Milner, Bernal Salazar et al. 2019, Pinnington and Barnett 2019). Several evaluations adopted a case-study approach, which typically involves multiple methods, including a combination of desk research, interviews, surveys and quantitative methods (Geels 2019, Biegelbauer, Hartmann et al. 2020). A ToC- based approach (with an impact framework and associated metrics) has also been used to evaluate several programmes (Hayter 2015, Lalli, Ruysen et al. 2018, Pinnington and Barnett 2019) or proposed conceptually as a potential method of evaluation (van Drooge and Spaapen 2017). Developing a ToC is helpful to understand the various processes and elements needed to address a particular challenge (Hayter 2015). Developing a ToC often requires a multi-method approach. For example, the Saving Lives at Birth partnership developed a ToC using a review of literature, a series of workshops and consultations with partners, finalists and current innovators across all funding stages (Lalli, Ruysen et al. 2018).

Our evaluation approach should have a strong emphasis on a mixed-method approach, based on a ToC, to ensure that we capture the full range of benefits of long-term missions. Our framework and approach should combine qualitative work, including workshops, interviews and case studies, with quantitative econometric methods and data. A ToC-based framework is helpful to understand the processes and elements needed to address a particular challenge and can inform future directions through analysis of lessons learned. In addition to measuring the impact of the ISCF, a ToC-based approach enables comparison of the observed impact of the ISCF with a pre-determined theory of the intended impacts, which can inform future directions.

## Evaluations of multi-challenge funds have also adopted a mixed-method approach

The REA provided two examples of evaluations of multi-challenge funds: Saving Brains, Grand Challenges Canada (GCC), which focuses on innovations for early child development (Milner, Bernal Salazar et al. 2019) and the Saving Lives at Birth partnership, which focuses on innovations for reducing maternal and newborn deaths and stillbirths at the community level (Lalli, Ruysen et al. 2018). The Saving Brains portfolio used of a ToC approach, which was valued by multiple stakeholders in encouraging forward planning (Milner, Bernal Salazar et al. 2019). The authors highlight that this approach considers pathways to impact and potential challenges to scaling from early stages of design, which is important when considering innovations that are complex, interrelated and dynamic. In the Saving Lives at Birth partnership, a ToC and impact framework was developed retrospectively, drawing on expertise across the partnership and stakeholders (Lalli, Ruysen et al. 2018). The authors found that developing the ToC and identifying a uniform set of prioritised metrics for use across the portfolio proved to be challenging. They indicate that they adopted a ‘multifaceted approach’ to ensure that inputs into the design of the impact framework and prioritised metrics were appropriate to the spirit of the programme.

## There is some scope for the use of econometric methods in mission-oriented R&I evaluations

Deleidi and Mazzucato (2021) made use of an econometric methodology to investigate how public defence-related R&D investment, used as a proxy for spending on mission-oriented policies, affected GDP and private R&D investment in the United States. The structural vector autoregression (SVAR) model that Deleidi and Mazzucato (2021) used can be applied more generally to measure the effect of mission-oriented policies on macroeconomic outcomes. A SVAR model estimates relationships between different variables as they change over time. For each variable, there is an equation that models its evolution over time. This equation includes lagged values of the variable itself, as well as the lagged variables of the other variables and a residual term. Some restrictions, which Deleidi and Mazzucato (2021) based on economic intuition, set conditions on how the relationship between different variables can take shape. The model parameters are estimated econometrically and can be used to measure the effect that changing one variable in the model has on the evolution of the other variables over time.

Shimada, Tsukada and Suzuki (2017) made use of econometric methods to investigate the impact of mission-oriented research grants on researchers’ performance. With a difference-in-differences technique, they compared the performance of researchers who received a mission-oriented research grant with that of researchers who did not. As part of their difference-in-differences technique, Shimada, Tsukada and Suzuki (2017) econometrically estimated, for every researcher, the researcher’s probability of being awarded a mission-oriented research grant, based on certain characteristics. They then econometrically matched

researchers who received the research grant with researchers who did not but had similar probabilities. The difference between the number of publications and citations of researchers who received a mission-oriented research grant with those of matched researchers who did not, provides an estimation of the impact of mission-oriented grants on researchers' performance. The difference-in-differences approach from Shimada, Tsukada and Suzuki (2017) can be applied more generally to measure the impact that mission-oriented policies have on beneficiaries' performance.

## 2.4. Insights for the evaluation framework

The REA provides insights on key considerations for the development of the evaluation framework and the

The difference-in-differences approach from Shimada, Tsukada and Suzuki (2017) allows for a granular assessment of the effect of mission-oriented R&I policies. It allows for an examination of the effect of the ISCF at the firm-level, and will therefore be useful for the evaluation. In principle, the approach can be applied whenever there is firm-level data reporting relevant outcomes that relate to the intended benefits of the ISCF (e.g. business performance, innovation performance) and where the outcome data can be linked to firms that have participated in, or benefitted from, one or more of the Challenges. By comparing trends in outcomes for this 'treatment group' with a matched 'control group' of similar businesses that did not receive ISCF support, robust inference can be made about the impact of the ISCF, subject to the comparability of the two groups and the ability of any analysis to control for relevant factors that affect both whether or not a firm is supported by the ISCF, and the outcomes of interest.

The SVAR model from Deleidi and Mazzucato (2021) can be useful to generate insights on the economy-wide impacts of the ISCF. Examples would include its impact on GDP and private investment in R&D. However, the methodology may not be able to sufficiently isolate the impact of the ISCF from other wider factors. Major macroeconomic shocks such as Brexit and Covid-19, as well as other government policies supporting innovation, will also substantially influence macroeconomic outcomes. It may not be feasible to distinguish the effect of the ISCF from the effects of these other factors. Furthermore, the methodology from Deleidi and Mazzucato (2021) may be less suited to identifying sector-specific effects of the ISCF. The ISCF provides targeted support to a number of specific sectors aligned to the mission-oriented R&D approach, and may therefore impact some sectors relatively more than others. These differences in sector-specific impacts will not be uncovered with a methodology that measures aggregate, economy-wide impacts.

evaluation itself. Below, we divide these into key insights regarding the evaluation's purpose, evaluation framework design and the approach to implementation of the evaluation. In each case, we highlight how this evaluation framework has been developed in line with these insights. The ways in which our evaluation builds on these insights are explained further in Chapter 3 of this report.

### Purpose of the evaluation

- **The evaluation should focus on learning:** The literature highlights that the primary function of evaluation of mission-oriented R&I should focus on mutual and system-level learning to enable a

better understanding of the impact-generating mechanisms (van Drooge and Spaapen 2017). Our evaluation framework has been designed to enable learning from experience and the evolution of the programme. It considers the multiple pathways to the different categories of impact (across three different themes), to enable understanding of impact-generating mechanisms. The evaluation is conducted Iteratively, enabling early insights and learning to be shared on an ongoing basis. Opportunities for engagement with a wide range of stakeholders have been built in through a programme of workshops with different groups. We also have interaction and sharing of learning with Fund management structured into our processes at every stage of the evaluation.

- **The evaluation should be forward-looking:** Frameworks that have been specifically developed for mission-oriented R&I consider a forward-looking approach in the methods and indicators proposed to determine the intended and unintended impacts on society (Fisher, Chicot et al. 2018). Although the ISCF programme is already underway, the evaluation will run concurrently with the Fund and there are frequent opportunities for learning and reflection throughout the evaluation to inform ongoing activities. We have also built reflection on the implications for mission-oriented R&I explicitly into the evaluation design and the ToC, meaning this work can inform wider ongoing activities within UKRI and more widely. The evaluation will also involve considering and recommending an appropriate approach to a future, follow-on phase of evaluation.

## Framework design

- **The evaluation framework should be broad in scope and consider multiple types of impact:** The literature emphasises that evaluation frameworks for mission-oriented R&I require a range of indicators (scientific, technological and societal) that together describe the complexities of mission-oriented R&I (Amanatidou, Cunningham et al. 2014). In addition, it is important to consider both specific and spillover impacts because mission-oriented programmes frequently generate spillovers (Mendonça, van Aduard de Macedo-Soares et al. 2018).
  - The evaluation framework considers multiple types of outcomes and impacts, with multiple qualitative and quantitative evaluation criteria and indicators. The framework not only captures outputs and outcomes such as the production of new knowledge and technologies, but also aims to capture wider societal benefits (e.g. behavioural changes), including both unexpected and unintended consequences, which are explicitly called out in the ToC.
  - The framework also captures elements related to encouraging interdisciplinary working, such as the formation of clusters, networks and collaborations across and within public and private sectors, and between disciplines, and multidisciplinary and interdisciplinary research around the Challenge areas.
- **The evaluation framework should be flexible:** The literature suggests it is necessary to develop an evaluation framework with a high degree of flexibility and adaptability through defining intermediate goals to keep track of progress towards the mission objective, and to potentially scale back the initiative if the objective is not being met (Mendonça, van Aduard de Macedo-Soares et al. 2018, Geels 2019, Biegelbauer, Hartmann et al. 2020). The evaluation framework should build

in ‘review points’ whereby suitability of indicators can be reviewed regularly, based on impacts that have materialised to date. This will enable monitoring of programme performance and progress across multiple timeframes

- **The evaluation framework should recognise the uniqueness of the mission-oriented R&I programme:** It has been emphasised in the literature that each mission-oriented R&I programme is unique, and therefore evaluation should adapt to the specific characteristics of a particular mission (Wesseling and Meijerhof 2020). This is a particular challenge for this evaluation since the Fund-level evaluation aims to evaluate the performance of the Fund as a whole, which comprises many individual missions. As such, we have taken an approach that acknowledges this diversity and draws on the Challenge-level evaluations, which are conducted with this mission-specific focus. The evaluation framework seeks to explore the impact of the Fund as a whole, at a higher level of abstraction. We broadly characterise the impacts of the Fund across health and wellbeing, environment and sustainability, infrastructure and services, and the economy, using both quantitative as well as qualitative indicators, and assess the extent to which the Fund creates an enabling environment to facilitate these impacts, recognising that the specifics of these impacts, and the contextualised pathways through which they occur, will vary by Challenge area but also that impacts will cross over between the categories and may fall into more than one. As such, each Challenge should see itself reflected in the ToC and the evaluation framework, but not all aspects of the framework and ToC will be relevant to any one Challenge.

### Approach to evaluation

- **The evaluation should ensure wide stakeholder involvement:** The literature and frameworks identified suggest that evaluation should also be a joint effort between multiple stakeholders, to improve collaborative understanding of the joint process and progress towards the common societal goal (van Drooge and Spaapen 2017). The evaluation framework considers multiple avenues for wide stakeholder engagement throughout the pathway to enable a participatory approach to evaluation. Wide stakeholder engagement (e.g. policymakers, investors, industry, academics, the wider public) is planned early on as part of the inputs and activities through various means (e.g. workshops, conferences, events and meetings). We also have close links to Fund oversight within UKRI and have workshops with Fund leadership and oversight groups at every stage of the evaluation to ensure learning is shared.
- **The evaluation should adopt a multi-method approach:** Evaluations in the literature typically adopted mixed-method approaches (Hayter 2015, Lalli, Ruysen et al. 2018, Gibson, Stutchbury et al. 2019, Milner, Bernal Salazar et al. 2019, Pinnington and Barnett 2019), and academic authors have recommend adopting a mix of complementary quantitative and qualitative approaches for mission-oriented R&I (Joly and Matt 2017). Our framework includes diverse data collection methods that combine qualitative work, including workshops, interviews and case studies, with quantitative econometric methods and secondary data analysis. The ISCF evaluation will also take place at two levels: the wave level – amalgamating findings from Challenge-level evaluations – and cross-cutting analysis at the Fund level.

## 3. Evaluation approach

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### 3.1. Our overarching approach

We plan to take a theory-based approach to the evaluation using contribution analysis<sup>16</sup>. A theory-based evaluation begins by identifying the aims (that is, the desired outputs and impacts) of a programme or initiative, and the perceived steps (that is, the core activities and processes) that must be undertaken to achieve these desired aims. In most cases, this is performed through the development of a programme ToC, accompanied by a logic model that provides a representation of how an intervention will produce intended effects, typically organised around inputs, activities, outputs, outcomes and impacts. The logic model helps to consider the desired impacts in a structured and organised way, which can be used to inform evaluation questions and protocols (Weiss 1995, Pawson, R. and Tilley 1996, Connell and Kubish 1998, Marjanovic et al. 2012). The ToC we have developed for the ISCF is set out in Chapter 4.

Contribution analysis is ‘a form of theory-based evaluation where effectiveness is the main question and where experimental designs are not possible’ (Wimbush et al. 2012). The central aim of contribution analysis is to establish the validity of a project’s logic model and to provide a plausible explanation regarding the difference a programme is making to observed outcomes (Mayne 2008). Rigor in this type of causal analysis involves systematically collecting evidence of a programme’s impacts whilst also identifying and investigating alternative explanations for observed impacts (Leeuw, F. and Vaessen, J. 2009). Given its strength as a means of assessing programme impacts in a variety of contexts, contribution analysis is a common evaluation approach and has been used across a range of sectors (e.g. health, development, migration).

A theory-based approach using contribution analysis is appropriate for this evaluation for four overarching reasons. The first is that a contribution analysis-based approach provides an effective and structured method for synthesising different types of data, collected across multiple domains, jurisdictions, time points, and stakeholders, into a coherent narrative regarding a programme’s contribution (Mayne 2008). This is well-suited to the structure of the ISCF, comprised as it is of diverse Challenges and stakeholder groups, including across different sectors, fields, contexts and implementation timescales. Secondly, the timescales over which the ISCF can be expected to achieve its ultimate impacts are significantly longer than the timescales of the evaluation. Contribution analysis enables evaluation to be conducted at earlier stages,

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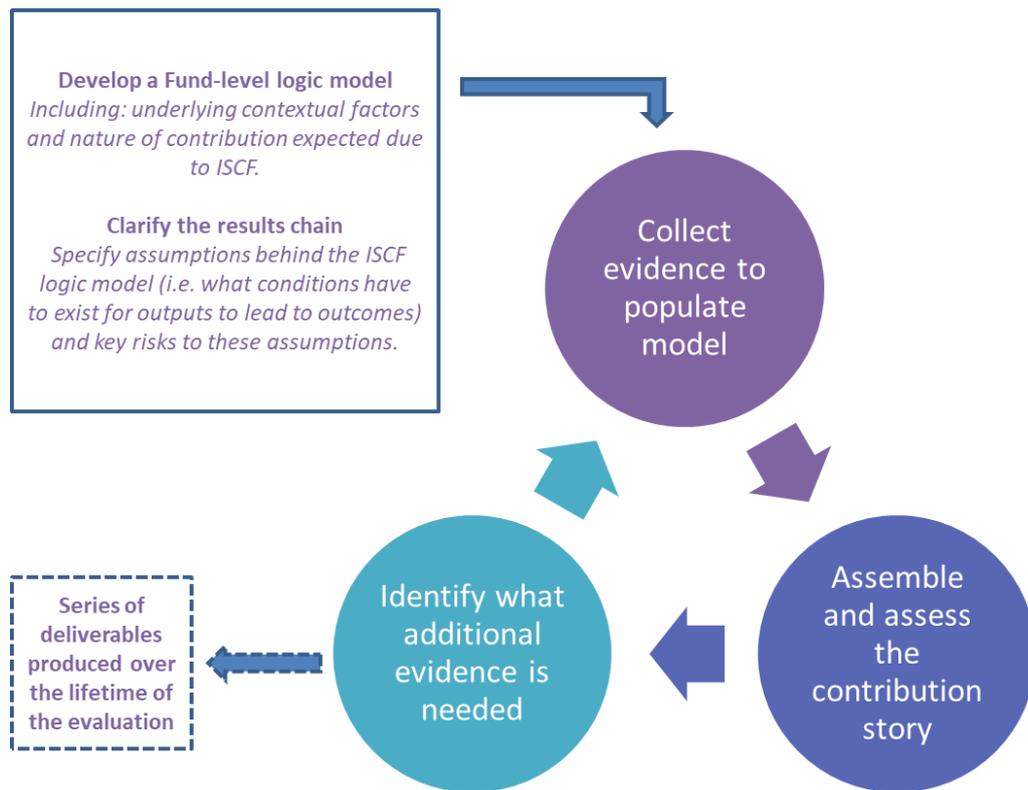
<sup>16</sup> A brief overview of alternative possible approaches that were considered is provided in Annex J.

testing whether the expected contribution story is developed against the ToC even if final impacts have yet to occur – and providing a basis and structure for further evaluation at later timepoints if desired. Thirdly, contribution analysis is well-suited to an iterative and cumulative approach to evaluation in which evidence is gathered and assessed, gaps identified, and further data collected and assessed against the refined model. This is particularly relevant to this evaluation, which will be conducted iteratively over the course of several years, starting with a mix of review of Challenge-level data and new data collection at the baseline phase, then reviewing evidence from each wave of the Fund as it becomes available over the following two years, and culminating in the Fund-level primary data collection in the final phase of the work. Finally, contribution analysis is particularly valuable for evaluating interventions that take place in a complex landscape with many other potential external factors to take into account, since it allows the presence and role of those external factors to be considered within the evaluation as they are articulated within the contribution story. The ISCF is part of a wider changing R&I landscape and sits within a range of other interventions addressing industrial strategy, such as the Sector Deals, as well as wider political, social and economic drivers. Being able to define the ISCF's causal contribution within this complex landscape whilst also acknowledging these wider contextual factors will be crucial to delivering a meaningful evaluation.

A key underpinning of a theory-based evaluation and of contribution analysis is that the evaluation is closely structured around a ToC, with the evaluation questions and resulting indicators and approaches clearly reflecting and capturing evidence relevant to test the intervention logic set out in that ToC. As such, in the following chapters we set out both the ToC and a set of evaluation questions and indicators that are closely structured around this. This means that at each stage of the evaluation we can use the collected data to develop the 'contribution story' based on the evidence relating to each aspect of the evaluation framework. The contribution story can then be critically assessed to identify whether the evidence is strong or weak, and to consider possible alternative explanations for any observed impacts. This also allows us to identify any gaps in knowledge and what new evidence may be needed to better understand the extent to which the ISCF has contributed to change. Figure 1 below presents a visualisation of our contribution-based approach to this evaluation and how the cycle of data collection over time will enable new insights to build on previous stages of the evaluation.

In addition, it is important to emphasise that this evaluation is focused on assessment of the ISCF at the Fund level. Separate Challenge-level evaluations are being conducted in parallel and the aim of our work is not to reproduce these but to focus on what the Fund as a whole has achieved and what we can learn about how effective the approach developed has been in achieving the intended aims at this overarching level. The ToC and the evaluation framework have been developed with this in mind, aiming to assess what is the overarching intended intervention logic for the Fund, and the extent to which this has been realised.

Figure 1: Our theory-based approach to the evaluation using contribution analysis



### 3.2. Our approach to counterfactuals

Contribution analysis is particularly useful in cases where developing an appropriate counterfactual for the purposes of analysis is challenging, or where the nature of the impacts from an intervention are diverse and emerge in a complex environment in which sole attribution of those impacts is difficult. Instead of attempting to statistically analyse the outcomes of the intervention, a contribution story is assembled and analysed. Certainly, in terms of the contribution of the ISCF to societal impacts – on health, the environment and other social and cultural benefits – the landscape is complex and multifactorial, and attribution of any change exclusively to the role of the Fund would likely not be possible. In this context, a contribution analysis-based approach is most appropriate to deliver a meaningful and formative evaluation of the ISCF. However, there are aspects of the Fund which lend themselves to a more formal statistical analysis and for which it may be possible to construct a plausible counterfactual. This applies specifically to the economic impact of the Fund with a focus on those businesses directly engaged. Here, it is possible to construct a counterfactual set of comparable businesses that did not participate in the ISCF and assess their comparative performance over time. Therefore, we will conduct a difference-in-differences analysis to assess the effect of the ISCF on these economic impacts (see Section 6.6.5).

Though contribution analysis can negate the need for the counterfactual, it is still necessary to set the context for the intervention and understand the landscape to which the ISCF is contributing. To do this, we will conduct a baseline analysis, in which we consider the state of the world prior to the initiation of the Fund. This will consist of two elements. Firstly, for key outcomes indicators, where feasible and appropriate, we will aim to make a quantitative assessment of performance prior to the establishment of the ISCF. For

some aspects tied directly to the operation of the Fund (for example, number of publications produced), such quantitative baselining will not be feasible or appropriate. However, where this is feasible – for example in terms of wider population level indicators, or for prior business performance, we will make a quantitative assessment of performance prior to the establishment of the ISCF. Secondly, we will baseline the contextual factors that might impact upon the success of the ISCF. This will take a largely qualitative approach, capturing perceptions on the nature and status of the R&I landscape prior to the ISCF and the potential barriers to, and enablers of, its implementation and delivery.

Another important aspect of this study is to understand the extent to which mission-oriented R&I is an effective funding mechanism. With this in mind, it would also be helpful to compare, where possible, the effects of R&I funded through the ISCF to funding distributed through other mechanisms. To do this, we can make comparisons to wider UKRI and/or Innovate UK (IUK)-funded research. This could include comparisons against aggregate performance across UKRI/IUK but may also include analysis against a set of comparator awards where feasible, and where appropriate data are available. The feasibility of establishing a comparator group will be explored further during the baselining phase of the study. The intention is to identify this comparator group (which will be a group of IUK-funded awards outside the ISCF), if feasible, during the baseline phase. In identifying the comparator group, we will work closely with UKRI experts to ensure the selected awards represent a suitable comparison to the ISCF awards. Key considerations in this respect will include ensuring a set of awards covering sectors, types of funding, and year of award, as well as total funding value covered by ISCF awards. The analysis of this comparator group will be conducted in phase 4 of the evaluation, in parallel to the analysis of ISCF awards. The analysis of this comparator group will focus on UKRI/IUK held data (e.g. information on multidisciplinary and interdisciplinary, data from Project Closeout Forms (PCFs)/Researchfish returns, equality, diversity and inclusion (EDI) data), serving to baseline these quantitative datasets. We do not propose any new data collection in terms of the comparator group of awards. However, we will also explore the role and relevance of other prior funding mechanisms qualitatively as part of the baselining workshops and will discuss other influencing factors (including other funding mechanisms) in the impact workshops to be held in phase 4.

Overall, this combination of an underpinning contribution analysis-based approach, supplemented with assessment of outcomes relative to a counterfactual where possible and appropriate, and a baselining step to quantitatively and qualitatively establish the state of play prior to the ISCF being established, provides a relatively comprehensive and robust approach to contextualising our assessment of the ISCF's performance and impact.

### 3.3. Participatory, formative evaluation design

Another key feature of our evaluation design is a participatory approach that is focused on learning, drawing on the PIPA framework (van Drooge and Spaapen 2017). As set out in Chapter 2, mission-oriented R&I is best served by an evaluation approach that is focused on learning and engages with the broad, cross-sectoral range of stakeholders engaged in the delivery of the mission. Beyond that, with the ISCF, we face the additional challenge that we are not trying to evaluate one specific mission-oriented R&I programme, but a combination of 24, focusing on the strategic and structural elements that provide an overarching frame for all these different missions. As such, there is a need for reflection and engagement throughout –

but also significant scope for learning, facilitating the sharing of experiences across Challenges and helping to create connections and add value to the Fund's learning cycle. Where innovations are happening at individual Challenge levels, sharing the learning from these with other Challenges ensures that this is capitalised on and can contribute to the Fund being more than the sum of its parts. We see our evaluation playing a role in supporting that Fund-level learning cycle.

As such, we have designed our approach to ensure input, engagement and cross-Challenge learning. We have built a range of workshops into our evaluation to enable multidirectional learning and our stakeholder engagement approach is set out in Chapter 6. We have built workshops with Fund management (i.e. the ISCF Evaluation Working Group), as key stakeholders, into each phase of the evaluation. Our overarching design also feeds directly into a formative approach. Contribution analysis is fundamentally a formative approach, since it provides insights into the pathways through which impacts emerge and sets these in context. It allows for emergence and facilitates discussion on the nature of the contribution story and potential alternative explanations for observations. Throughout the evaluation, we will emphasise this formative aspect. Reports produced at each phase of the evaluation will contain recommendations based on the findings of that phase. These recommendations will also be presented to, and discussed with, ISCF leadership through the aforementioned workshops held at each phase. In addition, following completion of each stage of the evaluation, we will also hold informal Challenge-level learning workshops in which we will present and discuss the findings and recommendations of each phase to key Challenge-level stakeholders. Participants in these learning workshops will likely include a mixture of Challenge leadership teams and Challenge-level evaluation teams.

### 3.4. Evaluation at the Fund level

This evaluation is intended to focus on the Fund level, noting that Challenge-level evaluations are taking place in parallel and that we do not wish to duplicate the work of those evaluations. We have therefore developed a ToC at the Fund level that, while reflecting aspects of the work of each Challenge, is designed to operate at a higher level and explore the extent to which the overarching model is delivering against broader objectives and impacts beyond the scope of any one Challenge. The Fund-level evaluation is explicitly designed around that Fund-level ToC and so, while drawing on the evidence from the Challenge-level evaluations (particularly in phase 3), we will use that evidence to build Fund-level insights that can support learning beyond the scope of those specific Challenges. In addition, in phase 4 of the evaluation, we have explicit, Fund-level data collection which will give us both insights into the effectiveness of the overarching Fund-level processes and design, and the economic and wider impacts achieved beyond the scope of any individual Challenge. In addition, as noted above, we intend to consider not just the ISCF and its specific implementation, but also its underlying design as a mission-oriented R&I fund as part of the evaluation, assessing the extent to which it was effectively delivered as a mission-oriented fund, and the benefits (or disbenefits) this mission-oriented structure may have conferred.

### 3.5. Addressing key challenges

We identify a number of potential challenges for this evaluation, resulting both from the challenges inherent in evaluating mission-oriented R&I, and specific challenges or risks related to the particular context of the ISCF or the evaluation approach selected. These are set out in Table 6, with both a description of the challenge, and the way we have addressed the challenge through our evaluation design.

**Table 6: How our evaluation will address key challenges**

Challenge	Description	Response
The ISCF operates in a complex landscape with a range of external factors making attribution challenging	Attributing ultimate impacts solely to the intervention of the Fund is not feasible, since there are a wide range of other potential causal factors.	Rather than seeking to directly attribute outcomes and impacts to the Fund, we look to assess the contribution the ISCF has made to them and consider wider alternative contributory factors that could explain changes observed.
Scale and complexity of the Fund	The ISCF is a large multidimensional Fund, and the evaluation needs to account for the multiple possible pathways for the translation of R&I activities into impacts, and the fact that the system transformation associated with the Challenges is a complex process with multiple causes and consequences.	We have devised a broad and cross-cutting ToC that enables different pathways and aspects of system change. The contribution analysis led approach enables wider contexts to be accounted for in the analysis of the Fund.
The Fund comprises multiple different missions	It has been emphasised in the literature that each mission-oriented R&I programme is unique and therefore evaluation should adapt to the specific characteristics of a particular mission. The ISCF comprises multiple different missions, presenting difficulties for the evaluation design.	Our ToC and evaluation framework are focused less on the specifics of the missions and more on the extent to which the Fund provides an enabling environment and pathways for all the ISCF Challenges to progress regardless of their specific context. This broader framing should allow us to capture and understand progress across ISCF Challenges and bring together a broader narrative of the Fund’s impact. It is also to be noted that our evaluation draws upon Challenge-level evaluations which do evaluate the individual ISCF Challenges in context. Our aim is to synthesise that evidence to understand the effects of the wider ISCF model and the collective outcomes of the Fund as a whole, drawing on those contextualised Challenge-level evaluations.
Impacts will occur over timeframes beyond the lifetime of the evaluation	It is likely that achieving the ultimate aims of many of the missions will take a long time – 10+ years – and certainly beyond the timeframe of this evaluation.	Contribution analysis allows us to judge whether the emerging contribution story is valid at this point in time and, reflecting on the logic model, whether subsequent steps to impact are likely to be feasible. The study will also set out recommendations for the most appropriate approach to a future, follow-on phase of the evaluation over a longer timeframe.

Challenge	Description	Response
Risk of positive bias when using contribution analysis	Contribution analysis presents a risk of bias since it is reliant on the judgement of the evaluator in assessing the extent to which the evidence supports the causal links in the logic model developed. There is a risk that the evaluator is more likely to identify causal links that map to those set out in the logic model rather than considering alternative explanations.	This risk can be mitigated against by developing alternative theories and wider external factors that may be driving the changes observed. This will be an important part of the baseline analysis. Open-ended questions will also be built into the qualitative aspects of the work, allowing opportunities for alternative explanations to be postulated rather than responses being driven by the evaluators' assumptions.
Mission-led R&I produces multiple types of impact	Mission-led R&I is liable to produce multiple, diverse forms of impact, which given the system complexity may be unexpected or unintended. Additionally, mission-led R&I requires not just technological advancements, but changes in attitudes and behaviours across stakeholder groups.	We have developed a broad and flexible evaluation framework that explicitly looks for, and captures, unexpected impacts, and which not only looks at the technology advancement, but also wider context and behavioural aspects associated with challenge-led R&I.
The ISCF has multiple stakeholders who must be engaged	Mission-led R&I, and the ISCF in particular, mobilises a diverse range of stakeholders across disciplines and sectors, both as Fund actors and recipients of the R&I produced. These stakeholders will bring differing perspectives and need to be adequately engaged in the evaluation.	As set out above, we will take a participatory evaluation approach, given the diversity of actors and perspectives. This will mean involving a variety of stakeholders in the design and implementation of the evaluation to ensure criteria and metrics capture a wide variety of views.
Balancing needs for accountability and learning	As an investment of taxpayer money, it is important that the ISCF is held to account for the use of funds. However, as set out in Chapter 2, evidence from the literature indicates that evaluation of mission-oriented R&I should be formative, and this is also aligned with the needs of the ISCF.	Our primary focus in the evaluation, as shown throughout our evaluation design, is on learning. Ensuring the evaluation is formative, can support improvement of the Fund and can inform future R&I investments, is a key aim of the work and has influenced the selection of evaluation approach. However, we will also ensure relevant and sufficient data is captured to ensure accountability requirements are met – for example through our VfM analysis. Our aim is to show 'what' has been achieved, but set this into context, exploring 'how' and 'why' those achievements have come about.

Source: RAND Europe analysis

## 4. ISCF Theory of Change

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### 4.1. Overview

This chapter sets out the theory of change (ToC) for the ISCF. This consists of a visual presentation, or logic model, which presents the ToC in brief on one page, and a wider narrative ToC that explores the intervention logic in more detail. The ToC (both the logic model and narrative together) is intended to provide an articulation of the rationale for, and intended outcomes and impacts of, the Fund, as well as the assumptions underpinning that rationale and Fund design. The ToC was developed based on a number of inputs:

- A review of the initial ISCF framework developed around the time of the Fund's inception (Annex D)
- Desk research regarding the aims and operation of the Fund in context
- Findings of the literature review as summarised in Chapter 2, and the wider literature on the impact of R&I and how that can occur (Grant and Wooding 2010, Banzi R. 2011, Donovan and Hanney 2011, Penfield, Baker et al. 2014, Raftery J. 2016, Meagher and Martin 2017, Guthrie 2018)
- Analysis of Challenge-level logic models and the benefits of mapping work that has been conducted at the Challenge-level
- A workshop with the ISCF Evaluation Working Group (see Annex F) in which we shared a 'strawman' logic model (see Annex E) developed based on the tasks above for input and revision based on the current working aims of the ToC and with a forward-looking perspective

The ToC is intended to serve a number of purposes. First, it provides a key input and guiding framework for our theory-based evaluation approach. As such, the evaluation framework and methods that follow in the next few chapters all build on the ToC. Secondly, it aims to articulate a shared understanding of the aims of the ISCF and how it is anticipated these will be achieved, to help provide a common basis for discussion with stakeholders within UKRI but also across the Challenges and the Challenge-level evaluation teams. Finally, we hope it can provide a useful externally facing presentation of the aims and operation of the Fund to inform discussions with wider stakeholders. We note that achieving these multiple aims within one ToC can be challenging, since an external-facing ToC would benefit from a clear and simplified presentation, whilst a ToC for internal analytical purposes benefits from capturing additional complexity (Davies, 2018; Barr et al, 2019). We have aimed to strike a balance between these competing needs,

producing a relatively clear and visually presented logic model diagram, supported by this extended narrative that captures some of the wider issues and particularly the assumptions of relevance for internal stakeholders. Within the ToC we have aimed to map the Fund-level pathways through which the intended impacts can be achieved. These are necessarily high-level, but are intended to provide a plausible picture, with assumptions, of the way in which the Fund operated. As such, the ToC aims to describe how the Fund as a whole operates. Not all aspects of the ToC will apply to all Challenges, but all Challenges should be able to see their expected pathways and impact reflected across parts of the ToC. The ISCF is a large, complex Fund addressing many different societal challenges and involving a wide range of actors across academia, industry, government and the third sector. This adds additional complexity to the already complex mechanisms through which impact from R&I can occur. The ToC aims to acknowledge this complexity while still providing a clear, simplified model that can act as a guide to thinking for UKRI, researchers and innovators, and evaluators.

A particular challenge in developing a ToC for the ISCF is that the Fund consists of a range of mission-led R&I Challenges across different societal issues. Each of these will have different unique circumstances, contexts and barriers to progress that would ideally be reflected in a ToC for that particular Challenge (Wesseling and Meijerhof, 2020; van Drooge and Spaapen, 2017) – and indeed these are being produced for the Challenge-level evaluations. It is not possible to reflect and represent all of these in a Fund-level ToC that encompasses all the Challenges. Rather, we aim to understand the commonalities and features that are characteristics of the purpose and intended mechanisms of operation of the Fund overall, and the ways in which the Challenges collectively and individually create an enabling environment that allows the aims of the missions – regardless of specific topic – to be addressed while also facilitating UK economic growth.

It is noted that a criticism of ToCs is that their evaluability can be limited by the fact that absent connectors or multiple pathways give many routes to success, and that in centring the intervention they may not fully acknowledge the wider context (Davies 2018). However, these criticisms are more relevant to ToCs for specific programmes, where there are fewer potential pathways through the theory and the model can be considered more linear (Barr et al, 2019). It is important to consider that the landscape for the ISCF is both complicated – a system of multiple interrelated parts in which ‘processes are broadly predictable and outputs arrive at outcomes in well-understood ways’ (Ling 2012) – and, as we progress towards outcomes and impacts, complex, ‘characterized by feedback loops, adaptation and learning by both those delivering and those receiving the intervention...both sensitive to starting conditions and outcomes tend to change, possibly significantly, over time’ (Ling 2012). As such, the ToC needs to allow for pathways and options spanning a diversity of Challenges and a correspondingly wide range of R&I activities, and hence requires a less deterministic and more open structure. Therefore, to keep the logic model diagram clear and accessible we have provided a detailed accompanying narrative that captures more of the nuance around the ToC. In addition, we have prepared an alternative presentation that does intend to capture the connectors and the feedback loops in more extensive detail to illustrate our thinking. This may be of relevance to internal audiences and is provided in Annex G.

## 4.2. Guide to the ToC

The ToC takes a ‘logic model’ approach, capturing the inputs, activities, outputs and outcomes of the Fund sequentially from left to right. The ToC is intended to be read from left to right, but this is not intended to imply a simple linear progression between these aspects – indeed there will be many non-linearities and feedback loops within the operation of the Fund. Equally, the picture is not ‘static’. The ISCF is operating within a changing landscape. Over the lifetime of the Fund there have been, and will be, changes in government priorities (e.g. emergence of net zero, refresh of industrial strategy, increasing importance of place-based interventions and levelling up), a changing socioeconomic landscape, and some system ‘shocks’ – notably the Covid-19 pandemic and Brexit. Alongside this, there will be learning from experience across waves and from other UKRI funds that can inform both strategy and processes within the ISCF. These are captured as the two feedback loops on the ToC representation, showing the activities of the Fund as a ‘learning cycle’.

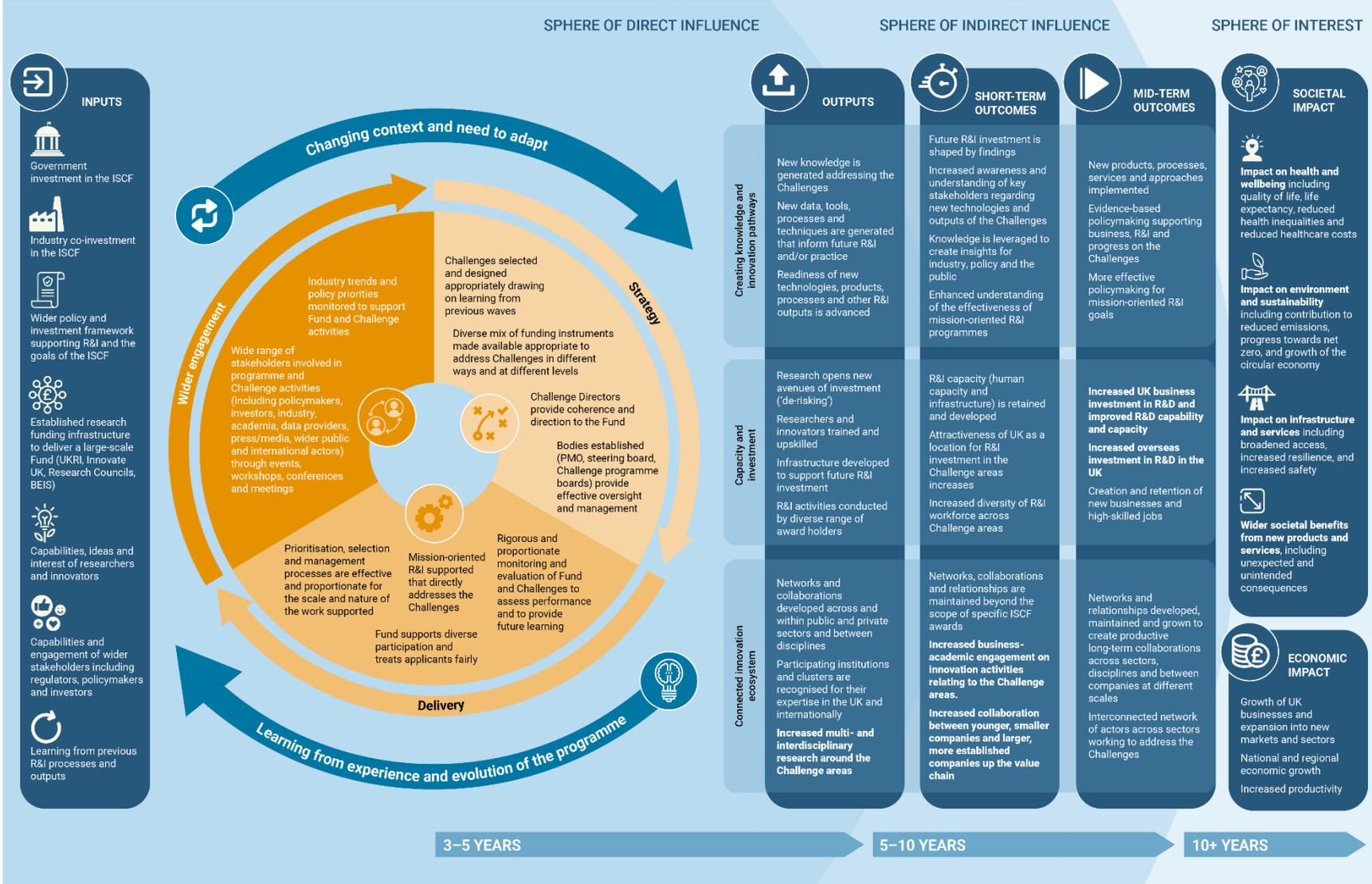
The ToC also draws on the ‘spheres of influence’ model (Barr, Bryan et al. 2019); (Ofir 2016). This is in recognition of the fact that, in common with most R&I programmes, the degree of control which Fund leadership has over many aspects of the ToC may be limited. We may expect that UKRI have a relatively large degree of control over its activities and ‘direct influence’ over many (though perhaps not all) inputs to the Fund. We can also expect some ‘direct influence’ over the outputs within the ToC. However, outcomes and impacts are more indirectly influenced by the activities of the Fund. This recognises that there may be very many other factors contributing to the outcomes and particularly the impacts targeted, and that though we can expect the work of the Fund to make a contribution to these impacts, direct and quantified attribution may be difficult to achieve for many of these intended impacts. Rather, the ToC provides a clear causal pathway to these intended impacts, and hence allows measurement of intermediate steps as we move from left to right in the ToC and further from the direct influence of the Fund. This is not to say that the ISCF is not responsible for taking action to address these longer-term outcomes – indeed it is necessary that the iscf go further than just generating high quality R&I. The ISCF also retains accountability for generating the conditions in which the intended outcomes and impacts of the Fund can be realised, through early and ongoing engagement and partnership with key stakeholders who can support and drive change towards the societal challenge addressed, and through a learning and reflective approach which enables the ISCF to adapt to a changing context and drive forward activities that contribute towards the Fund’s goals. However, directly attributing what proportion of a particular impact (e.g. on the environment or health) is due to the ISCF is likely not feasible or appropriate in many cases – though we will attempt to look at this for some of the economic impacts where we can develop a suitable counterfactual, as set out in Section 6.6.

The ToC also includes the specified aims of the Fund to:

1. Increase multidisciplinary and interdisciplinary research around the Challenge areas
2. Increase business-academic engagement on innovation activities relating to the Challenge areas
3. Increase collaboration between younger, smaller companies and larger, more established companies up the value chain
4. Increase UK business investment in R&D and improved R&D capability and capacity
5. Increase overseas investment in R&D in the UK

These do not sit collectively in one place within the ToC since they comprise a mix of direct outputs of the work of the Fund, and short- and mid-term outcomes. They are not ultimate goals of the Fund – hence they do not feature as impacts – rather these aims are intended to provide the conditions needed to support progress against the specific Challenges, and ultimately to contribute to the wider Industrial Strategy. They are highlighted in bold text on the ToC for clarity.

Figure 2: ISCF Theory of Change



### 4.3. Impacts of the ISCF

We identify two groups of impacts from the ISCF: societal impacts and economic impacts.<sup>17</sup> These are summarised as follows:

#### Societal impacts

- **Impact on health and wellbeing, including quality of life, life expectancy, reduced health inequalities and reduced healthcare costs:** These reflect the range of Challenges intended to deliver health and health sector benefits
- **Impact on environment and sustainability, including contribution to reduced emissions, progress towards net zero and growth of the circular economy:** This captures the work of many of the Challenges that intend to help the UK address its environmental and sustainability needs through a range of activities from improving battery technology and decarbonising housing, through to reducing the use of plastics and supporting net-zero industry clusters
- **Impact on infrastructure and services, including broadened access, increased resilience and increased safety:** This captures the aims of several Challenges that look to improve services and infrastructure across a range of areas spanning transport, digital infrastructure, access to culture and others
- **Wider societal benefits from new products and services, including unexpected and unintended consequences:** We recognise that not all benefits from R&I are planned or expected, and equally that within the diversity of the ISCF portfolio many additional benefits may come about that are beyond the scope and expectations of the initial mandate of a particular Challenge; therefore we maintain an open perspective and look to address and capture the wider benefits of the enabling environment created through ISCF investment

#### Economic impacts<sup>18</sup>

- **Growth of UK businesses and expansion into new markets and sectors:** This may include growth internationally into new markets as well as diversification and growth across sectors
- **National and regional economic growth:** The ISCF aims to produce economic growth within the UK and it will be important to understand how this occurs both nationally and at a regional level as the importance of the levelling up agenda increases



**SOCIETAL IMPACT**



**Impact on health and wellbeing** including quality of life, life expectancy, reduced health inequalities and reduced healthcare costs



**Impact on environment and sustainability** including contribution to reduced emissions, progress towards net-zero, and growth of the circular economy



**Impact on infrastructure and services** including broadened access, increased resilience, and increased safety



**Wider societal benefits from new products and services**, including unexpected and unintended consequences



**ECONOMIC IMPACT**

Growth of UK businesses and expansion into new markets and sectors

National and regional economic growth

Increased productivity

- **Increased productivity:** Innovation is a key driver of productivity growth (Griliches, 1979; Carayannis and Grigoroudis, 2014) and the investment in ISCF is intended, in part, to increase UK productivity and help us better match international benchmarks

These are long-term impacts that will require a sustained effort for transformative change through the ISCF programme as a whole, beyond the lifespan of individual funding rounds or Challenge funds (Amanatidou, Cunningham et al. 2014; Joly and Matt, 2017). The ISCF will be one of many domestic and international drivers contributing to these impacts. The contribution of the ISCF must therefore be understood in the context of these drivers over many years, including: the UK’s broader innovation, economic and social policies; the relative attractiveness of the UK in the Challenge fund sectors in an internationally competitive market; and the underlying economic and social conditions that materialise over the years of the ISCF programme. The assumption that the ISCF contributes to observed changes in these impacts will therefore need to be considered carefully to account for this wider context. The two broad impact themes noted above are used for the ISCF programme rather than simply mapping to the Grand Challenges of the Industrial Strategy. This reflects that whilst there is strong overlap between these impacts and the aims of the Grand Challenges, the ISCF programme has additional aims beyond the Grand Challenges, and the Grand Challenges have many wider drivers beyond the ISCF.

There are two key aspects to the intended impacts of the ISCF. The first is that mission-oriented R&I can effectively deliver societal benefits through both the development of new innovations – be those products, services, tools or other outputs of R&I investment – as well as through the wider societal change they can bring in terms of changing attitudes, understanding and perceptions. The second is that these societal benefits run in parallel, and are complementary, to economic benefits such as productivity gains and economic growth. Finally, a key aspect of the ISCF is the intention that although each ISCF Challenge has its own particular area of focus, all of these are addressed by a mission-oriented R&I approach that aims to create an enabling environment in which knowledge and innovation adoption is advanced, there is growth in R&I capacity (both human and infrastructure capacity) and investment, and the innovation ecosystem is better connected. These are explored further in the impact assumptions set out below.

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<sup>17</sup> We note that work is ongoing within UKRI looking at categorising impacts that uses a different grouping, classifying impacts into four groupings: Society, Environment, Economy and Knowledge. This approach is broadly comparable, with society and environment grouped together as ‘societal’ impact in its broadest sense. We do not explicitly capture knowledge as an impact here though it certainly forms part of the overall ToC, since the mission-oriented nature of this Fund implies that knowledge for its own sake is not an aim of the ISCF, rather increased knowledge is a step towards achieving mission goals.

<sup>18</sup> The societal impacts of the ISCF as outlined above can also have an economic impact, beyond those aspects which would be valued explicitly by markets and hence captured below. For example, economic value can be placed on health benefits via estimation of gain in quality adjusted life years (QALYs) which have a notional monetary value assigned to them in certain contexts. In this evaluation, the non-market economic impacts of the ISCF will be evaluated as part of the VfM assessment, which will consider the total monetizable benefits of the ISCF compared against the total costs of delivering the Fund – as well as considering more qualitatively those aspect which are not monetizable.

## Box 1: Impact assumptions

**How and why will investment in mission-oriented R&I across a range of Challenges lead to societal and economic impacts?**

**Mission-oriented R&I is an effective way to address the challenges facing society:** Society faces a range of complex, multidimensional issues which are not readily addressed by any one sector or field, and which need urgent and targeted action which draws on multidisciplinary insights (Mazzucato, 2018; Amanatidou et al, 2014). These changes need to combine investment in technological solutions with measures to stimulate demand, as well as activities that can foster changes in perceptions, values and actions at a societal level (Cagnin et al 2011; Weber and Georghiou 2010; Amanatidou et al 2014). As such, to tackle these complex challenges – such as climate breakdown, an ageing society and the threat of pandemics – a mission-oriented approach is likely to be beneficial.

**Mission-oriented R&I investment can also deliver economic benefits:** Public investment in R&I is known to deliver economic benefits, stimulating productivity growth and increasing competitiveness, as well as crowding-in private sector investment (Haskel 2010, Haskel 2013; Carayannis 2014; Sussex 2016). Economic and societal impacts are closely interconnected. Increased productivity and growth drive new opportunities for investment and can contribute resources to support societal challenges. Equally, addressing societal challenges improving health, the environment, and infrastructure and services, can drive productivity gains and growth. Therefore, addressing the two together is likely not just effective, but necessary.

**A significant investment in mission-oriented R&I is needed to drive societal and economic benefits for the UK:** There is evidence that the UK needs to take action to improve its standing across the range of impact areas captured. In terms of health, the UK has slower growth in life expectancy than the EU average, and lower than EU average life expectancy for women. We also see years of disability-free life expectancy in the UK falling, particularly for women, and significant health inequalities including a marked north/south divide (Centre for Ageing Better 2020). On the environment, the UK has committed under the Paris Agreement to reduce greenhouse gas emissions by 68 per cent by 2030 relative to 1990 levels and has since set a target to reach 'net zero' by 2050, which will require significant and rapid changes to energy production and consumption. Economically, there is also a need for innovation-led growth, with the UK lagging behind the G7 average in terms of productivity (ONS 2016). As set out above, mission-oriented R&I provides a route to address these societal challenges and drive economic benefits for the UK in parallel.

#### 4.4. Inputs and activities (sphere of direct influence)

Inputs and activities are the aspects of the Fund that are within its ‘sphere of direct influence’. That is, the Fund has, to a large extent, direct influence over these activities and is able to steer and shape them. We have identified a range of key inputs into the ISCF which broadly span financial investment, infrastructure, capabilities and engagement of key actors, and learning from prior experience. The inputs identified are as follows:

- **Government investment in the ISCF:** This refers to the £2.6 billion investment of government funding in ISCF
- **Industry co-investment in the ISCF:** In addition to public funds, matched funding from industry partners intended to amount to £3 billion is central to the ISCF design
- **Wider policy and investment framework supporting R&I and the goals of ISCF:** The Fund exists within a wider policy framework around the Industrial Strategy comprising Grand Challenges and Sector Deals across a range of areas linked to the work of the Fund, as well as a wider programme of investment in R&I through UKRI and other routes, and a wider policy landscape aiming to grow the UK’s knowledge economy (e.g. 2.4 per cent target, levelling up)
- **Established R&I funding infrastructure to deliver a large-scale fund (UKRI and DPs, BEIS):** UKRI, IUK and the Research Councils have well-established infrastructure that can support effective delivery and oversight of a large-scale R&I fund building on prior experience
- **Capabilities, ideas and interest of researchers and innovators:** Delivery of the ISCF necessarily draws on the prior work, interest and ideas of those researchers and innovators who will conduct the R&I activities the Fund supports, as well as inputting at other levels
- **Capabilities and engagement of wider stakeholders including regulators, policymakers and investors:** The ISCF, as a mission-led R&I fund, also needs the input and engagement of a wider group of stakeholders relevant to the missions it supports – both to steer and shape the Fund, and to be active participants, beneficiaries and users of the work
- **Learning from previous R&I processes and outputs:** The ISCF draws on the existing evidence base regarding both R&I already conducted and the knowledge, methods and innovations already available that can be built upon, and the experience of UKRI and others in delivering funds of this nature effectively

The ToC implies that, subject to the assumptions set out in Box 2, these inputs are available and enable the activities of the Fund to take place. In analysing activities, we have focused very much on activities at the Fund level, given the scope and aims of this ToC. We do not attempt to reflect the actions


INPUTS



Government investment in the ISCF



Industry co-investment in the ISCF



Wider policy and investment framework supporting R&I and the goals of the ISCF



Established research funding infrastructure to deliver a large-scale Fund (UKRI, Innovate UK, Research Councils, BEIS)



Capabilities, ideas and interest of researchers and innovators



Capabilities and engagement of wider stakeholders including regulators, policymakers and investors

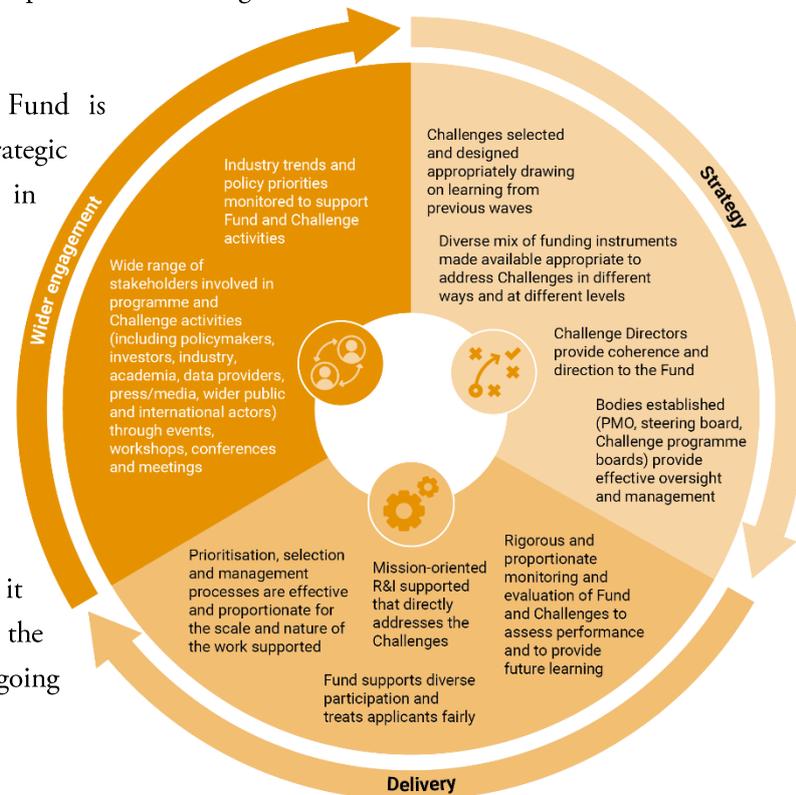


Learning from previous R&I processes and outputs

of individual award holders. Rather, we capture the activities that happen at the level of Fund oversight and implementation, which are intended to produce the enabling environment created by the ISCF and described in the next section. These activities are grouped into three categories.

Activities of the ISCF:

- **Strategy:** This articulates how the Fund is structured and designed, and the strategic governance and oversight processes in place
- **Delivery:** This sets out the way in which the Fund is delivered in terms of funding and managing the portfolio of R&I
- **Wider engagement:** This captures the outward-looking aspects of the Fund, particularly in terms of the ways it engages with wider stakeholders and the wider landscape to ensure its ongoing relevance and effective operation



The items captured in each grouping are as follows:

*Strategy:*

- **Challenges selected and designed to draw on learning from previous waves:** A key aspect of the ISCF's implementation is appropriate selection and design of the Challenges to be included as part of the Fund. Different approaches were taken to this across waves, learning from previous stages of the Fund.
- **Diverse mix of funding instruments made available to address Challenges in different ways and at different levels:** The Fund comprises a diverse range of funding instruments and structures recognising the needs of the different Challenges
- **Challenge Directors provide coherence and direction to the Fund:** For each Challenge, a Challenge Director is appointed to oversee and direct the Challenge portfolio and help drive forward the mission. These individuals are experts in the field and intended to help capitalise on the synergies between awards and ensure a portfolio perspective on the operation and delivery of the Fund is maintained, while supporting engagement of key stakeholders relevant to the Challenge.
- **Bodies established (Programme Management Office (PMO), steering board, Challenge project boards) provide effective oversight and management:** A number of oversight bodies have been put in place to support oversight, strategy and monitoring of the Fund. These include the PMO, the ISCF steering board, and Challenge programme boards

*Delivery:*

- **Prioritisation, selection and management processes are effective and proportionate to the scale and nature of the work supported:** Prioritisation and selection of awards and their ongoing management comprise a range of processes including proposal submission and evaluation processes, award processes and documentation, and ongoing management of awards over their lifecycle. The nature of these processes will vary depending on a range of factors including the scope and scale of the award, the type of award holder and the aims and strategies of particular Challenges. However, across these contexts processes should be effective and proportionate, balancing the need for accountability with bureaucratic burden.
- **Mission-oriented R&I supported to directly address the Challenges:** The ISCF explicitly aims to support mission-oriented R&I, and work supported should be aligned with, and address, the Challenges specified
- **Fund supports diverse participation and treats applicants fairly:** In line with wider UKRI equality, diversity and inclusion (EDI) standards, the ISCF should support diverse participation and treat all applicants fairly. In addition, in line with the wider aims of the Fund and the wider levelling up agenda, the ISCF should support participation from SMEs as well as larger companies, and participants from across the UK.
- **Rigorous and proportionate monitoring and evaluation of Fund and Challenges to assess performance and to provide future learning:** Effective monitoring and evaluation activities are needed to serve accountability purposes given the large investment of public funding, and are also crucial to support learning and improvement within and beyond the ISCF. The M&E activities therefore need to be rigorous and learning-oriented, feeding into the learning cycle illustrated in the logic model, but should also be proportionate and purposeful, avoiding ‘monitoring for monitoring’s sake’ and ensuring data collected is used and its purpose clear.

*Wider engagement:*

- **Industry trends and policy priorities monitored to support Fund and Challenge activities:** As discussed previously, the ISCF operates within a complex changing environment and it is important that the Fund evolves alongside that environment, as captured in the learning cycle representation. To do this, it is crucial that industry trends and policy priorities are monitored to ensure that the Fund moves with, and adapts to, the changing environment and remains relevant.
- **Wide range of stakeholders involved in programme and Challenge activities (including policymakers, investors, industry, academia, data providers, press/media, wider public and international actors) through events, workshops, conferences and meetings:** As highlighted in the literature and in our evaluation approach, the ISCF has a wide range of potential stakeholders, and engaging these groups is crucial to the successful delivery of mission-oriented R&I. These groups need to shape and inform the work of the Fund, but should also be primed as the potential adopters of the outputs of the Fund through ongoing engagement, participation and a sense of ‘shared ownership’ of the Challenges and their aims.

We represent these activities not as sequential and separate, nor as static, but as part of a learning cycle in which the changing context and learning from the experience of the programme result in a constant evolution of strategy, processes and engagement over the lifecycle of the Fund. Equally, within that learning cycle, we see the different aspects as interlinked and connected, with strategy flowing into delivery changes and these processes informing and shaping engagement, which, through a process of learning and listening in turn drives changes and improvements in strategy and delivery.

#### Box 2: Input to activity assumptions

- There are a wide range of companies relevant to the identified Challenges that are able and willing to provide necessary co-investment to participate in the ISCF
- Existing research infrastructure within UKRI is appropriate, or is able to adapt, to facilitate the delivery of mission-oriented R&I
- Researchers and innovators have the interest and the capability to participate in mission-oriented R&I
- Learning from previous funds, and from the ISCF as it progresses, as well as changing contextual factors, is used to inform Fund design and management on an ongoing basis, producing the learning cycle depicted
- The wider policy and investment framework (e.g. Sector Deals, Industrial Strategy, other R&I investment) is aligned with and supports the work of the ISCF
- The ISCF is able to effectively engage the right key stakeholders across sectors with the capabilities to inform and shape the design and operation of the Fund and ensure its success

#### 4.5. Outputs and outcomes (sphere of indirect influence)

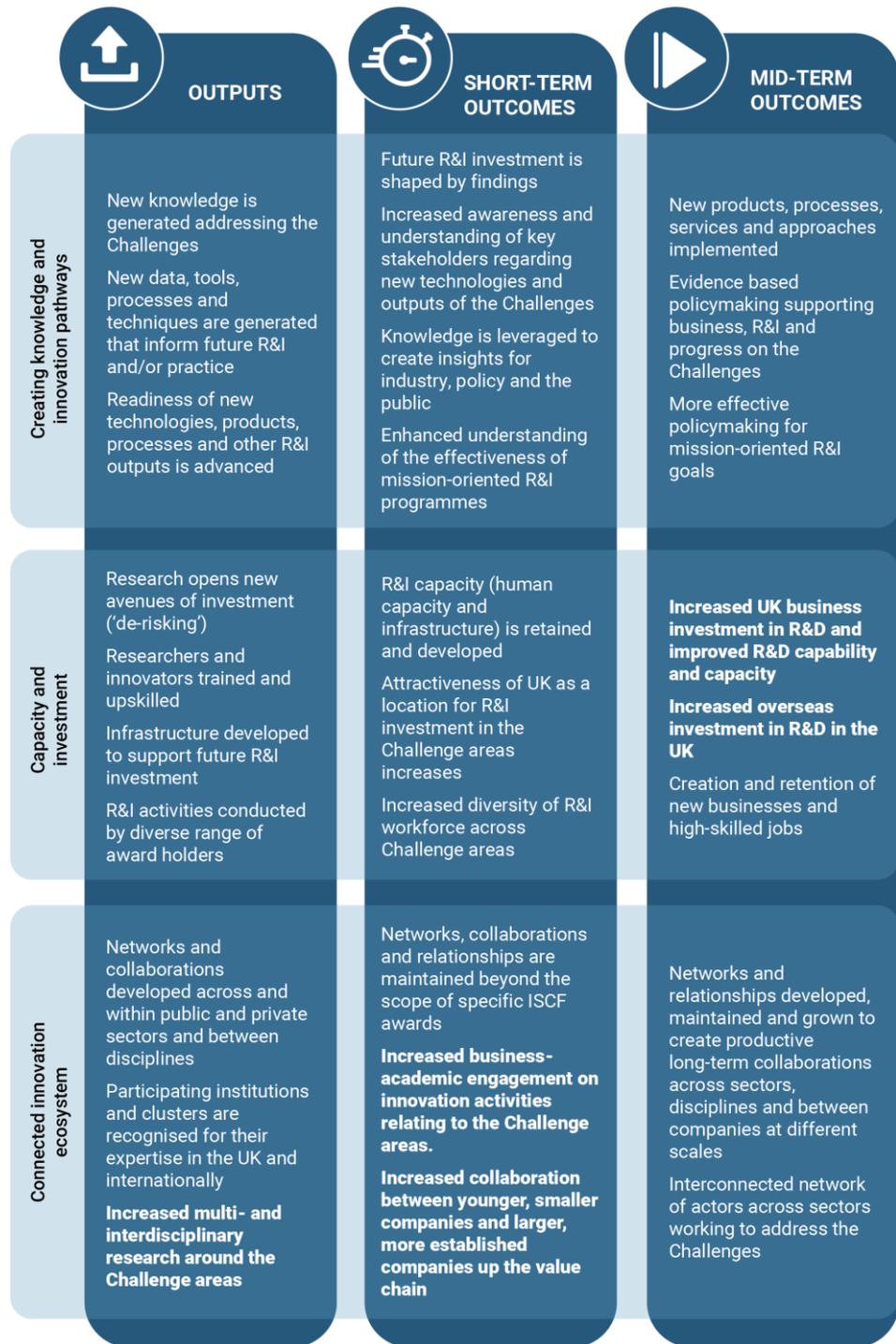
The outputs and outcomes of the Fund are depicted as progressing from the sphere of direct influence to the sphere of indirect influence. Although the initial outputs of the R&I activities supported by the ISCF could be considered to be within the direct influence of the Fund, as these progress towards outcomes (and ultimately impacts) it is clear that although the ISCF makes a contribution, these outcomes are dependent on a range of wider factors and are beyond the Fund's direct purview.

The outputs and outcomes of the Fund are structured across three groupings related to the intended mechanisms of change of the Fund:

- **Creating knowledge and innovation pathways:** A key objective of the ISCF is to develop new knowledge addressing the Challenges and promoting the advancement and adoption of new innovations. This includes advancement of new products and services, but also takes in the wider social changes that are intrinsic to mission-oriented R&I investment, such as increasing public awareness and acceptance, and informing the policy and regulatory changes that need to take place for change to occur.

- Capacity and investment:** A core aim of the Fund is to increase capacity and investment in R&I in the UK, to ensure the investment in the Fund is leveraged to generate further funding towards addressing the Challenges, and to ensure the skills, physical infrastructure and supply chains are in place to enable, encourage and capitalise upon that investment
- Connected innovation ecosystem:** A key feature of the operation of the Fund, and a key element of all mission-oriented R&I, is collaboration and networks. Complex missions require a range of actors across sectors to work together to foster change and not just develop innovative solutions but ensure the wider environment for adoption and improvement is in place. ISCF funding is all collaborative in nature, and the wider activities of the Fund are intended to be inclusive and outward-looking, bringing together the right coalition of stakeholders to drive the Challenges forward.

These categories broadly align with frameworks and approaches in the literature regarding the purpose and focus of mission-oriented



R&I<sup>19</sup>. Although these categories are of course interrelated and connected, they represent distinct key features of the structure and intended outcomes of the Fund.

Within each of these categories, we distinguish outputs, short-term outcomes and mid-term outcomes. There are clear distinctions between these ‘timepoints’ that reflect the diffusion of the contributions of the ISCF beyond the bounds of the Fund itself and those involved. Outputs represent the direct products of the R&I supported by ISCF investment. These include, across the categories, the following:

*Creating knowledge and innovation pathways:*

- New knowledge is generated addressing the Challenges
- New data, tools, processes and techniques are generated that inform future R&I and/or practice
- Readiness of new technologies, products, processes and other R&I outputs is advanced

*Capacity and investment:*

- Research opens new avenues of investment (‘de-risking’)
- Researchers and innovators trained and upskilled
- Infrastructure developed to support future R&I investment
- R&I activities conducted by diverse range of award holders

*Connected innovation ecosystem:*

- Networks and collaborations developed across and within public and private sectors and between disciplines
- Participating institutions and clusters are recognised for their expertise in the UK and internationally
- Increased multidisciplinary and interdisciplinary research around the Challenge areas

Broadly these outputs might be expected to be achieved within, or shortly following, the lifetime of the Fund. Indicatively, we have therefore said that we might expect to see some achievements against these outputs within three to five years of funding investment, subject to the assumptions set out in Box 3.

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<sup>19</sup> E.g. the ‘evolutionary/structuralist’ framework for public intervention noted by Georghiou et al (2002) in which public intervention is justified in terms of addressing learning failures, systems failures and knowledge-processing failures. In the progression from Fund-level actors to awareness and ultimately action of wider actors between outputs and mid-term outcomes, we reflect the points raised by Gök (2012) and Amanatidou et al (2014) regarding the need to capture ‘behavioural’ additionality in any evaluation of mission-oriented R&I.

**Box 3: Activity to output assumptions**

- Sufficient high-quality applications for funding are received
- Applications received align well with the needs of the Challenges, and represent an appropriate portfolio spanning the different requirements of the Challenges
- Applications are received from a diverse mix of applicants
- Researchers and innovators are able and willing to work together across sector and disciplinary boundaries
- R&I investment addresses ‘market failures’ and provides support to ‘risky’ R&I that would not normally be conducted by industry
- Researchers and innovators are able to make progress creating new knowledge, tools, data and other insights and outputs through ISCF investment

Broadly, effective achievement of the outputs is dependent on the willingness of the R&I community to engage, which will drive the diversity, quality and appropriateness of the applications received and hence the portfolio of awards funded.

Short-term outcomes denote the point at which effects are sustained beyond the lifetime of the Fund, and move beyond the direct actors involved in the delivery of the Fund and start to affect, shape and influence wider actors of relevance to the Challenge areas. A summary of the assumptions required for these short-term outcomes to follow from the outputs described is set out in Box 4.

**Box 4: Output to short-term outcome assumptions**

- Researchers, innovators and/or other Fund-level actors (e.g. Challenge Directors) are willing and able to communicate outputs effectively to a range of audiences
- Key stakeholders in policy, industry and other settings are receptive to findings, given the wider social, political and economic landscape
- Researchers and innovators have the resources and willingness to maintain and build on ISCF activities beyond the lifetime of the funding
- Researchers and innovators find ISCF involvement a positive experience and are motivated to seek further opportunities to build networks and conduct R&I
- Effective learning mechanisms are in place to enable future R&I investment to build on ISCF findings and experiences

Broadly, progress from outputs to short-term outcomes requires effective communication and learning from ISCF experiences, and will be reliant on the commitment and motivation of award holders and other key actors (e.g. Challenge Directors) to pursue and extend the achievements of the funded R&I beyond the lifetime of the award, as well as the extent to which the wider affected community have been engaged as part of the Fund, ‘priming’ them to be engaged recipients of the outputs of the Fund.

In the case of creating knowledge pathways, this can be considered as the dissemination step – where knowledge is spread beyond those conducting R&I to inform others, be they other researchers and innovators, policymakers, the public or wider industry. We also highlight here the knowledge gained regarding the effectiveness of mission-oriented R&I programmes, which may influence policy and funding beyond the confines of the ISCF. In terms of capacity and investment, this is characterised in terms of the capacity and infrastructure gains built through the Fund being maintained beyond its lifetime, and this

influencing wider stakeholders in terms of the attractiveness of investing in R&I in the Challenge areas in the UK. In the context of a connected innovation ecosystem, short-term outcomes are achieved where networks and collaborations are maintained beyond the scope of the Fund and have an effect on the overall scope and range of collaborations in the relevant Challenge areas more widely. Short-term outcomes across the categories are summarised below.

*Creating knowledge and innovation pathways:*

- Future R&I investment is shaped by findings
- Increased awareness and understanding of key stakeholders regarding new technologies and outputs of the Challenges
- Knowledge is leveraged to create insights for industry, policy and the public
- Enhanced understanding of the effectiveness of mission-oriented R&I programmes

*Capacity and investment:*

- R&I capacity (human capacity and infrastructure) is retained and developed
- Attractiveness of the UK as a location for R&I investment in the Challenge areas increases
- Increased diversity of R&I workforce across the Challenge areas

*Connected innovation ecosystem:*

- Networks, collaborations and relationships are maintained beyond the scope of specific ISCF awards
- Increased business-academic engagement on innovation activities relating to the Challenge areas
- Increased collaboration between younger, smaller companies and larger, more established companies up the value chain

Subject to the assumptions specified in Box 5, we expect these short-term outcomes to translate into a set of mid-term outcomes. These mid-term outcomes, across the categories, are the point at which the intended changes to the R&I and wider Challenge ecosystem are delivered that are intended to provide an enabling environment which can support the achievement of the impacts described. This is where the results of the Fund that have persisted beyond its lifetime, and outside the scope of the Fund's initial actors, are now embedded into practical system changes that can support the delivery of benefits for society and the economy.

**Box 5: Short-term outcomes to mid-term outcomes assumptions**

- Insights and knowledge shared from the ISCF are salient enough and sufficiently well-communicated to enable and compel stakeholders beyond those engaged with the Fund to take action
- Increased attractiveness and capacity of UK R&I system in Challenge areas is sufficiently competitive relative to international comparators to attract additional investment
- Economic conditions enable businesses to continue and grow their investment in R&I
- The benefits of collaboration and the ties developed are strong enough to maintain, grow and deepen, rather than fade over time

Overall, progress over the mid-term requires that the momentum created by ISCF investment across the Challenge areas is sufficient to be maintained over five to 10 years such that the influence can grow and expand beyond those immediately engaged in the Fund.

In the case of creating knowledge and innovation pathways, this means that wider stakeholders take the knowledge and insights from the work of the Fund and implement them to put in place new products, processes and services, and make changes to policy. This requires, and builds on, not just the technological advancements made and the further R&I conducted, but also the societal acceptance and political will developed through the wider sharing of knowledge. In capacity and investment, mid-term outcomes represent the point where the increased attractiveness of the UK as a place for investment in R&I, and the strengthened capacity achieved at the ‘short-term outcomes’ point leads to increased investment (both by UK and overseas businesses) and the creation and retention of jobs in the relevant sectors, cementing increased R&I capacity over the long term. Finally, for the connected innovation ecosystem, in the mid-term we see those networks embedded to create productive long-term collaborations, and an active network of interconnected actors across sectors working to deliver against the Challenges. The mid-term outcomes, across categories, are as follows.

*Creating knowledge and innovation pathways:*

- New products, processes, services and approaches implemented
- Evidence-based policymaking supporting business, R&I and progress on the Challenges
- More effective policymaking for mission-oriented R&I goals

*Capacity and investment:*

- Increased UK business investment in R&D and improved R&D capability and capacity
- Increased overseas investment in R&D in the UK
- Creation and retention of new businesses and high-skilled jobs

*Connected innovation ecosystem:*

- Networks and relationships are developed, maintained and grow to create productive long-term collaborations across sectors, disciplines and between companies at different scales
- Interconnected network of actors across sectors working to address the Challenges

Indicatively, these short- and mid-term outcomes could be expected to evolve over the five to 10 years following investment in the Fund. However, this is highly dependent on a range of contextual factors such as the maturity of the field, the extent of existing networks, the level of development of specific technologies or innovations required, and wider socioeconomic drivers that may inhibit or facilitate the development of the field. As such, these are likely to vary across Challenges and even across individual awards within those Challenges.



The ToC implies that by achieving these mid-term outcomes, the ISCF can create an enabling environment which contributes to the societal and economic impacts described on the right-hand side of the ToC. This is supported by existing literature (e.g. Georghiou et al. 2002; Mazzucato 2018), but is, however, subject to a number of assumptions as specified in Box 6.

**Box 6: Mid-term outcome to impact assumptions**

- Increased capacity and investment in R&I are targeted towards addressing societal challenges and promoting economic growth
- New products, processes, services and approaches implemented work effectively in practice to deliver benefits
- Challenges maintain their relevance to address current societal issues over the timescales needed for impacts to be achieved
- Economic growth is facilitated by increased collaboration and networks
- Networks and communities of actors are better able to make the step changes needed to achieve societal impact
- Skills and capacity developed remains relevant, or is able to adapt effectively, over the timescales needed for impacts to be achieved
- Wider social, political, economic and other factors – including unexpected shocks – do not have sufficient impact to negate the effects of the Fund on the R&I and Challenge area ecosystems

Broadly, the translation from mid-term outcomes to impact is reliant on two key underlying assumptions. Firstly, that the enabling environment described makes an effective contribution to achieving Challenge aims across their differing contexts. Secondly, it assumes that the relevance of those Challenges and the activities of the Fund, as well as the outputs and outcomes that build upon them, is maintained over the timelines required for the impacts to be achieved.

Beyond this, the wider assumptions around the effectiveness of mission-oriented R&I for achieving societal and economic change as set out in Box 1 should also be considered.

Although this represents current impressions regarding the aims and intended pathways through which the ISCF intends to deliver benefits, the Fund is not static. As shown in the diagram, the Fund is changing and adapting over time based on learning and through changes in wider contextual factors. This means it is likely that over the lifetime of the evaluation the operation of the Fund may change, and although the ToC has been designed with this necessary flexibility in mind, there may be a need to revisit the ToC at a later stage of the evaluation. As such, this ToC provides our best available understanding of the operation of the Fund as it stands, but is not a static and fixed point – rather it is a tool to stimulate discussion and support investigation over the course of the evaluation, and consequently may evolve as the Fund, and our understanding of it, grows and changes.

## 5. Evaluation framework

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### 5.1. Overview

In the preceding chapter, we set out a ToC for the ISCF. The ToC presented a schematic representation of the ISCF inputs, activities, outputs, outcomes and impacts. In doing so, it also categorised the ISCF's activities, outputs, outcomes and impacts into key evaluation themes. These themes represent broad, high-level categories that aim to conceptualise and group together related processes and impacts. In this chapter, we use these evaluation themes to establish an evaluation framework for the ISCF. Taking each evaluation theme in turn, we operationalise that theme for evaluation by identifying evaluation questions, indicators and data sources. In doing so, we establish evaluation frameworks for both the process and the impact evaluation of the ISCF.

For the process evaluation framework, we identify evaluation questions, indicators and data sources for the three activity themes set out within the ToC – strategy, delivery and wider engagement. For the impact evaluation framework, we do this first for the three output/outcome themes outlined by the ToC – creating knowledge and innovation pathways, capacity and investment, connected innovation ecosystem – and subsequently for the broader impact themes – societal impact and economic impact. In both the process and the impact evaluation frameworks, we have also incorporated a small number of additional evaluation questions to address 'cross-cutting' process questions and 'value for money' respectively. The evaluation framework contains evaluation questions that have been developed to reflect the ISCF ToC, while also maintaining consistency with the evaluation questions as set out in the ITT.

Our approach to mapping data against the evaluation questions reflects the distinctive structure of this evaluation. As a Fund-level evaluation conducted alongside ongoing individual Challenge-level evaluations, a key aspect of our evaluation framework is the mapping of relevant Challenge-level indicators against our evaluation questions. This has been performed through a review of Challenge-level evaluation frameworks provided to the evaluation team.<sup>20</sup> As the evaluation proceeds, the review of the Challenges' progress against these indicators will present an important mechanism for evaluating the performance of the ISCF against each evaluation question. In particular, the analysis of the Challenges' progress will form part of the review

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<sup>20</sup> We have reviewed evaluation frameworks for the following Challenges: Prospering from the Energy Revolution, Creative Industries Clusters Programme, Digital Security by Design, Faraday Battery, Future Flight, Audience of the Future, Medicines Manufacturing, Next Generation Services, Prospering from the Energy Revolution, Robotics and Artificial Intelligence in Extreme Environments and Smart Sustainable Plastic Packaging.

of Challenge-level evaluation reports undertaken in phase 3 of the evaluation. This list of relevant Challenge-level indicators will be added to as additional Challenge-level evaluation frameworks are established.

For each evaluation question, our evaluation framework also identifies Fund-level indicators. Building on the identified Challenge-level indicators, these Fund-level indicators represent the key indicators (both quantitative and qualitative) that we will use to assess the performance of the Fund as a whole. While Challenge-level indicators will be most relevant to our review of Challenge-level evaluation reports (phase 3), these Fund-level indicators will be most relevant to the Fund-level evaluation methods (including primary data collection) that we undertake in phase 4. In addition to identifying Fund-level indicators for each evaluation question, the framework presented below also identifies data sources through which we will acquire data relevant to these indicators. At different points, these include the review of UKRI-collated Fund-level data, the review of wider non-UKRI data sources, and own primary data collection methods, comprising key informant interviews, workshops, case studies, econometric analysis, network analysis and VfM analysis.

The evaluation framework outlined below presents our understanding of the available data sources to support evaluation of the evaluation questions at the time of submitting this report. Given the long timeframe of this evaluation, and the fact that primary data collection will not take place until the evaluation's fourth phase, it is possible that further data sources not highlighted below may also be incorporated into the evaluation approach. During the baselining phase of the evaluation, we will be undertaking further scoping of a select number of additional data sources, focusing on databases that we have identified as potentially adding value to the evaluation. The databases to be considered during this scoping are Lens and/or Orbis data (to inform patent analysis) and Beauhurst and/or Crunchbase data (to inform analysis of investment in ISCF supported companies). Scoping work will consider the extent to which ISCF-supported organisations are included within these databases, the specific forms of data available on those organisations, and the extent to which there is alignment between databases' definition of sectors and the ISCF Challenge sectors.<sup>21</sup> In addition to exploring the use of these databases for phase 4 primary data collection, this further scoping will also examine their use for baselining patent and investment data against standard datasets. The identification of Lens, Orbis, Crunchbase and Beauhurst as the focus of further scoping follows an initial consideration of the uses of additional databases by the study team during

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<sup>21</sup> Our prior expectation is that these datasets will have only limited value, as much of the data will not correspond closely enough to meaningful indicators, and coverage may be limited due to narrow criteria for inclusion. In the case of Beauhurst and Crunchbase, the main variables relate to companies' raising funds rather than R&D investment per se. In the case of Lens and Orbis, our understanding is that while these datasets contain information on patents, if this is just a measure of number of filings it will serve as a poor proxy for R&D activity. And while the datasets may contain further financial variables, these will be derived from published filings, and so reporting thresholds will entail poor coverage, which again limits the usefulness relative to the core ONS data. Nevertheless, a more thorough investigation on these points is warranted.

the evaluation framework design. The sources considered and the key determinations made in this respect are summarised in Annex A.

## 5.2. Process evaluation framework

In this section, we present the evaluation framework for the process evaluation of the ISCF. The process evaluation framework builds upon the three activity themes identified by the ToC (strategy, delivery and wider engagement) and identifies evaluation questions, indicators and data sources for each. In addition, the framework also does this for a number of broader cross-cutting process evaluation questions.

To inform the development of this framework, we analysed available Challenge-level evaluation frameworks and their process evaluation indicators. Of the Challenge-level evaluation frameworks that we reviewed,<sup>22</sup> six reported assessment criteria, indicators and metrics that they intend to use to answer their own process evaluation questions. In the tables presented below, we have mapped these Challenge-level indicators to our Fund-level evaluation questions. In the text that accompanies the tables, we have also considered more broadly how the approaches of the Challenge-level process evaluations will provide data that corresponds to our evaluation questions. The identification of relevant Challenge-level indicators and data is of particular relevance to the review of Challenge-level evaluation reports conducted in phase 3 of the study.

In addition to identifying relevant Challenge-level indicators, the framework presented below also identifies Fund-level process evaluation indicators. As noted above, these Fund-level indicators will be particularly relevant to our broader Fund-level data collection during phase 4 of the evaluation. The framework also identifies key sources we will use to collect data in relation to these Fund-level indicators, including our own primary data collection. For the process evaluation, the principal primary data collection methods will be key informant interviews and workshops, which we anticipate will provide insights across the evaluation themes and questions. While not presented in the tables below, it is also anticipated that case studies, conducted in phase 4 of the evaluation, will also provide insights in relation to many of our evaluation themes and questions. Our approach to collecting primary data against the process evaluation framework, including through case studies, is explained further in Chapter 6 of this report.

The process evaluation framework presented below builds upon the recently published NAO report on *UK Research and Innovation's Management of the Industrial Strategy Fund* (Davies 2021), while also adopting a distinctive focus. While the NAO report considered the extent to which UKRI's management of the Fund has achieved value for money to date, this process evaluation framework will consider more broadly the extent to which the design and delivery of the ISCF have contributed to the impacts of the Fund over a longer timeframe, including when impacts are more observable. Evaluation questions and indicators have been designed in light of these aims. As highlighted below, however, where there is crossover between these

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<sup>22</sup> These are: Prospering from the Energy Revolution, Creative Industries Clusters Programme, Digital Security by Design; Faraday Battery, Future Flight, Audience of the Future, Medicines Manufacturing, Next Generation Services, Prospering from the Energy Revolution, Robotics and Artificial Intelligence in Extreme Environments and Smart Sustainable Plastic Packaging.

evaluation questions and the work undertaken by the NAO, the NAO report will be used as a starting point for our own analysis.

### 5.2.1. Strategy

Our first process evaluation theme is ‘strategy’. **This theme aims to examine the ISCF’s design, structure and responsiveness with a view to considering how the Fund’s strategy has contributed to any observed impacts.** This strand asks questions around the role of the Challenge Directors, examining how and to what extent they facilitated the success of the Challenges; the design of the funding instruments and how, if at all, they promoted collaborative working; how learning took place, if at all, between waves; and to what extent, and how, the governance of ISCF has been effective and agile to a changing policy landscape. Table 7 below sets out evaluation questions, relevant Challenge-level and Fund-level indicators and data sources for this theme.

**Table 7: Process evaluation framework – strategy**

Sub-category	Evaluation question	Relevant Challenge-level evaluation indicators	Relevant Fund-level data	Other data sources	Fund-level evaluation indicators (largely qualitative)	Primary data collection
Challenge Directors	1. To what extent have the Challenge Directors maximised R&I opportunities across the different domains (government, academia, businesses) for the benefit of the programme in a coherent and directed way? How have they ensured that projects within the Challenges complement each other and do not come into conflict?	Projects across workstreams forming collaborations	Challenge Director quarterly reviews; quarterly portfolio performance and monitoring reports	NAO 2021 report on UKRI's management of the ISCF	Perceptions of key stakeholders on the role and effectiveness of Challenge Directors  Analysis of composition of portfolio  Case study examples of the role and influence of Challenge Directors  Perceptions of Challenge Directors on their role, autonomy and effectiveness	Key informant interviews; ISCF stakeholder workshop
	2. To what extent have the Challenge Directors led to appropriate investment decisions that focus on the industrial Challenges assigned to each programme?					
	3. How much autonomy have Challenge Directors had in designing and delivering their programmes? How would increased autonomy for Challenge Directors regarding preferred timelines, scope and activities for the Challenge have changed the likely benefits and costs?					
	4. How adaptable have Challenge Directors been in responding to changing circumstances? Did they adjust decision-making appropriately?					
	5. What additional value have Challenge Directors provided compared to standard grants in UKRI? What are the lessons learned from this approach in terms of the role of industry experts in advancing R&D?					

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Sub-category	Evaluation question	Relevant Challenge-level evaluation indicators	Relevant Fund-level data	Other data sources	Fund-level evaluation indicators (largely qualitative)	Primary data collection
Funding instruments	6. To what extent, and how, have the various funding instruments (e.g. CR&D, Hubs/centres) helped develop an ecosystem within Challenges that enables collaboration across different domains (government, academia and businesses)?	# business events; # collaborative projects; stakeholder feedback and views	Challenge Director quarterly reviews; quarterly portfolio performance and monitoring reports	NAO 2021 report on UKRI's management of the ISCF	Perception of key stakeholders on the effectiveness of funding instruments in place, and any gaps or weaknesses  Case study examples of the way in which funding instruments enabled (or impeded) collaboration and effective delivery  Analysis of levels of collaboration and key outcomes by funding instrument	Key informant interviews; ISCF stakeholder workshop
	7. What alternative funding instruments or improvements could be introduced to improve the collaborations across different domains?					
Learning between waves	8. How, and in what ways, did wave 1, 2 and 3 identify the Challenges? How were improvements made and learnings taken up after each wave? What can be learned for future waves of the ISCF and/or other R&I funding programmes?	Views of board members, knowledge from early projects feeding into later ones	Challenge Director quarterly reviews; quarterly portfolio performance and monitoring reports	NAO 2021 report on UKRI's management of the ISCF	Perceptions of key stakeholders on the learning and change between waves  Documentary evidence on changes in process and rationales  Comparative analysis of overarching (process and impact) evaluation findings by wave	Key informant interviews; ISCF stakeholder workshop

Sub-category	Evaluation question	Relevant Challenge-level evaluation indicators	Relevant Fund-level data	Other data sources	Fund-level evaluation indicators (largely qualitative)	Primary data collection
Governance	9. How has the ISCF governance and set up, supported and enabled delivery of the ISCF? (e.g. how effective has the ISCF steering board been in decision-making? How have the performance and monitoring board analysed the portfolio's performance and the individual Challenge governance set-up with senior responsible officer, Challenge programme board and advisory board)? How have these boards done this effectively?	Stakeholder satisfaction; recommendations of meeting minutes; views on effectiveness; correlation between recommendations of Advisory Group and Steering Group and competition specifications; industry, academic, and innovation lead stakeholder feedback; views of board members	ISCF steering board review Challenge Director quarterly reviews; quarterly portfolio performance and monitoring reports	NAO 2021 report on UKRI's management of the ISCF	Perceptions of key stakeholders on the governance structures in place and their effectiveness in supporting delivery of the iscf, as well as their agility to respond to a changing landscape  Case study examples of the role of governance structures in supporting (or impeding) effective delivery against Challenge aims  Documentary analysis of changes in approach over time and in response to critical events, and rationale for these changes	Key informant interviews; ISCF stakeholder workshop
	10. Using Covid-19 and Brexit as examples, how well has the ISCF governance allowed for an effective response in guiding the Challenges to adjust and adapt appropriately?	Adaptability of programme; stakeholder satisfaction	Challenge Director quarterly reviews; quarterly portfolio performance and monitoring reports	NAO 2021 report on UKRI's management of the ISCF		
	11. More broadly, how has the ISCF adapted to evolving ministerial priorities and been agile in response to a changing policy landscape?	Stakeholder views				

Source: RAND Europe analysis

Although the Challenge-level evaluations provide almost no clear metrics or indicators on the role of the Challenge Director specifically, several Challenge-level evaluations (Smart Sustainable Packaging, Future Flight and Audience of the Future) have indicated that they intend to interview the relevant Challenge Director. These interviews can at least partially inform the Challenge-level evaluation. In addition to this, broader questions on ‘governance’ can also be expected to clarify the role of the Challenge Director in managing the ISCF. However, to determine the exact role of the Challenge Director, it is clear that at the ISCF level, we will need to complete further interviews with a sample of Challenge Directors (see Section 6.5.2).

On funding instruments, the Digital Security by Design evaluation, Next Generation Services, Prospering from the Energy Revolution evaluation, and Medicines Manufacturing evaluation, provide a number of indicators relating to current funding instruments and whether, and how, they have increased collaboration. However, given the lack of Challenge-level indicators surrounding potential alternatives, we would need to collect further stakeholder views on what these alternative funding arrangements might look like.

Considering ‘learning between waves’, the Smart Sustainable Packaging and Prospering from the Energy Revolution evaluation frameworks provide some indicators that are relevant and will inform our process evaluation. However, it is clear that we will require to speak to stakeholders across different Challenges to assess to what extent learning has been facilitated across waves and streams of funding. In particular, we will conduct our analysis of Challenge-level information by wave, so we can compare process (and impact) evaluations across these waves and consider what effect the changes between waves have had on perceptions and experiences at the Challenge-level.

The ‘governance’ sub-theme is relatively well covered by the Challenge-level indicators, as Prospering from the Energy Revolution, Medicines Manufacturing, Digital Security by Design, Next Generation Services, Smart Sustainable Packaging, all have related indicators. In many of these Challenge evaluations, the associated framework report makes clear that figures from the ISCF PMO, senior management at UKRI, and the Research Councils will be interviewed. In our process-level evaluations, we will look to analyse these interviews, both to inform our analysis and avoid duplication.

For all strategy sub-themes, the 2021 NAO report will act as a guide and starting point for interviews and case studies. In particular, we will examine the interview findings as we aim to interview similar stakeholders and will use this content to avoid duplication and explore whether the findings of the NAO report have been acted upon in the intervening period. Similarly, across all strategy sub-themes, we will refer to quarterly portfolio performance and monitoring reports and Challenge summaries.

### 5.2.2. Delivery

The second theme of our process evaluation is ‘delivery’. **This theme focuses on how effectively and efficiently internal delivery mechanisms have supported the Fund’s goals.** Evaluation questions within this theme consider how ISCF funding instruments have, in practice, facilitated R&I activities that address the Challenges; to what extent the ISCF has been efficiently managed and well-co-ordinated across the different Challenges; and the extent to which internal protocols and processes are useful and have improved

the delivery of the Fund. Table 8 below sets out evaluation questions, relevant Challenge-level and Fund-level indicators and data sources for this theme.

Table 8: Process evaluation framework – delivery

Sub-category	Evaluation question	Relevant Challenge-level evaluation indicators	Relevant Fund-level data	Other data sources	Fund-level evaluation indicators (largely qualitative)	Primary data collection	
Funding instruments	1. How has the ISCF funnelled investment into enabling technologies to support the key Industrial Strategy policies such as the Grand Challenges and other BEIS policy objectives?	Satisfaction with financial model of Challenge	Quarterly IUK-administered project monitoring; quarterly portfolio performance and monitoring reports; UKRI risk appetite framework for ISCF	NAO 2021 report on UKRI's management of the ISCF	Perceptions of key stakeholders on how funding instruments have enabled innovation and aligned with Grand Challenges	Key informant interviews; ISCF stakeholder workshop	
	2. To what extent, and how, have the ISCF Challenges focused on 'high-risk' investment areas and enabled the de-risking of investment? Further, what is the difference in the level of impacts of focusing on high- and low-risk investment areas?				Perceptions of key stakeholders on how far the ISCF has 'de-risked' investment in relevant R&I		Analysis of risk portfolio based on quarterly reporting
Effective and proportionate processes of Fund management	3. How, if at all, has the ISCF PMO enabled a centralised, coordinated and consistent approach to delivering ISCF Challenges?		Quarterly IUK-administered project monitoring; performance and monitoring report; quarterly portfolio performance and monitoring reports; UKRI risk appetite framework for the ISCF	NAO 2021 report on UKRI management of the ISCF	View of ISCF PMO staff and UKRI/IUK performance monitoring and analysis staff on management processes		
	4. How effectively has the ISCF been managed? How has the ISCF struck a balance between effective quality assurance and minimising delays?	Assessor views; delays; stakeholder views; % of projects on red/amber of RAG rating for all aspects of the project; # of overruns; timescales and delays; views of industry/academic stakeholders			Perceptions of key stakeholders, including award holders, on the effectiveness and appropriateness of Fund management processes		

Sub-category	Evaluation question	Relevant Challenge-level evaluation indicators	Relevant Fund-level data	Other data sources	Fund-level evaluation indicators (largely qualitative)	Primary data collection
Effective and proportionate processes of Fund management	5. To what extent are processes, such as the application processes, monitoring the performance of the Fund and establishing Challenges, appropriate and proportionate?	Success rate; time and cost of application to government and applicants; assessor's views; views on assessors; assessor feedback analysis	Quarterly IUK-administered project monitoring/Research Council monitoring <sup>23</sup> ; performance and monitoring report; quarterly portfolio performance and monitoring reports; UKRI risk appetite framework for the ISCF	NAO 2021 report on UKRI's management of the ISCF	View of ISCF PMO staff and UKRI/IUK performance monitoring and analysis staff on management processes  Perceptions of key stakeholders, including award holders, on the effectiveness and appropriateness of Fund management processes  Case study examples of the role and effectiveness of Fund management  Analysis of time-to-fund data across the portfolio  Perceptions and documentary evidence on the way in which data is used and informs decision-making	Key informant interviews; ISCF stakeholder workshop
	6. How effective was the use of performance monitoring to support management decisions for the ISCF? Specifically, how did performance monitoring facilitate cross-wave learning? What are the lessons learned for similar funds?	Stakeholder views on learnings, monitoring office views, escalating/de-escalating RAG status; evaluator views				

Source: RAND Europe analysis

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<sup>23</sup> While listed here, it is also recognised that research council monitoring of ISCF-funded projects it is not as systematic as IUK project monitoring and may therefore be less useful for our evaluation.

On the funding instruments sub-category, there appears to be a limited range of indicators from only the Smart Sustainable Packaging and Next Generation Services evaluations on both questions. Further to this, while some of the evaluation reports, such as for the Medicines Manufacturing Challenge, mention de-risking, it is not necessarily clear how this will be captured in their evaluation questions and data that we could use. Therefore, for our process evaluation, it will be key to specifically explore with stakeholders the de-risking approaches taken across the ISCF.

In contrast with ‘funding instruments’, the ‘effective and proportionate process of Fund management’ sub-strand is well-covered by indicators from across all evaluation reports for which indicators are currently available. While the associated interviews and surveys done to address these indicators at the Challenge-level will inform our analysis, it will nonetheless be important to engage with stakeholders further, asking higher-level questions around ISCF management and internal protocols.

Regarding Fund-level data, we aim to use quarterly IUK-administered project monitoring data in the process evaluation to collect information on the six monitoring criteria of Cost, Exploitation, Risk, Project Management, Scope and Timing, including the Fund summary of this in the portfolio performance and monitoring reports. To answer questions around the ISCF’s approach to risk, we will examine the risk appetite first set out by UKRI in September 2020 and any subsequent reports.

Finally, the 2021 NAO report on ISCF management provides specific quantitative information on the length of time taken to approve Challenges, as well as stakeholders’ perceptions on those processes.

### 5.2.3. Wider engagement

**The third theme of our process evaluation is wider engagement. The aim of this theme is to understand how the ISCF has engaged with a range of stakeholders, including both academic and industrial partners.** This thematic strand aims to determine how the ISCF has engaged a diversity of stakeholders across all stages, from inception to delivery, and how industrial financial commitments have been made. Evaluation questions, relevant Challenge-level and Fund-level indicators and data sources for this theme are set out in Table 9 below.

**Table 9: Process evaluation framework – wider engagement**

Sub-category	Evaluation question	Relevant Challenge-level evaluation indicator	Relevant Fund-level data	Other data sources	Fund-level evaluation indicators (largely qualitative)	Primary data collection
Wider engagement	1. To what extent, and how, has the ISCF reached business, academia, and broader stakeholders across sectors and across disciplines? What might be the consequences and implications of this?	Industry needs converted to ISCF activities; representation of industry on boards; views of private/public sector stakeholders, number of participating companies by size and type	Quarterly portfolio performance and monitoring reports; ISCF core data; grant partner data (Research Councils only)	NAO 2021 report on UKRI's management of the ISCF	Perceptions of key stakeholders across groups (academia, industry, policy, third sector) on their own and wider engagement in the ISCF, responsiveness of the Fund and consequences/implications of engagement	Key informant interviews; ISCF stakeholder workshop
	2. How responsive was the ISCF to a wide variety of stakeholders in identifying industrial and societal needs for establishing the Challenges?	Views of industry, pharmaceutical, and academic stakeholders, instances of industry needs being converted into ISCF activities, review of ERRC delivery plan and related strategy documents			Perceptions of award holders and Fund management on the role wider stakeholder engagement has played and avenues that were more, or less, effective	
	3. How effectively have wider stakeholder groups been involved in programme and Challenge activities? Which activities have been most effective in engaging different stakeholders?				Case study examples on the nature and role of stakeholder engagement	
					Industry co-investment levels, overall and by Challenge, wave and business type	
					Range and nature of participants in ISCF awards (e.g. by sector, organisation type) <sup>24</sup>	

<sup>24</sup> To the extent permitted by the data, we may also consider the extent to which the ISCF has reached ‘new’ businesses and organisations through its funding distribution.

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Sub-category	Evaluation question	Relevant Challenge-level evaluation indicator	Relevant Fund-level data	Other data sources	Fund-level evaluation indicators (largely qualitative)	Primary data collection
	4. How effective has the ISCF been in obtaining industry commitment and investment?	Number of co-investors; £ private investment; ratio of public to private investment; perceptions of investors, industry stakeholders and policymakers				

Source: RAND Europe analysis

The 'wider engagement' thematic strand has indicators from the Prospering from the Energy Revolution, and Next Generation Services Challenge-level evaluations, largely relating to qualitative stakeholder views, but with some quantitative indicators relating to industry representation also available. While this theme is generally well covered, no Challenge-level indicators are available for our process evaluation question around activities to engage a diverse range of stakeholders. This question is closely related to question 1 of this theme, so to an extent some of the indicators may overlap. However, to target this, we will require dedicated interview questions and desk research.

Regarding question 4 of this theme, the Digital Security by Design report provides a number of specific quantitative indicators, as well some stakeholder perceptions, but it is not covered explicitly by the other Challenge-level process evaluations. To fill this potential gap, we will need to ensure adequate consultation with industry stakeholders in our Fund-level process evaluation.

Much like other evaluation themes, the 2021 NAO report covers relevant stakeholder interview content, as they interviewed several relevant industrial stakeholders, which will inform our analysis. Relevant Fund-level data for this theme relates to co-investment progress, the number of unique participants and SME engagement, which will inform our process evaluation.

#### 5.2.4. Cross-cutting

Across each of the above three thematic strands, there are cross-cutting concerns that are important to consider for all process elements of the ISCF. These concerns cannot necessarily be confined to strategy, delivery or wider engagement, but rather have relevance to the operation and management of the Fund as a whole. These cross-cutting elements are explored by our final 'cross-cutting' process evaluation theme. **The aim of this theme is to explore how the ISCF has promoted diversity and equal opportunities; what unexpected barriers and facilitators of effective processes have there been; and what lessons have been learned regarding processes across the portfolio.** Cross-cutting process evaluation questions are set out in Table 10 below, together with Challenge-level and Fund-level indicators and the data collection sources.

Table 10: Process evaluation framework – cross-cutting

Sub-category	Evaluation question	Relevant Challenge-level evaluation indicators	Relevant Fund-level data	Other data sources	Fund-level evaluation indicators (largely qualitative)	Primary data collection
Diversity and fairness	1. How did the ISCF ensure diversity among participants, especially in regard to gender and ethnicity?		IUK data (EDI survey)	NAO 2021 report on UKRI’s management of the ISCF	Proportion of applicants and proportion of awardees with different diversity characteristics (e.g. gender, ethnicity) <sup>25</sup>	Key informant interviews; ISCF stakeholder workshop
	2. How, if at all, did the ISCF promote equal opportunities?				Diversity (demographic, sector and regional background) of key decision-making groups, including review panels, oversight groups and peer reviewers	
	3. How, if at all, did the ISCF contribute to tackling regional inequalities?		ISCF core data quarterly portfolio performance and monitoring reports, UKRI evidence on place impact of the ISCF		Proportion of applying businesses and proportion of participating businesses that are SME, mid-size businesses, large businesses, etc. <sup>26</sup>	
					Proportion of applicants from different geographic regions	
					Perceptions of SME stakeholders and larger companies on their engagement and access to the ISCF	
					Perceptions of Challenge Directors and other key stakeholders on the extent to which the ISCF is open to different applicant types	

<sup>25</sup> To the extent that the relevant data is available, we will also consider the EDI characteristics of those involved in ISCF projects who were not direct awardees.

<sup>26</sup> To the extent permitted by the data, we may also consider the extent to which the ISCF has targeted ‘new’ businesses versus established companies.

Sub-category	Evaluation question	Relevant Challenge-level evaluation indicators	Relevant Fund-level data	Other data sources	Fund-level evaluation indicators (largely qualitative)	
	4. How balanced was the ISCF in selecting the industry it targets (e.g. achieving the balance between selecting small and micro companies and larger companies)?	Stakeholder and applicant views; % new applicants; size of applicant companies	ISCF core data			
Facilitators and barriers	5. What were the unexpected facilitators or barriers to implementing and delivering the ISCF, if any (e.g. recruitment of Challenge Directors)?	Delivery team perception		NAO 2021 report on UKRI's management of the ISCF	Perceptions of ISCF leadership and management and Challenge Directors on any challenges in implementing the Fund	
Lessons learned	6. Overall, what are the lessons learned from the ISCF's challenge-led approach to funding R&I?				Perceptions of a wide range of stakeholders on the successes and weaknesses of the Fund and lessons learned.	

Source: RAND Europe analysis

In general, the ‘cross-cutting’ thematic strand had very few associated Challenge-level indicators. As highlighted above, there are currently almost no Challenge indicators related to the diversity and fairness aspect of our process evaluation, as only question four had relevant indicators from the Robotics and Artificial Intelligence in Extreme Environments, Prospering from the Energy Revolution and Digital Security by Design. While some Challenge-level reports, such as for Future Flight, allude to monitoring of age, gender, and other protected characteristics, we will need to address this gap, specifically regarding process, with the data sources suggested above. Meanwhile, the ‘facilitators and barriers’ theme only had one associated indicator from the Digital Security by Design evaluation around stakeholder perceptions, and ‘lessons learned’ currently has none. These may emerge from the broader observations and findings of the Challenge-level evaluations but will also need to be addressed at the Fund-level.

The NAO report provides specific quantitative data on regional distribution of ISCF funding, which will be a useful guide for our process evaluation questions on how, and to what extent, the ISCF has contributed to the levelling up agenda. Similarly, the UKRI quarterly portfolio performance report provides information on regional distribution of ISCF funds, as well as breakdown by Challenge. In response to the NAO report, UKRI will also be developing further impact on the place impact of the ISCF, which may also provide data of relevant to our process evaluation.

### 5.3. Impact evaluation framework

In this section, we present the evaluation framework for the impact evaluation of the ISCF. The overarching aims of the impact evaluation are:

- To understand whether the ISCF met its objectives and demonstrates accountability
- To understand the wider impact of the ISCF in terms of knowledge, society and economy and to demonstrate the return to the taxpayer

To fulfil these two high-level aims, the impact evaluation will use a framework that builds upon the themes set out within the ToC. Specifically, the impact framework builds upon the three ToC output/outcome themes (creating knowledge and innovation pathways, capacity and investment, wider engagement) and the two ToC impact themes (societal impact and economic impact), and establishes evaluation questions, indicators and data sources for each. The framework also incorporates the additional evaluation theme of ‘value for money’, with evaluation questions, indicators and data sources also established relevant to this theme. In this way, the impact evaluation framework will consider the ISCF’s impact against the five key ISCF objectives, while also considering the impact of the Fund against the wider outcome and impact categories set out within the ToC.

To inform the development of this framework, we analysed available Challenge-level evaluation frameworks and their indicators.<sup>27</sup> We also reviewed the indicators established under Challenge-level benefits realisation plans where available.<sup>28</sup> In the tables below, we have mapped these Challenge-level indicators to our Fund-level evaluation questions.

In addition to identifying relevant Challenge-level indicators, the impact evaluation framework presented below also identifies Fund-level indicators. As noted above, while the identification of relevant Challenge-level indicators is of particular relevance to the review of Challenge-level evaluation reports conducted in phase 3 of the evaluation, Fund-level indicators will be of more relevance to our broader Fund-level data collection during phase 4. In identifying Fund-level indicators, the tables below also identify wider data sources that we plan to draw upon to inform our impact evaluation. These include relevant UKRI-collated data, wider data sources, and our own primary data collection methods. For the impact evaluation, primary data collection will comprise key informant interviews, workshops, econometric analysis, network analysis and VfM analysis. These primary data collection methods have been planned to focus on those areas where we anticipate gaps in the information from other data sources. While not presented in the tables below, it is also anticipated that case studies, conducted in phase 4 of the evaluation, will provide insights in relation to many of our evaluation themes and questions. Our approach to collecting primary data against the impact evaluation framework, including through case studies, is explained further in Chapter 6 of this report. As also noted above, it is possible that further data sources not highlighted in the tables below may also be incorporated into the evaluation approach. During the baselining phase of the evaluation, we will undertake further scoping of a select number of additional data sources to assess their potential value for the evaluation, building on initial consideration of these sources during the development of this framework.<sup>29</sup>

### 5.3.1. Anticipated strength of evidence

The tables presented below outline the anticipated sources of evidence that will be used to assess the ISCF against the impact evaluation questions. In Annex K to this report, we provide an initial assessment of impact evaluation data gaps in the form of a 'RAG' (red–amber–green) table. For each impact evaluation question, the table provides the evaluation team's initial assessment of the anticipated strength of evidence

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<sup>27</sup> The Challenges for which we reviewed Challenge-level evaluation frameworks are as follows: Medicines Manufacturing, Digital Security by Design, Robotics and Artificial Intelligence in Extreme Environments, Next Generation Services, Faraday Battery, Future Flight, Audience of the Future, Prospering from the Energy Revolution, Creative Industries Clusters Programme and Smart Sustainable Plastic Packaging.

<sup>28</sup> The Challenges for which we reviewed benefits realisation plans are as follows: Smart Sustainable Plastic Packaging; Medicines Manufacturing; Accelerating Detection of Disease, Quantum Technologies, Robotics and Artificial Intelligence in Extreme Environments, Transforming Food Production, Transforming Construction, Next Generation Services, Prospering from the Energy Revolution, Healthy Ageing, Data to Early Diagnosis, Transforming Foundation Industries, Industrial Decarbonisation, Future Flight, Audience of the Future and Low Cost Nuclear.

<sup>29</sup> The databases to be considered during this scoping are Lens and/or Orbis data (to inform patent analysis) and Beauhurst and/or Crunchbase data (to inform analysis of investment in ISCF supported companies). The identification of Lens, Orbis, Beauhurst and Crunchbase as the focus of further scoping follows initial consideration of additional databases by the study team during the evaluation framework design. The sources considered and the key determinations made in this respect are summarised in Annex L.

from both the Challenge-level evaluations (phase 3) and the primary data collection/review of wider data sources (phase 4), with comments on anticipated data gaps where appropriate. In some cases, the table in Annex K also outlines potential additional actions that might be taken to address data gaps, pending further discussion between the evaluation team and UKRI.

### 5.3.2. Creating knowledge and innovation pathways

**In this theme, the evaluation will seek to understand to what extent the ISCF has advanced knowledge creation, innovation development and adoption both in the UK and internationally.** This topic will be explored through investigating both the characteristics and effects of different types of outputs of the Fund, which include publications, datasets, technologies and new business models, among others. Effects studied comprise the following areas: degree of stakeholder awareness and understanding of outputs, whether these outputs have been adopted or implemented in society including contributions to evidence-based policymaking, and how ISCF outputs have contributed to knowledge regarding the effectiveness of mission-oriented R&I programmes.

As highlighted by the table below, most evaluation questions under this theme will be able to draw upon relevant Challenge-level indicators, with good coverage across the Challenges in most cases. Evaluation questions 1, 2 and 3 of this theme will be answered predominantly through quantitative data from the Challenge-level, possibly combined with Fund-level data from PCFs and Researchfish. For all other questions, a combination of qualitative and quantitative data is anticipated. This will include both quantitative and qualitative data collected by the Challenge-level evaluations, quantitative Fund-level data (for questions 4 and 6), as well as qualitative data collected by our primary data collection in phase 4 of the evaluation. In terms of our own data collection, key informant interviews will aim to gather more data on the following topics relating to this theme: evidence of increased stakeholder Awareness; evidence of outputs being adopted; evidence of informing policymaking; and evidence of the ISCF's contribution to knowledge regarding mission-oriented R&I programmes.

Table 11: Impact evaluation framework – creating knowledge and innovation pathways

Evaluation question	Relevant Challenge-level evaluation indicators	Challenges with relevant evaluation indicators	Relevant Fund-level data	Other data sources	Fund-level evaluation indicators (qualitative and quantitative)	Primary data collection
1. What has been the contribution of the ISCF to new knowledge addressing the Challenges, both within the UK and internationally (publications)?	# of articles, papers, reports, blog posts, guidance documents, think pieces published (+ in peer-reviewed papers, that are internationally recognised, that are highly cited, jointly published by industry and academia, that demonstrate X) # of new technologies or processes being developed, collected through publications # Stakeholders' opinions on whether publications are accessible, valuable	CICP, D2ED, DSD, FBC, IDC, AoTF, NGS, Quantum, RAI, SSPP, TFI	Researchfish data; PCF data		Number of publications and coverage across Challenges	
2. What has been the contribution of the ISCF to new knowledge addressing the Challenges, both within the UK and internationally (other)? (Datasets, services, business models, outputs)	# (and %, nature, quality) of outputs (that do X) Degree to which outputs address their priorities	CICP, FFC, D2ED, DSD, FBC, SSPP, IDC, MM, AoTF, TFI, TFP, NGS, PFER, RAI	Researchfish data; PCF data		Evidence of other (non-publication) outputs by type (e.g. software, datasets, tools) and by challenge <sup>30</sup>	

<sup>30</sup> Indicator refers broadly to 'evidence of', given the possibility that Researchfish and PCFs may not produce reliable data on specific number of outputs but will likely produce useful evidence to support the evaluation. The specific evidence presented for this indicator will be refined in phase 4 of the evaluation based on data completeness, quality and availability.

Evaluation question	Relevant Challenge-level evaluation indicators	Challenges with relevant evaluation indicators	Relevant Fund-level data	Other data sources	Fund-level evaluation indicators (qualitative and quantitative)	Primary data collection
1. To what extent has the ISCF advanced the readiness of new technologies, products and processes?	<p># of patents, joint academia-industry patents, IP agreements, licensing agreements; increased share of relevant patents; # of organisations stating that they have developed new and/or exploitable IP</p> <p>Technology readiness levels (TRLs)/Market readiness levels (MRLs) levels associated with projects; value of higher TRL projects; comparison of TRL levels before and after investment</p>	DSD, FBC, PFER, FFC, AoTF, Quantum, RAI, SSPP, MM, NGS, TFI, TFP	Researchfish data <sup>31</sup> ; PCF data		<p>Evidence of patent licensing agreements and coverage across Challenges<sup>32</sup></p> <p>Evidence of movement across TRLs/Commerical readiness levels (CRLs)</p> <p>Evidence on other measures of IP (e.g. trademark, registered design, copyright) and coverage across Challenges<sup>33</sup></p>	

<sup>31</sup> There are some known quality issues with respect to patent data captured in Researchfish (for example, missing/invalid patent IDs).

<sup>32</sup> Indicator refers broadly to ‘evidence of’, given the possibility that Researchfish and PCFs may not produce reliable data on specific number of outputs but will likely produce useful evidence to support the evaluation. The specific evidence presented for this indicator will be refined in phase 4 of the evaluation based on data completeness, quality and availability.

<sup>33</sup> Indicator refers broadly to ‘evidence of’, given the possibility that Researchfish and PCFs may not produce reliable data on specific number of outputs but will likely produce useful evidence to support the evaluation. The specific evidence presented for this indicator will be refined in phase 4 of the evaluation based on data completeness, quality and availability.

Evaluation question	Relevant Challenge-level evaluation indicators	Challenges with relevant evaluation indicators	Relevant Fund-level data	Other data sources	Fund-level evaluation indicators (qualitative and quantitative)	Primary data collection
4. To what extent has the ISCF leveraged knowledge and insights to create increased awareness and understanding among key stakeholders of new technologies and outputs addressing the Challenges?	<p>Evidence of increased awareness/understanding/interest/change in attitude/recognition, etc. among businesses, researchers and stakeholders (sometimes expressed as %)</p> <p># of events to increase awareness</p> <p>Evidence of or # of outputs being cited or subscribed to</p>	AoTF, CICP, DSD, FBC, MM, NGS, PFER, RAI, TFP	Researchfish data; PCF data; Knowledge Transfer Network (KTN) data		<p>Examples of engagement activities that have led to increased awareness and understanding (of stakeholders)</p> <p>Stakeholder perceptions on the awareness and understanding of key stakeholders and the influence of ISCF-funded activities</p>	Key informant interviews
5. To what extent have ISCF outputs (technologies, products, processes, services, approaches, etc.) been implemented/adopted within society?	<p>Evidence of or # of outputs being used/implemented/adopted</p> <p>Stakeholder opinion on whether output has been used</p>	CICP, D2ED, DSD, FBC, FFC, IDC, AoTF, MM, NGS, PFER, Quantum, RAI, SSPP, TFI	Researchfish data; PCF data		<p>Evidence on number and nature of examples of adoption reported (on aggregate and by Challenge)</p> <p>Examples of implementation and adoption of outputs in context</p> <p>Stakeholder perceptions on the extent of adoption and role of the ISCF</p>	Key informant interviews

Evaluation question	Relevant Challenge-level evaluation indicators	Challenges with relevant evaluation indicators	Relevant Fund-level data	Other data sources	Fund-level evaluation indicators (qualitative and quantitative)	Primary data collection
6. To what extent has the ISCF contributed to evidence-based policymaking surrounding the Challenges?	<p>Evidence of informing/changing policy; policy recognising importance of sector (whether on national, regional or local level)</p> <p>Regulations and standards</p> <p>Policymaker opinion on accessibility or impact of outputs</p> <p># of citations in government publications</p>	DSD, FBC, FFC, IDC, AoTF, PFER, SSPP, TFI	Researchfish data; PCF data		<p>Examples of engagements with policy stakeholders that have contributed to evidence-based policymaking</p> <p>Perceptions of policy stakeholders (and others) on the extent and nature of the contribution of the ISCF to evidence-based policymaking</p>	Key informant interviews
7. To what extent has the ISCF enhanced understanding of the effectiveness of mission-oriented R&I programmes and informed more effective policymaking for mission-oriented goals?					<p>Perceptions of key stakeholders on the nature and extent of the learning from the ISCF on mission-oriented R&amp;I</p> <p>Examples of the influence of ISCF on wider mission-oriented R&amp;I activities identified by key stakeholders</p>	Key informant interviews

Source: RAND Europe analysis

### 5.3.3. Capacity and investment

This theme will examine the extent to which the ISCF has contributed to increased investment opportunities and increased capability and capacity development for UK R&D. The theme will also explore the extent to which these opportunities have resulted in new business and job creation, as well in advancements to equality, diversity, and inclusion (EDI). The first five evaluation questions specifically investigate the investment in R&D from UK businesses or overseas investors that contribute towards the 2.4 per cent R&D investment target or new avenues of investment and determine where investments have taken place. The remaining questions focus on the effects of the ISCF on the capabilities and capacities of researchers and innovators, the physical infrastructure available to support R&D investment, the influx of overseas talent into the UK, the amount of new business, and progress towards EDI goals.

As with the previous theme, in most cases, evaluation questions under this theme will be able to draw upon relevant Challenge-level indicators. At the same time, the coverage of these indicators across Challenges is varied. Evaluations questions 1 and 3 relating to R&D investment will primarily be answered through quantitative data, and with broad coverage across the Challenges. Here, Fund-level data sources will also provide relevant insights. While evaluation questions 2 and 4 regarding overseas investment and de-risking will draw upon quantitative data at the Challenge-level, to answer this question, we will likely draw more from qualitative assessments, both from the Challenge-level evaluations and from our own phase 4 key informant interviews. Questions 6 and 7 regarding capabilities, capacities and infrastructure will draw upon both quantitative and qualitative data at the Challenge-level, together with Fund-level data where appropriate and, in the case of question 7, key informant interviews. Meanwhile, questions 5 and 9 will be answered primarily using Fund-level data, supplemented by key informant interviews. To answer question 8, in addition to relevant Challenge-level indicators, we will also look to gain insights from key informant interviews and by reviewing ONS data to obtain a broader picture of the UK academic researcher landscape. To answer question 10 regarding business and job creation we will use a combination of Challenge-level data, Fund-level data and, potentially, our own econometric analysis. To explore the extent to which jobs created have been high-skilled jobs, key informant interviews may also be used.

**Table 12: Impact evaluation framework – capacity and investment**

Evaluation question	Relevant Challenge-level evaluation indicators	Challenges with relevant indicators	Relevant Fund-level data	Other data sources	Fund-level evaluation indicators (qualitative and quantitative)	Primary data collection
1. To what extent has the ISCF increased UK businesses' investment in R&D?	<p>£ industry/outside of ISCF investment; # and value of grants</p> <p>Ration of government funding to private sector investment</p> <p>Investor confidence in sector (regarding ease of securing investment)</p> <p>% of applicants stating that programme made solutions more ready for private sector investment</p> <p>Research to commercialisation indicators</p>	AoTF, CICP, DSD, FBC, RAI, FFC, IDC, MM, SSPP, NGS, PFER, Quantum, TFI, TFP	ISCF core data; grant partner data (Research Councils only)		Amount of business investment in R&D generated (on aggregate, by sector <sup>34</sup> and by Challenge) <sup>35</sup>	
2. To what extent has ISCF increased overseas investment in R&D in the UK?	<p>£ industry/outside of ISCF investment (if overseas; overseas investment; # and value of grants (if overseas)</p> <p>Ration of government funding to private sector investment (if overseas)</p> <p>Investor (if overseas) confidence in sector (regarding ease of securing investment)</p>				Stakeholder perceptions on the extent to which the ISCF has increased overseas investment in UK R&D	Key informant interviews

<sup>34</sup> Analysis of sector will likely rely on SIC code data, which may not reflect emergence of new sectors and may not align with the wider ISCF approach to defining sectors for the Challenges.

<sup>35</sup> This analysis will consider not just co-investment in the award but also from additional aligned and accompanying investments leveraged.

Evaluation question	Relevant Challenge-level evaluation indicators	Challenges with relevant evaluation indicators	Relevant Fund-level data	Other data sources	Fund-level evaluation indicators (qualitative and quantitative)	Primary data collection
	% of applicants stating that programme made solutions more ready for private sector investment (if overseas investment)  Research to commercialisation indicators					
3. How much additional public and private R&D investment has the ISCF contributed towards the R&D target of 2.4% of GDP by 2027?	£ industry/overseas/outside of ISCF investment; # and value of grants Ration of government funding to private sector investment Investor confidence in sector (regarding ease of securing investment) % of applicants stating that the programme made solutions more ready for private sector investment Research to commercialisation indicators	AoTF, CICP, DSD, FBC, RAI, FFC, IDC, MM, SSPP, NGS, PFER, Quantum, TFI, TFP	ISCF core data		Overall amount of investment in R&D generated (and measured against the 2.4% target) <sup>36</sup>	
4. To what extent has research supported by the ISCF opened up new avenues of investment (de-risking)?	£ industry/overseas/outside of ISCF investment; # and value of grants Ratio of government funding to private sector investment Investor confidence in sector (regarding ease of securing investment) % of applicants stating that the programme made solutions more ready for private sector investment Research to commercialisation indicators		Researchfish data; PCF data		Evidence on the amount and source of investments in R&D resulting from participation in ISCF projects <sup>37</sup>  Examples of ISCF research that has opened up new avenues of investment Stakeholder perceptions on the extent to which ISCF challenges have contributed to de-risking.	Key informant interviews

<sup>36</sup> While we can measure the amount of investment enabled through the ISCF and compare it to the 2.4% target, it will not be possible to know how much of this investment is ‘additional’. For example, private investment enabled through the ISCF may instead displace funding that would have happened in any case.

<sup>37</sup> Indicator refers broadly to ‘evidence of’, given the possibility that Researchfish and PCFs may not produce reliable data on specific number of outputs but will likely produce useful evidence to support the evaluation. The specific evidence presented for this indicator will be refined in phase 4 of the evaluation based on data completeness, quality and availability.

Evaluation question	Relevant Challenge-level evaluation indicators	Challenges with relevant evaluation indicators	Relevant Fund-level data	Other data sources	Fund-level evaluation indicators (qualitative and quantitative)	Primary data collection
5. While the ISCF is place-agnostic, to what extent have the Fund's investments and activities been widely distributed across the UK?			ISCF core data		Geographic spread of ISCF investment and activities (location of participants)  Stakeholder perception regarding extent to which ISCF investment and activities have been widely spread	Key informant interviews
6. How and to what extent has the ISCF increased individual capabilities and capacities both in research and innovation?	# of staff trained, apprenticeships, courses developed # of qualifications obtained Increase in knowledge, skills, absorptive capacity Opinion on whether new skills enabled innovation	AoTF, CICP, DSD, FFC, IDC, MM, NGS, PFER, RAI, SSPP, TFI, TFP	Researchfish data; PCF data <sup>38</sup>		Evidence of individuals receiving training/skills development through the ISCF (on aggregate and by Challenge)  Examples of individual capability/capacity development	
7. How and to what extent has the ISCF contributed to improved infrastructure to support future R&I investment?	Varied depending on interpretation of 'infrastructure': e.g.: - Programme resulting in policymakers' recognising importance of X - Strengthening of trade links - User assessments of value added - Contribution to city's economic development strategies - Research findings used to inform design of business models - Physical infrastructure, e.g. space, buildings	AoTF, CICP, MM, SSPP	Researchfish data; PCF data		Number of infrastructure projects/amount awarded <sup>39</sup>  Examples of ISCF-supported infrastructure that support future R&I  Stakeholder perceptions regarding the extent to which the ISCF has contributed to establishment of infrastructure that supports future R&I investment	Key informant interviews

<sup>38</sup> Data on number of individuals trained may also be obtained through ad-hoc data requests from the Challenges.

<sup>39</sup> Measurement of this indicator will depend upon identifying specific infrastructure projects that are in scope of the analysis. It is expected that such data will be able to be acquired through engagement with Challenge-level personnel.

Evaluation question	Relevant Challenge-level evaluation indicators	Challenges with relevant indicators	Relevant Fund-level data	Other data sources	Fund-level evaluation indicators (qualitative and quantitative)	Primary data collection
8. To what extent has the ISCF attracted additional talent and Challenge-associated skills into the UK?	# of people attracted to UK Stakeholder opinion on whether people are attracted to UK Degree to which clusters are attracting people with relevant skills	CICP, FBC, TFP		ONS data (on academics in UK, e.g. what country they came from, by sector, % EU nationals, qualification level, measure of skill)	Stakeholder perception regarding the extent to which the ISCF has attracted additional talent and skills  Number of non-UK academics working in the challenge areas, before the ISCF and after	Key informant interviews

Evaluation question	Relevant Challenge-level evaluation indicators	Challenges with relevant indicators	Relevant Fund-level data	Other data sources	Fund-level evaluation indicators (qualitative and quantitative)	Primary data collection
<p>9. How has the ISCF contributed to EDI?</p>	<p>Diversity of workforce, HR practices, industry attendees</p> <p>Research conducted on diversity</p> <p>Government policy supporting diversity</p> <p>Evidence of businesses adopting socially responsible practices</p> <p>Stakeholder opinion on whether outputs address diversity</p>	<p>CICP, FFC</p>	<p>IUK data (EDI survey)</p> <p>EDI policy documentation and guidance</p>		<p>Diversity characteristics of ISCF advisory and programme boards and Challenge teams</p> <p>Diversity characteristics of ISCF applicants, lead investigators and project partners, and application assessors (on aggregate and by Challenge)</p> <p>Extent to which ISCF communications and engagement support EDI</p> <p>Stakeholder perceptions of whether ISCF processes and impacts have contributed to EDI</p>	<p>Key informant interviews</p>

Evaluation question	Relevant Challenge-level evaluation indicators	Challenges with relevant indicators	Relevant Fund-level data	Other data sources	Fund-level evaluation indicators (qualitative and quantitative)	Primary data collection
10. To what extent has the ISCF contributed to the creation and retention of new businesses and high-skilled jobs?	<p># of new businesses created</p> <p>Valuation/market share/financial returns/commercial revenue of new businesses</p> <p>Existence of sustainable demand for solutions of businesses</p> <p>Productivity/wages/turnover data</p> <p>Change in employment/# of new jobs created (will be likely difficult to determine which of these are high-skilled)</p>	AoTF, CICP, D2ED, Quantum, DSD, FBC, FFC, RAI, HA, IDC, MM, TFP, NGS, PFER	Researchfish data; PCF data		<p>Number of new businesses created (on aggregate, by sector<sup>40</sup>and by Challenge)</p> <p>Extent to which ISCF support is associated with business performance and survival</p> <p>Number of jobs retained and created (on aggregate and by Challenge)</p> <p>Stakeholder perceptions regarding the extent to which jobs created have been high-skilled jobs</p>	<p>Econometric analysis can explore extent to which ISCF support is associated with business survival, and increases in productivity (measured as turnover per worker), employment and turnover</p> <p>Key informant interviews</p>

Source: RAND Europe analysis

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<sup>40</sup> Analysis of sector will likely rely on SIC code data, which may not reflect emergence of new sectors and may not align with the wider ISCF approach to defining sectors for the Challenges.

#### 5.3.4. Connected innovation ecosystem

**This theme will examine the extent to which the ISCF has contributed to the creation of a collaborative and connected, multi-stakeholder ecosystem for fostering innovation focused on addressing societal and industrial challenges.** The evaluation questions focus on whether the Fund increased collaboration among businesses, as well as between businesses and academics, resulting in multidisciplinary and interdisciplinary research that improved UK and international recognition of the ISCF Challenges.

In all cases, evaluation questions under this theme will be able to draw upon relevant Challenge-level indicators, with good coverage across the Challenges. For all evaluation questions, we will also be able to draw upon relevant data collected at the Fund-level, as well as insights from our own original network analysis. While data collected for this evaluation theme will be primarily quantitative, in some cases Challenge-level evaluations will also be collecting qualitative data. This will be supplemented by our own primary qualitative data collected through key informant interviews. In particular, key informant interviews will explore questions 2, 3 and 4 covering the role of the ISCF on business-academic engagement, collaboration between businesses and the reputation of the relevant institutions and clusters.

**Table 13: Impact evaluation framework – connected innovation ecosystem**

Evaluation question	Relevant Challenge-level evaluation indicators	Challenges with relevant indicators	Relevant Fund-level data	Other data sources	Fund-level evaluation indicators (qualitative and quantitative)	Primary data collection
1. To what extent has the ISCF increased multi- and interdisciplinary (MIDRI) research around the Challenge areas?	<p># of cross sector/discipline projects</p> <p>Multidisciplinary composition of teams</p> <p>Level of collaboration among different disciplines</p> <p>Publishing of papers on multidisciplinary research areas</p>	CICP, DSD, FBC, RAI, TFI	ISCF core data; grant classifications (Research Councils only)		Number of cross—disciplinary projects (on aggregate and by Challenge) and extent of cross-disciplinarity <sup>41</sup>	

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<sup>41</sup> We are aware that internal analysis of MIDRI is based on ‘classification areas’ which list research topics associated with each grant by counting awards associated with two or more disciplines. We propose, assuming these data can be made available to us, to conduct a more nuanced analysis on the nature and extent of MIDRI. This would involve mapping the classification areas against existing typologies of research fields (e.g. the Australian and New Zealand Standard Research Classification Field of Research codes) that provide classification at different levels and thus measures of ‘proximity’ of fields. This will allow us to look at the extent of MIDRI in each award in terms of the intellectual distance between fields as well as whether it is present, and also explore the types and numbers of disciplines collaborating.

Evaluation question	Relevant Challenge-level evaluation indicators	Challenges with relevant indicators	Relevant Fund-level data	Other data sources	Fund-level evaluation indicators (qualitative and quantitative)	Primary data collection
<p>2. To what extent has the ISCF increased business-academic engagement on innovation activities relating to the Challenge areas?</p>	<p># of joint publications/patents/projects/collaborations across academia &amp; industry</p> <p>% of programmes that led to greater business/academia engagement</p> <p>Mix of partner types engaged in programme (if focused on business/industry and academia)</p>	<p>DSD, IDC, MM, NGS, RAI, TFP, CICIP, FBC, AoTF, SSPP, TFI</p>	<p>ISCF core data; grant partners (Research Councils only);</p>		<p>Number of businesses engaged in ISCF projects (on aggregate, by sector, by business size and by Challenge)</p> <p>Centrality and connectivity metrics for networks of organisations supported by Challenges</p> <p>Perceptions of stakeholders regarding the extent to which these networks are productive and sustained beyond the life of ISCF awards</p>	<p>Network analysis</p> <p>Key informant interviews</p>
<p>3. To what extent has ISCF increased collaboration between businesses, including between younger, smaller companies and larger, more established companies up the value chain?</p>	<p>#/comparison over time of new collaborations, partnerships, projects, secondments</p> <p># of collaborations between two or more parts of value chain/organisations that had not previously worked together/large companies and SMEs or micro businesses</p> <p>% that agree that project led to new collaborations (if between smaller and larger companies)</p> <p>Mix of company types</p>	<p>CICIP, DSD, FFC, IDC, AoTF, MM, NGS, Quantum, RAI, SSPP, TFI, TFP</p>	<p>ISCF core data; grant partners (Research Councils only)</p>		<p>Number of collaborations between businesses (on aggregate and by Challenge)</p> <p>Number of collaborations between larger and smaller companies (on aggregate and by Challenge)</p> <p>Centrality and connectivity metrics for networks of organisations supported by Challenges</p> <p>Perceptions of stakeholders regarding the extent to which these networks are productive and sustained beyond the life of ISCF awards</p>	<p>Network analysis</p> <p>Key informant interviews</p>

Evaluation question	Relevant Challenge-level evaluation indicators	Challenges with relevant evaluation indicators	Relevant Fund-level data	Other data sources	Fund-level evaluation indicators (qualitative and quantitative)	Primary data collection
4. To what extent have institutions and clusters participating in the ISCF Challenges been recognised for their expertise within the UK and internationally?	<p># of awards received</p> <p>Stakeholder opinion on role of programme on increasing reputation</p> <p># of mentions in (international) press of programme</p> <p>Evidence of global leadership</p> <p>Rank position on global tables</p>	AoTF, CICIP, D2ED, MM, RAI, TFI	Researchfish data; PCF data		<p>Evidence of awards and recognition received (on aggregate and by Challenge)<sup>42</sup></p> <p>Stakeholder perception on the extent to which participating institution and cluster expertise has been recognised</p>	Key informant interviews

Source: RAND Europe analysis

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<sup>42</sup> Indicator refers broadly to ‘evidence of’, given the possibility that Researchfish and PCF forms may not produce reliable data on specific number of outputs but will likely produce useful evidence to support the evaluation. The specific evidence presented for this indicator will be refined in phase 4 of the evaluation based on data completeness, quality and availability.

### 5.3.5. Societal impact

The ToC identifies two broad impact themes: societal impact and economic impact. Compared to the outputs and outcomes envisioned in relation to the three themes described above, the impacts envisioned under these two themes are both broader and more long-term in nature. As noted in Chapter 3, these are also impacts to which many actors beyond the ISCF, both domestic and international, will also be contributing. As such, the extent to which the ISCF has actually contributed will need to be carefully considered by this evaluation.

Societal impact constitutes the first of our two impact themes. **This theme will examine the extent to which the ISCF has contributed impacts to health and wellbeing, the environment and sustainability, and infrastructure and services. Under this impact theme, we will also consider the extent to which the ISCF has contributed to wider impacts including unexpected and unintended consequences.**

In the table below, we identify Challenge-level indicators that we may draw upon to gain insights in relation to these evaluation questions. We also identify those Challenges which, while not presenting relevant indicators at this stage, may also produce impacts (and indicators measuring those impacts) during the course of our evaluation. While the table highlights a wide range of potentially relevant Challenge-level indicators, it is anticipated that our approach to examining societal impact will also draw heavily on more qualitative assessments, informed by our own primary data collection. As described in Chapter 6, the principal way in which we collect data on societal impact is through stakeholder impact workshops conducted in phase 4 of the evaluation. While not presented in the tables below, it is also anticipated that case studies, also conducted in phase 4, will provide a particularly important data source in relation to the societal impact them. In answering the evaluation questions under this theme, we will also draw upon wider data sources in the form of the metrics used by the Industrial Strategy Council (ISC) to track societal progress against the Grand Challenges (as these relate to the areas covered by our evaluation questions).<sup>43</sup> Notably, the ISC metrics will also be used to inform our baseline measurement of the ISCF, as explained further in Chapter 6.

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<sup>43</sup> While the ISC itself is to be wound down, the ISC metrics draw on external data sources which could potentially be used throughout the timeframe of this evaluation.

**Table 14: Impact evaluation framework – societal impact**

Evaluation question	Relevant Challenge-level evaluation indicators	Challenges with relevant evaluation indicators	Other Challenges expected to produce relevant impacts	Other data sources	Fund-level evaluation indicators (qualitative)	Primary data collection
<p>1. To what extent has the ISCF contributed to health and wellbeing benefits, including quality of life, life expectancy, reduced health inequalities and reduced healthcare costs?</p>	<p>QALYs gained by patients</p> <p>Reduction in returns to A&amp;E/GP</p> <p># of therapies that are reimbursed</p> <p># of NHS hospitals capable of administering advanced therapy medical products (ATMPs)</p> <p># of innovative therapies</p> <p># of patients receiving treatment through the advanced therapy treatment centre (ATTC) supply chain network</p> <p>Time from initial presentation to definitive diagnosis</p> <p># of products adopted into NHS</p> <p>Reduction in returns to A&amp;E/GP</p> <p>Time taken to complete clinical trials; number of patients taking part</p> <p># of therapies and diagnostic tools</p> <p>Social, health and safety benefits from new aviation services</p>	<p>MM, D2ED, FFC</p>	<p>ADD, HA</p>	<p>ISC metrics<sup>44</sup> for the Ageing Society Grand Challenge, especially:</p> <p>Indicator 7.1.1 – Healthy life expectancy</p> <p>Indicator 7.1.2 – Disability free life expectancy</p>	<p>Stakeholder perceptions regarding health and wellbeing benefits delivered and supported by the ISCF</p> <p>Perceptions and evidence from stakeholders on the extent to which the health and wellbeing focused Challenges are on track to achieve their mission</p> <p>Perceptions of stakeholders on the extent to which the enabling environment (knowledge, capacity and networks) produced by the ISCF supports the delivery of health and wellbeing impacts</p> <p>Examples of impact of the ISCF on health and wellbeing</p>	<p>Stakeholder impact workshops</p>

<sup>44</sup> While the ISC itself is to be wound down, the ISC metrics draw on external data sources which could potentially be used throughout the timeframe of this evaluation.

Evaluation question	Relevant Challenge-level evaluation indicators	Challenges with relevant evaluation indicators	Other Challenges expected to produce relevant impacts	Other data sources	Fund-level evaluation indicators (qualitative)	Primary data collection
<p>2. To what extent has the ISCF contributed environmental and sustainability benefits, including contribution to reduced emissions, progress towards net zero, and growth of the circular economy?</p>	<p>Market share of packaging that is recyclable/reusable/compostable</p> <p>Evidence of the Challenge contributing to a step change towards a more sustainable value chain</p> <p>Increased number of integrated smart local energy systems (SLES) operational/# of end-users using SLES services/products</p> <p>Changes in behavioural attitudes towards energy usage</p> <p>UK % of renewables</p> <p>UK carbon emissions/reduced carbon emissions v BAU</p> <p>Air transport emissions</p> <p>Change in MWh generated through renewables across UK</p> <p>Technologies employed to service clean energy or decommission existing infrastructure</p> <p>Value of buildings contracted or specified using active energy technology</p>	<p>SSPP, PFER, FFC, FBC, RAI, TCC, IDC, CICP</p>	<p>MMS, TFP, TFI, MMS, TC, LCN</p>	<p>ISC metrics<sup>45</sup> for the Clean Growth Grand Challenge, especially:</p> <p>Indicator 8.1.1 – Emissions intensity ratio</p> <p>Indicator 8.2.1 – Low carbon and renewable energy economy – turnover</p> <p>Indicator 8.2.2 – Low carbon and renewable energy economy – employment</p> <p>Indicator 8.2.3 – Low carbon and renewable energy economy – exports</p> <p>Indicator 8.3.1 – R&amp;D budget on low-carbon technologies</p>	<p>Stakeholder perceptions regarding environmental and sustainability benefits delivered and supported by the ISCF</p> <p>Perceptions of stakeholders on the extent to which the enabling environment (knowledge, capacity and networks) produced by the ISCF supports the delivery of environmental and sustainability impacts</p> <p>Perceptions and evidence from stakeholders on the extent to which the environmental and sustainability focused Challenges are on track to achieve their mission</p>	<p>Stakeholder impact workshops</p>

<sup>45</sup> While the ISC itself is to be wound down, the ISC metrics draw on external data sources which could potentially be used throughout the timeframe of this evaluation.

Evaluation question	Relevant Challenge-level evaluation indicators	Challenges with relevant evaluation indicators	Other Challenges expected to produce relevant impacts	Other data sources	Fund-level evaluation indicators (qualitative)	Primary data collection
	Stakeholder and documentary evidence that the Challenge's aims and outcomes contribute to wider sustainable city region growth strategies					

Evaluation question	Relevant Challenge-level evaluation indicators	Challenges with relevant evaluation indicators	Other Challenges expected to produce relevant impacts	Other data sources	Fund-level evaluation indicators (qualitative)	Primary data collection
<p>3. To what extent has the ISCF contributed benefits to infrastructure and services including broadened access, increased resilience, and increased safety?</p>	<p><b>Infrastructure:</b>                      Evidence of research findings being used to inform the design of infrastructure                      User assessments of the value added by infrastructure/asset investments                      Installation or planned installation of ground infrastructure                      Capital investment for construction and equipment (£)                      Travel time savings or new multimodal commuter routes (FFC)</p> <p><b>Increased safe access to services:</b>                      Examples of solutions that have helped speed up processes for the consumer (incl. estimates of time saved, monetised when possible)                      Proxy: Y products/services/processes commercialised that increase access of the service to the taxpayer                      x products/services commercialised offering new, more tailor services                      Social, health and safety benefits from new aviation services</p>	<p>SSPP, CICP, PFER, AoTF, FFC, RAI, MM, NGS, DSD</p>	<p>SDV, DER</p>	<p>ISC metrics<sup>46</sup> for the Artificial Intelligence and Data and Future of Mobility Grand Challenges, especially:</p> <p>Indicator 6.1.1 — Public attitudes towards AI</p> <p>Indicator 6.2.1 — Public sector adoption readiness</p> <p>Indicator 6.3.1 — Prevalence of open data</p> <p>Indicator 9.1.1 — Registrations of electric vehicles</p>	<p>Stakeholder perceptions regarding infrastructure and services benefits delivered and supported by the ISCF</p> <p>Perceptions of stakeholders on the extent to which the enabling environment (knowledge, capacity and networks) produced by the ISCF supports the delivery of infrastructure and services impacts</p> <p>Perceptions and evidence from stakeholders on the extent to which the</p>	<p>Stakeholder impact workshops</p>

<sup>46</sup> While the ISC itself is to be wound down, the ISC metrics draw on external data sources which could potentially be used throughout the timeframe of this evaluation.

Evaluation question	Relevant Challenge-level evaluation indicators	Challenges with relevant evaluation indicators	Other challenges expected to produce relevant impacts	Other data sources	Fund-level evaluation indicators (qualitative)	Primary data collection
	<p>Perceived contributions in instigating technological, industrial and societal changes with respect to cybersecurity products/service design and awareness Reduction in number of successful cyber-attacks</p> <p><b>Reduced fuel poverty:</b> Cost reduction at system level (cost of energy in kWh, modelled effects by ERIS) Bills reduced 10–25% vs BAU (end user bills) Reduction in end-user costs (£/kWh) (modelled by ERIS as £ per kWh and energy systems infrastructure costs) Attributable weighted-average bill saving £ per relevant end user/yr x no. of relevant end users x no. of attributable years Fuel poverty estimate – baseline (correct for attributable to PFER &amp; in relevant local areas) 25% reduction vs BAU in spend on local energy infrastructure upgrades</p> <p><b>Increased resilience:</b> UK % of domestic energy provision vs imports (resilience)</p> <p><b>Broadened access to culture and creativity:</b> Number and % of organisations reporting new creative immersive product Number and % of organisations reporting improved content, product or service Audience numbers that experience the new immersive content (created as part of the programme) in location Number of enterprises and organisations exporting creative immersive content</p>			<p>Indicator 9.1.2 – Public perception towards transport technologies</p> <p>Indicator 9.2.1 – Domestic and international road freight activity</p>	<p>infrastructure and services focused Challenges are on track to achieve their mission</p> <p>Examples of impact of the ISCF on infrastructure and services</p>	

Evaluation question	Relevant Challenge-level evaluation indicators	Challenges with relevant evaluation indicators	Other challenges expected to produce relevant impacts	Other data sources	Fund-level evaluation indicators (qualitative)	Primary data collection
	<p>Examples of creative immersive content/solutions developed as part of the programme applied to other industries.</p> <p><b>Increased safety:</b>                      Examples of RAI solutions developed under the programme that led to safer nuclear decommissioning and maintenance (and associated economic value)                      The number of full time equivalents (FTE) removed from contact with hazardous environments by the implementation of ISCF RAI-funded project outputs                      The number of FTE removed from contact with nuclear hazardous environments by the implementation of ISCF RAI-funded project outputs/accident rate                      Examples of solutions developed under the programme that led to reduced human exposure to hazardous environments.</p>					

Evaluation question	Relevant Challenge-level evaluation indicators	Challenges with relevant evaluation indicators	Other Challenges expected to produce relevant impacts	Other data sources	Fund-level evaluation indicators (qualitative)	Primary data collection
4. To what extent has the ISCF contributed wider societal benefits, including unexpected and unintended consequences?	<b>Space exploration:</b> Examples of solutions developed under the programme that led to further exploration in space (RAI)	RAI	All Challenges		Stakeholder perceptions on wider benefits delivered by the ISCF, including unexpected/unanticipated impacts  Examples of wider impacts of the ISCF, including unexpected/unanticipated impacts	Stakeholder impact workshops

Source: RAND Europe analysis

### 5.3.6. Economic impact

Our second impact theme is economic impact. **This theme will examine the extent to which the ISCF has contributed to the growth of UK businesses and expansion into new markets and sectors, the contribution of the ISCF to gross value add (GVA), the extent to which the economic benefits of the ISCF have been distributed across the UK, and the extent to which the ISCF has contributed to increased productivity.**

Here again, our evaluation may potentially draw upon a number of Challenge-level indicators, with generally strong coverage of these indicators across different Challenges. Moreover, to answer evaluation questions 1, 2 and 4 of this theme, we will also draw heavily on our own econometric analysis. To evaluate the distribution of economic benefits across different regions of the UK, we will likely draw upon a combination of Challenge-level indicators (though coverage of these indicators is limited across the Challenges), together with analysis of the business supported by the ISCF by region.<sup>47</sup>

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<sup>47</sup> Evaluation of the impact of the ISCF on different regions of the UK may also draw on evidence of the place impact of the ISCF being collated by UKRI.

**Table 15: Impact evaluation framework – economic impact**

Evaluation question	Relevant Challenge-level evaluation indicators	Challenges with relevant evaluation indicators/metrics	Challenges expected to produce relevant indicators/metrics	Fund-level evaluation indicators	Primary data collection
1. To what extent have the ISCF Challenges supported the growth of UK businesses and created new markets or enabled increase of the UK's share in global market in their respective sector?	Market share indicators Import/export indicators Spinouts, start-ups, companies (volume, valuation, growth) Organisational performance: revenue, turnover, earnings	SSPP, CICP, PFER, AoTF, FFC, FBC, NGS, RAI, DSD, D2ED, TFP, MM, IDC, Quantum	All Challenges	Number and characteristics of businesses supported (size, region, sector) Headcount employment of ISCF-funded businesses Turnover of ISCF-funded businesses Survival rates of ISCF-funded businesses	Econometric analysis focused on impact on employment and turnover growth in supported organisations
2. What has been the increase in GVA (including the creation of new products and services in relevant sectors and/or the creation of new markets)?	GVA indicators (business, sector)	PFER, AoTF, FFC, FBC, MM, IDC, TFI		GVA impact of the ISCF	Econometric analysis using derived multipliers to translate turnover impacts to GVA
3. While the ISCF is place-agnostic, to what extent have the economic impacts of the ISCF been widely distributed across the UK?	Value of international sales across the Creative R&D Partnerships (CRDPs) for the relevant sub-sectors/geographies Stakeholder evidence on the creation and strengthening of trade links between city regions and clusters and international markets and the role of the CRDPs Distribution of Future Flight sector companies by size, sector, UK region, foreign ownership and age Regional economic growth around IDC clusters	CICP, FFC, IDC		Number of businesses supported by region Headcount employment of businesses supported by region Turnover of businesses supported by region	Econometric analysis
4. What has been the productivity change (capital, labour or combined)?	GVA per worker/FTE/capita Value added per employee	CICP, PFER, AoTF, FFC, FBC, NGS, RAI, MM, RAI		Turnover per worker for ISCF-funded businesses GVA impact of the ISCF per worker	Econometric analysis

Source: RAND Europe analysis

### 5.3.7. Value for Money

The final theme of our evaluation framework is value for money (VfM). Distinct from other themes within our impact evaluation, the focus of this theme is to understand how impacts and benefits that can be attributed to the ISCF compare against the Fund costs. The specific evaluation question associated with this theme concerns the extent to which the ISCF provides return on investment given overall impact on knowledge, economy and society relative to the size of the investment; that is, does the ISCF represent VfM overall? Given the focus of this question on the costs associated with the ISCF programme overall, our approach to answering this question will naturally draw less on Challenge-level indicators than questions under other evaluation themes. The principal way in which we will address this question is through our own VfM analysis. While the specifics of our approach to this analysis are still to be determined, the general principles that we will follow are outlined in Chapter 6.

**Table 16: Impact evaluation framework – value for money**

Evaluation question	Relevant Challenge-level indicators evaluation	Challenges with relevant evaluation indicators/metrics	Challenges expected to produce relevant indicators/metrics	Fund level evaluation indicators	Primary data collection
1. To what extent does the ISCF represent value for money?	User assessments of the value added by the CRDP infrastructure/asset investments	CICP		<p>Total economic cost of implementing the ISCF (including public and private investment)</p> <p>ROI based on total economic benefits relative to total economic costs (total benefits includes non-market valuations, e.g. of environmental outcomes, where feasible to do so)</p> <p>Wider judgement of ROI taking into account overall impact on knowledge, society and the economy relative to size of investment</p>	VfM analysis

Source: RAND Europe analysis

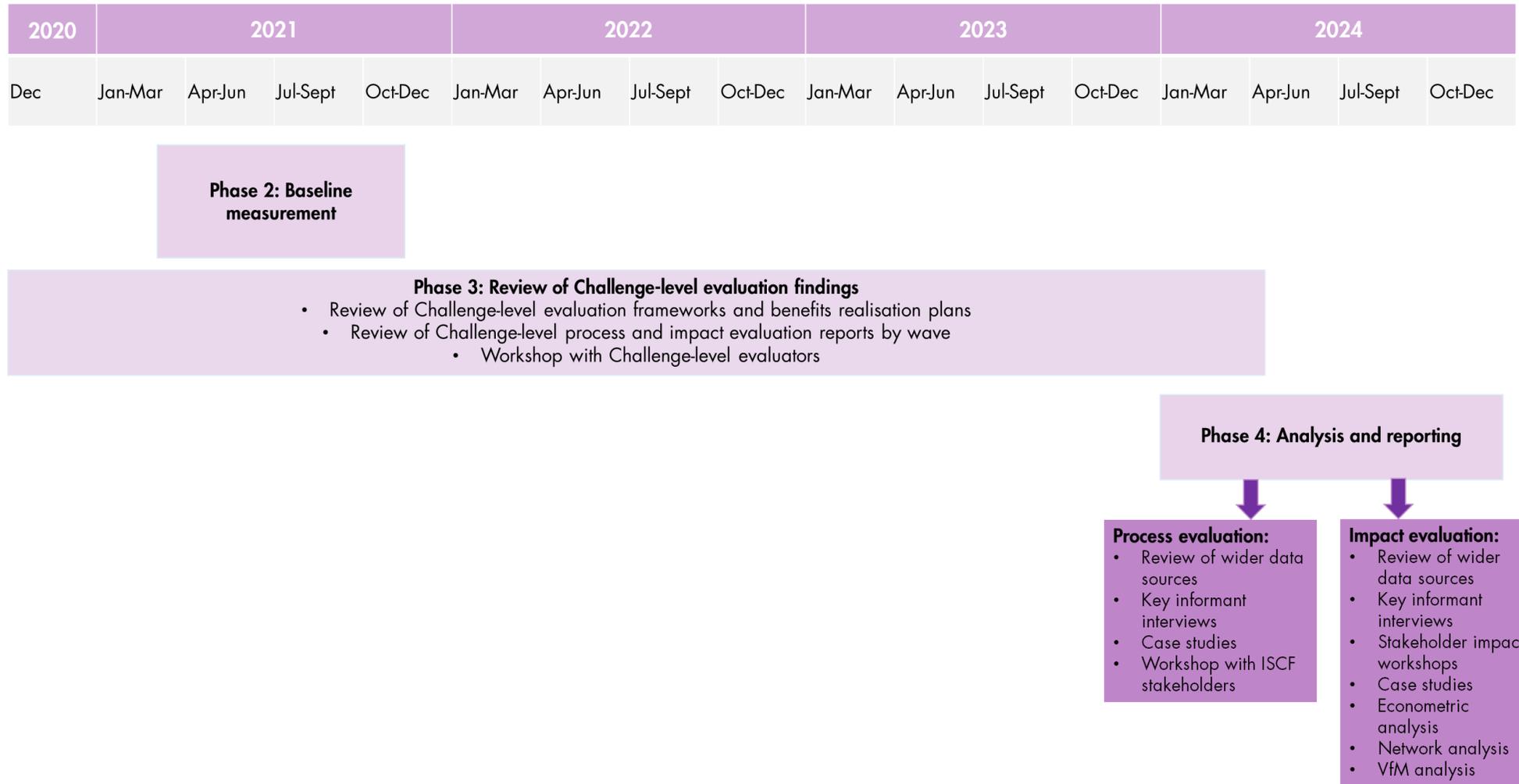
## 6. How we will implement the evaluation: methods and timeframe

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### 6.1. Overview

Building on the process and impact evaluation frameworks presented in the previous chapter, this chapter provides more detail on how we will implement this evaluation framework over time. Below, we outline the staged approach through which we will implement the evaluation. Beginning with baseline measurement (phase 2), this staged approach will then move to the analysis of Challenge-level findings (phase 3), before commencing a period of mixed-method primary data collection – in the form of workshops, interviews, case studies, econometric modelling, network analysis and VfM analysis – during the final phase (phase 4). In designing primary data collection methods, we have focused on addressing anticipated gaps within the Challenge-level data to be collected during earlier phases. At the same time, going beyond the amalgamation of Challenge-level findings, our primary data collection methods will also focus on establishing a stronger evidence base regarding the impact (and underlying processes) of the ISCF as a whole. The key implementation phases for this evaluation, and the methods to be used within each, are visualised in Figure 3.

Figure 3: Evaluation implementation timeframe and methods



## 6.2. Phase 2: Baseline measurement

The first stage of the evaluation is to establish a baseline in order to establish the context in which the intervention was made, and hence the landscape to which the ISCF is making a contribution. Our baselining consists of two aspects:

- Quantitative baselining of key outcome and impact indicators
- Baselining of contextual factors that may impact on the Fund through (primarily) qualitative research, to establish the status of the R&I landscape prior to the Fund being established

Analysis of the Challenge-level baseline reports (where these are available within the required timeframe) will support both aspects of this analysis. In addition, we will conduct further qualitative and quantitative data collection to support our baseline assessment. These aspects are set out below.

### 6.2.1. Analysis of Challenge-level baseline reports

Each Challenge will also be conducting a baselining exercise and where possible we will draw upon these reports to inform our own baselining activities. However, we note that the timing of these activities does not align for all the Challenges, and hence we do not expect to have baseline reports available for all Challenges in sufficient time to inform our baseline analysis.<sup>48</sup> Those reports that are available we will analyse in two ways. Firstly, we will identify key quantitative data that can inform our baselining of the Challenge-level indicators we plan to assess as set out in the evaluation in Chapter 5. Secondly, we will analyse the qualitative information captured in relation to the baselining exercise and will map these findings against our evaluation framework. This evidence will be used to inform and refine our approach to the workshops described below, where relevant information is available for some or all of the Challenges, and will also inform our wider analysis of the contextual factors and wider landscape that influences the success of the ISCF and may be driving changes observed. From a practical point of view, this will consist of coding the reports in a qualitative analysis software such as NVivo against a codebook comprised of our evaluation framework, then analysing the findings for each aspect of the framework thematically across Challenges to draw out Fund-level messages.

### 6.2.2. Baselining key outcome and impact indicators

We will also look to quantitatively baseline a number of the key outcome and impact indicators we will be analysing at the Fund level. Table 17 below sets out those indicators which we will be baselining quantitatively and the data sources we will use to do this. This broadly consists of three main tasks: analysis of UKRI/IUK data sets (on the Fund, and more widely); analysis of wider secondary datasets (primarily ONS data and ISC metrics); and collection of data to inform the economic and network analysis. As noted

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<sup>48</sup> We anticipate that 18 Challenges will have baseline reports by October 2021. This number includes the wave 1a creative industries clusters programme.

above (see Section 5.1), during the baselining phase, we will also be conducting further scoping to explore the use of wider datasets – Lens, Orbis, Crunchbase and Beauhurst – for baselining key indicators relating to patents and investment.

**Table 17: Approach to baselining key outcome and impact indicators at the Fund level (in addition to the aggregation of evidence from the Challenge-level evaluation baselining)**

Theme	Indicator	Baseline assessment <sup>49</sup>
Creating knowledge and innovation pathways	Number of publications and coverage across Challenges	Average number of publications per award in UKRI/IUK portfolio <sup>50</sup>
	Evidence of other (non-publication) outputs by type (e.g. software, datasets, tools) and by Challenge	Average number of different types of output per award in UKRI/IUK portfolio <sup>51</sup>
	Evidence of patent licensing agreements or other measures of IP, and coverage across Challenges	Number of UKRI/IUK projects resulting in at least one patent
	Evidence of movement across TRLs/CRLs	N/A <sup>52</sup>
	Evidence on other measures of IP (e.g. trademark, registered design, copyright) and coverage across Challenges	Average numbers per award in UKRI/IUK portfolio <sup>53</sup>
	Examples of engagement activities that have led to increased awareness and understanding of stakeholders	N/A
	Stakeholder perceptions on the awareness and understanding of key stakeholders and the influence of ISCF-funded activities	Qualitative baselining (see workshops below)
	Evidence on number and nature of examples of adoption reported (on aggregate and by Challenge)	UK Innovation Survey (UKIS) – proportion of firms engaging in innovation activity
	Examples of implementation and adoption of outputs in context	N/A
	Stakeholder perceptions on the extent of adoption and role of the ISCF	Qualitative baselining (see workshops below)

<sup>49</sup> For several indicators, we have indicated that we will baseline measures against average UKRI/IUK performance. The precise scope and content of this baseline – for example which awards are included – is still to be finalised. We are working with data teams within UKRI to see what can be made available to us to support this analysis (either aggregate values, or a wider set of data for our analysis). We are also exploring the possibility to pull data directly through Gateway to Research. An additional, though likely less comprehensive, approach would be to look at data included in annual reports.

<sup>50</sup> Data will draw from PCF data, for which significant data quality issues exist. These will need to be considered and reflected in baseline reporting and analysis.

<sup>51</sup> At the time of writing, we are working with UKRI to investigate the possibility of acquiring relevant baseline data on non-publication outputs for all UKRI awards. Any data will draw from PCF data, for which significant data quality issues exist. These will need to be considered and reflected in baseline reporting and analysis.

<sup>52</sup> N/A in this context means not applicable, i.e. we do not consider it possible to establish a baseline for this indicator based on our assessment of the nature of the indicator and the availability of data. In cases where N/A has been inserted, it may be that review of Challenge-level baseline reports provides some relevant insights from the Challenge level.

<sup>53</sup> Data will draw from PCF data, for which significant data quality issues exist. These will need to be considered and reflected in baseline reporting and analysis.

	Examples of engagements with policy stakeholders that have contributed to evidence-based policymaking	N/A
	Perceptions of policy stakeholders (and others) on the extent and nature of the contribution of the ISCF to evidence-based policymaking	Qualitative baselining (see workshops below)
	Perceptions of key stakeholders on the nature and extent of the learning from the ISCF on mission-oriented R&I	Qualitative baselining (see workshops below)
	Examples of the influence of the ISCF on wider mission-oriented R&I activities identified by key stakeholders	N/A
Capacity and investment	Amount of business investment in R&D generated (on aggregate, by sector and by Challenge)	ONS data and trends on aggregate and by broad field UKIS data on innovation expenditure
	Stakeholder perceptions on the extent to which the ISCF has increased overseas investment in UK R&D	ONS data and trends on aggregate and by broad field Department for International Trade data on overseas investment Qualitative baselining (see workshops below)
	Overall amount of investment in R&D generated (and measured against the 2.4% target)	ONS data and trends
	Evidence on the amount and source of investments in R&D resulting from participation in ISCF projects	N/A
	Examples of ISCF research that has opened up new avenues of investment	N/A
	Stakeholder perception on the extent to which ISCF Challenges have contributed to de-risking	Qualitative baselining (see workshops below)
	Geographic spread of ISCF investment and activities	ONS data and trends on aggregate and by broad field
	Stakeholder perception regarding extent to which ISCF investment and activities have been widely spread	N/A
	Evidence of individuals receiving training/skills development through the ISCF (on aggregate and by Challenge)	Average numbers per award in UKRI/IUK portfolio <sup>54</sup>
	Examples of individual capacity /capability development	N/A
	Number of ISCF-supported infrastructure projects/amount awarded	N/A
	Examples of ISCF-supported infrastructure that support future R&I	N/A
	Stakeholder perception regarding the extent to which the ISCF has contributed	Qualitative baselining (see workshops below)

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<sup>54</sup> At the time of writing, we are working with UKRI to investigate the possibility of acquiring relevant baseline data on jobs/skills for all UKRI awards.

	to establishment of infrastructure that supports future R&I investment	
	Stakeholder perception regarding the extent to which the ISCF has attracted additional talent and skills	Qualitative baselining (see workshops below)
	Number of non-UK academics working in the Challenge areas, before the ISCF and after	ONS data on diversity of UK R&I workforce
	Diversity characteristics of ISCF advisory and programme boards and Challenge teams	
	Diversity characteristics of ISCF applicants, lead investigators and project partners, and application assessors (on aggregate and by Challenge)	
	Extent to which ISCF communications and engagement support EDI	N/A
	Stakeholder perception of whether ISCF processes and impacts have contributed to EDI	Qualitative baselining (see workshops below)
	Number of new businesses created (on aggregate, by sector and by Challenge)	ONS business demography data on new businesses by sector
	Extent to which ISCF support is associated with business performance and survival	N/A
	Number of jobs retained and created (on aggregate and by Challenge)	ONS data and trends on R&D employment (both in general and within specific sectors)
	Stakeholder perception on the extent to which jobs created have been high-skilled jobs	Qualitative baselining (see workshops below)
Connected innovation ecosystem	Number of cross—discipline projects (on aggregate and by Challenge) and extent of cross-disciplinarity	Average number of cross-disciplinary awards in IUK portfolio <sup>55</sup>
	Number of businesses engaged in ISCF projects (on aggregate, by sector, by business size and by Challenge)	Average number of businesses for IUK awards
	Centrality and connectivity metrics for networks of organisations supported by Challenges	N/A
	Perceptions of stakeholders on the extent to which these networks are productive and sustained beyond the life of ISCF awards	N/A

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<sup>55</sup> At the time of writing, we are working with UKRI to investigate the possibility of acquiring this data.

	Number of collaborations between businesses (on aggregate and by Challenge)	UKIS data on collaboration <sup>56</sup>
	Number of collaborations between larger and smaller companies (on aggregate and by Challenge)	UKIS data on collaboration <sup>57</sup>
	Perceptions of stakeholders on the extent to which these networks are productive and sustained beyond the life of ISCF awards	Qualitative baselining (see workshops below)
	Evidence of awards and recognition received (on aggregate and by Challenge)	Number of UKRI/IUK projects resulting in at least one award
	Stakeholder perception on the extent to which participating institution and cluster expertise has been recognised	Qualitative baselining (see workshops below)
Societal impact	Stakeholder perceptions on health and wellbeing benefits delivered by the ISCF	N/A
	Case study examples of impact of the ISCF on health and wellbeing	N/A
	UK healthy life expectancy	ISC metrics: Indicator 7.1.1 – Healthy life expectancy
	UK Disability free life expectancy	ISC metrics: Indicator 7.1.2 – Disability free life expectancy
	Stakeholder perceptions on environmental and sustainability benefits delivered by the ISCF	N/A
	Case study examples of impact of the ISCF on the environment and sustainability	N/A
	Emissions intensity ratio	ISC metrics: Indicator 8.1.1 – Emissions intensity ratio
	Low carbon and renewable energy economy – turnover	ISC metrics: Indicator 8.2.1 – Low carbon and renewable energy economy – turnover
	Low carbon and renewable energy economy – employment	ISC metrics: Indicator 8.2.2 – Low carbon and renewable energy economy – employment
	Low carbon and renewable energy economy – exports	ISC metrics: Indicator 8.2.3 – Low carbon and renewable energy economy – exports
R&D budget on low-carbon technologies	ISC metrics: Indicator 8.3.1 – R&D budget on low-carbon technologies	
Energy usage per dwelling	ISC metrics: Indicator 8.4.1 – Energy usage per dwelling	

<sup>56</sup> Note that our network analysis will look at organisations supported and the networks that form around Challenges but will not be ‘baselined’ directly. Rather, analysis of UKIS data will give us a broader picture of the nature and extent of business collaboration in the wider landscape.

<sup>57</sup> Note that our network analysis will look at organisations supported and the networks that form around Challenges but will not be ‘baselined’ directly. Rather, analysis of UKIS data will give us a broader picture of the nature and extent of business collaboration in the wider landscape.

	Electricity generation from renewable sources	ISC metrics: Indicator 8.5.1 – Electricity generation from renewable sources
	Stakeholder perceptions on infrastructure and services benefits delivered by the ISCF	N/A
	Case study examples of impact of the ISCF on the infrastructure and services	N/A
	Public attitudes towards AI	ISC metrics: Indicator 6.1.1 – Public attitudes towards AI
	Public sector adoption readiness	ISC metrics: Indicator 6.2.1 – Public sector adoption readiness
	Prevalence of open data	ISC metrics: Indicator 6.3.1 – Prevalence of open data
	Registrations of electric vehicles	ISC metrics: Indicator 9.1.1 – Registrations of electric vehicles
	Public perception towards transport technologies	ISC metrics: Indicator 9.1.2 – Public perception towards transport technologies
	Domestic and international road freight activity	ISC metrics: Indicator 9.2.1 – Domestic and international road freight activity
	Stakeholder perceptions regarding wider benefits delivered by the ISCF, including unexpected/unanticipated impacts	N/A
	Case study examples of wider impacts of the ISCF, including unexpected/unanticipated impacts	N/A
Economic impact	Number and characteristics of businesses supported (size, region, sector)	Analysis of data aggregated from Challenges and deduplicated
	Headcount employment of ISCF-funded businesses	N/A
	Turnover of ISCF funded-businesses	N/A
	Survival rates of ISCF funded-businesses	N/A
	GVA impact of the ISCF	N/A
	Number of businesses supported by region	Analysis of data aggregated from Challenges
	Headcount of businesses supported by region	N/A
	Turnover of businesses supported by region	N/A
	Turnover per worker for ISCF funded-businesses	N/A
	GVA impact of the ISCF per worker	N/A
Value for money	Total economic cost of implementing the ISCF (including public and private investment)	N/A
	ROI based on total economic benefits relative to total economic costs (total benefits includes non-market valuations,	N/A

	e.g. of environmental outcomes, where feasible to do so)	
	Wider judgement of ROI taking into account overall impact on knowledge, society and the economy relative to size of investment	N/A

Source: RAND Europe analysis

### Analysis of UKRI/Innovate UK data sets

Part of our baselining task will include the analysis of existing datasets held by UKRI regarding the Fund. Where Challenge-level baseline reports are available, we assume these data will have been analysed and summarised and we will draw on that evidence. However, we are aware that where Challenge-level baseline reports are not available, these baseline survey data may be available to inform and broaden our analysis of the Fund. In addition, we are aware that the UKRI annual report provides a wider picture on some aspects of the performance of the UKRI portfolio as a whole, presenting information such as numbers of innovations per project and numbers of patents granted. This is useful to provide a wider picture on the performance of the UKRI portfolio – with a particular focus on the IUK aspects of the portfolio that are more closely aligned to ISCF funding aims – prior to the launch of the ISCF. Finally, we are aware that diversity and inclusion data is captured and reported upon regularly for UKRI as a whole. Looking at these data prior to the ISCF launch will give a useful picture of the typical diversity characteristics associated with the R&I funding landscape prior to the Fund.

### Analysis of wider secondary datasets

There are two additional wider datasets that provide a useful picture of the national landscape regarding UK R&I prior to the launch of the Fund. Firstly, ONS data include a number of useful datasets that we can look at in terms of absolute numbers but also trends prior to the launch of the ISCF. In particular, there are measures of business R&D investment (including breakdowns by broad field and by geography); data on R&D employment and the diversity of the UK R&I workforce; and through the UK Innovation Survey (UKIS), data on collaboration (though only collected every two years). We will analyse these, aligning fields broadly to the areas of focus for the Challenges, where possible based on Challenge-level definitions of sectors/industries of relevance, and also looking at broader national trends, to provide a picture of the wider UK R&I landscape into which the ISCF was introduced.

Secondly, the ISC has developed a set of metrics to assess and monitor the performance of UK industrial strategy. Since these are aligned to the Grand Challenges, many of these are useful high-level indicators which align with the broad societal and economic impacts that are of relevance to the ISCF. We can look at these measures and the trends in these data prior to the launch of the Fund to provide an overall picture of existing progress towards these ultimate impacts.

### Collecting data to inform economic and network analysis

#### *Data collection for economic VfM analysis*

We will also explore data collection for the economic VfM analysis described in Section 5.6.7. Whilst this analysis will be undertaken as part of the impact analysis in the final phase of the evaluation, it is important

to ensure the required data collection processes are in place in intervening years, particularly in cases where some Challenges will have closed during this time.

The types of cost data required for the VfM analysis are: ISCF programme-level administrative costs, Challenge-level administrative costs, capital investments, training and skills investments, R&D costs, and private investment costs undertaken by organisations supported by each Challenge. The types of benefits data required are for impacts to the economy such as productivity or technological enhancements, as well as wider impacts such as health effects (e.g. quality-adjusted life years) and environmental effects (e.g. monetised carbon savings). We envisage combining evidence from the Challenge-level evaluations with secondary published data sets for these data. Our focus in the baseline phase will be on ensuring the right processes are in place to capture this data and address any gaps identified.

#### *Data collection and exploratory analysis for the econometric and network methods*

We will undertake provisional data collection and exploratory analysis for the econometric and network approaches described in Sections 5.6.5 and 5.6.6 respectively. For the econometric analysis this will allow the approach to be further refined in light of the available data. For the network analysis this will serve two purposes: providing a proof of concept to test and refine the analytical approaches with initial data; and providing early insights through descriptive statistics and analysis of the early network effects of the ISCF.

This will involve the following steps:

- **Step 1: data preparation and gap analysis:** Based on intelligence gathered so far, we will initially use centrally held data on the organisations supported by the Challenges through the databases identified in the scoping phase, such as Delphi and Knowledge Transfer Network (KTN) data. We understand this will largely capture engagements through project funding and events. We will clean this data and identify any data gaps. For example, we anticipate there may be some types of support, such as use of Challenge facilities, that may not be captured within the centrally held data.
- **Step 2: data request from individual Challenges:** We will then explore with individual Challenges any data they hold on other organisations they have supported to fill the gaps identified. We anticipate this will involve sharing a document outlining the identified data gaps, and an interview with each Challenge to determine the extent to which these gaps can be filled with Challenge-held data. Following the interviews, we would collect the relevant data from individual Challenges (via the central ISCF team).
- **Step 3: data merging:** Once the data from individual Challenges is received, we will merge the datasets together with the centrally held data to create a single analytical database of supported organisations.
- **Step 4: Exploratory analysis:** With the merged dataset, we will then undertake exploratory analysis. This will first involve descriptive statistics of the organisations receiving support across the ISCF, such as types of organisations, geographic distribution, etc. We will then explore the types of econometric and network analysis that are possible with the data, to refine the methods discussed in Sections 5.6.5 and 5.6.6 respectively.

The outputs from this analysis will be:

- Establishing a set of data collection methods for combining data held by individual Challenges on the organisations they support with centrally held data sets
- A refined approach to the econometric and network analysis to take forward for the impact analysis at the end of the evaluation
- Early insights on the types of organisations receiving support from the ISCF programme and how they interact as a network

### 6.2.3. Baseline contextual factors

In order to baseline the wider landscape and contextual factors to inform our analysis, we propose to hold a series of five expert workshops. These will be held via Microsoft Teams, given the likely timing, and will involve participants across academia, industry, government and the charity sector. Given the nature of the discussion around specific R&I and industry landscapes these will be clustered by thematic area of the Challenges as follows (Table 18).

**Table 18: Coverage of Challenges across the workshops<sup>58</sup>**

Workshop focus	Challenges covered
Health and healthcare sector	Medicines Manufacturing Data to Early Diagnosis and Precision Medicine Healthy Ageing Accelerating Detection of Disease
IT and data sector	Next Generation Services Digital Security by Design Quantum Technologies Commercialising Quantum Technologies Robotics and Artificial Intelligence in Extreme Environments Audience of the Future Creative Industries Clusters <sup>59</sup>
Energy sector	Prospering From the Energy Revolution Low Cost Nuclear Industrial Decarbonisation
Transport and space sector	Self Driving Vehicles National Satellite Test Facility Future Flight Driving the Electric Revolution Next Generation Aero Materials Faraday Battery
Manufacturing and sustainability	Transforming Food Production Smart Sustainable Plastic Packaging Transforming Construction Manufacturing Made Smarter Transforming Foundation Industries

<sup>58</sup> The expert workshops are structured around specific sectors to enable a common discussion of the context and landscape prior to the ISCF being introduced. To enable comparison between baselining and impact, the same structure will be used for the impact workshops conducted in phase 4.

<sup>59</sup> Note, this is technically not one of the ISCF Challenges and was funded through wave 1a support. However, we are aware that there is likely to be an evaluation of this portfolio and feel it would be relevant to include this as part of the Fund in the baselining workshops. It may be feasible to also include key stakeholders from other aspects of the wave 1a portfolio. We will discuss this with the ISCF evaluation working group at the start of the baselining phase.

We anticipate involving a mix of internal and external stakeholders in these workshops. For example, we would include the relevant Challenge Directors for each workshop, a sample of award holders, relevant government actors in the appropriate space, a few key academic experts in the area, and representatives from any other key organisations. We anticipate approximately 15 to 20 participants in each workshop. We find this number of participants is the maximum that is feasible to allow for some plenary discussion as well as breakout group sessions, and the workshop agenda would include a mix of these formats. A list of suggested participants for each workshop is provided in Table 19 and will be refined further in discussion with UKRI. Each workshop would be approximately 3.5 hours in length – we find that significantly longer than a half day is challenging in an online format – and would be structured around two aspects: firstly, capturing impressions about the state of play regarding aspects of our evaluation framework prior to the ISCF; and secondly understanding the wider factors influencing progress in these fields, both barriers and enablers. Box 7 provides an indicative set of topics for discussion in the workshops, though these will be refined and tailored for each session.

**Table 19: Suggested participants in baselining workshops**

Workshop focus	Participants
Health and healthcare sector	<p>Challenge Directors (4)</p> <p>Award holders (5–10)</p> <p>Representatives from the Department of Health and Social Care (DHSC), Public Health England (PHE)</p> <p>Representatives from relevant sector bodies such as the Association of the British Pharmaceutical Industry (ABPI), the Association of British HealthTech Industries (ABHI), Association of Medical Research Charities (AMRC)</p> <p>Representatives from relevant BEIS sector teams</p>
IT/Data sector	<p>Challenge Directors (6)</p> <p>Award holders (5–10)</p> <p>Representatives from relevant sector bodies such as TechUK, the Developers Alliance</p> <p>Representatives from relevant BEIS sector teams</p>
Energy sector	<p>Challenge Directors (3)</p> <p>Award holders (5–10)</p> <p>Representatives from BEIS</p> <p>Representatives from relevant sector bodies such as Energy UK</p> <p>Representatives from relevant BEIS sector teams</p>
Transport and space sector	<p>Challenge Directors (6)</p> <p>Award holders (5–10)</p> <p>Representatives from Department for Transport (DfT), UK Space Agency (UKSA)</p> <p>Representatives from relevant sector bodies such as (Chartered Institute of Logistics and Transport) CILT, Highways England, Civil Aviation Authority (UKCAA)</p> <p>Representatives from relevant BEIS sector teams</p>
Manufacturing and construction sector	<p>Challenge Directors (5)</p> <p>Award holders (5–10)</p> <p>Representatives from DfT, UKSA</p> <p>Representatives from relevant sector bodies such as IfM, Build UK, CIC</p> <p>Representatives from relevant BEIS sector teams</p>

**Box 7: Outline format for expert workshops**

**Outline format for workshop sessions (c.3.5 hours in total – indicative timings for sessions provided below)**

Introductions and discussion of aims of workshop (10min)

Introduction to the evaluation and the ToC, Q&A (20min)

Breakout 1: Capacity and investment in the field prior to the ISCF (30min)

*Note: breakout sessions will be organised by thematic area/sector as far as possible to facilitate shared understanding*

Breakout 2: Networks and collaboration in the field prior to the ISCF (30min)

Sharing observations in plenary and discussion (30min)

Comfort break (15min)

Breakout 3: Barriers and enablers to the ISCF delivering intended outcomes and impacts, including key influencing factors (45min)

Plenary discussion of the role of the ISCF in the wider UK R&I landscape and cross-cutting challenges, facilitators and influencing factors (30min)

Thanks and close

**6.2.4. Analysis and reporting on baseline measurement**

Drawing on our steps outlined above, we will present an evaluation baseline report. The report will present the outcome of quantitative baselining of key outcome and impact indicators as well as analysis of the qualitative insights gained through our expert baselining workshops focussed on contextual factors. The report will be structured around the key outcome and impact themes, as set out within the ToC, with a chapter on each setting out the baseline position for relevant indicators and wider qualitative assessment and considerations with regard to the picture prior to ISCF. There will also be a chapter setting out cross cutting issues and contextual factors and outlining the implications for the evaluation and our analysis in subsequent stages. As appropriate, the report will also provide recommendations for the future phases of the evaluation based on the baseline findings.

**6.3. Phase 3: Review of Challenge-level evaluation findings**

Following the establishment of an appropriate baseline, the next phase of the evaluation will begin collecting data with which to evaluate the ISCF. During this phase, the focus of our data collection efforts will be on the review of findings being produced at the Challenge-level. This review of Challenge-level findings will be used to inform both the process and impact aspects of our evaluation.

To facilitate comparison across the ISCF portfolio, this review of Challenge-level findings will be performed by wave. In reviewing the findings pertaining to wave 1, we also plan to conduct analysis of those wave 1 investments (i.e. wave 1a underpinning investments, as well as the Self Driving Cars, National Satellite Test Facility and the Next Generation Aero Materials programme established under wave 1b) that have not been established through a challenge-led approach. As indicated below, however, the extent to which this analysis

will be possible will depend upon the availability of suitable monitoring/evaluation reporting for these non-Challenge aspects of the Fund. This is a matter currently being considered by the evaluation team and UKRI.

The key steps to be taken during the review of challenge-level evaluation findings are set out below.

### Step 1: Review of Challenge-level evaluation framework reports and benefits realisation plans

In the evaluation framework presented in Chapter 5, we identified indicators established by individual Challenges that are relevant to the evaluation questions within our own evaluation framework. The identified indicators comprise process and impact indicators established by Challenge-level evaluation teams, as well as indicators established as part of Challenge-level benefits realisation plans. These indicators provide one means with which to assess the impact of the ISCF against the evaluation framework. During this first step of phase 3, we will review additional evaluation framework reports and benefits realisation plans as they are published, in order to further develop our understanding of Challenge-level indicators that are relevant to our evaluation questions.

### Step 2: Desk research and scoping interviews for each wave

In this step, in preparation for the publication of Challenge-level evaluation reports, we will undertake desk research and a small number of high-level scoping interviews (3 per wave) to help us better understand the context and key features of each wave. Factors considered by undertaking this initial scoping research will include the approach to selection of Challenges across waves and the composition (as well as the expected impacts) of the Challenges within each wave. Participants in the scoping interviews will therefore be individuals with knowledge of these aspects for each wave, and will likely include relevant personnel within the portfolio management office and programme managers.<sup>60</sup> By undertaking this initial scoping research, the study team will be better prepared to interpret key findings by wave in context.

### Step 3: Review of Challenge-level process and impact evaluation reports by wave

In the next step, we will review the findings from Challenge-level process and impact evaluation reports by wave. The aim of this review will be to develop an early picture of both the impacts of the ISCF (disaggregated by wave), as well as a sense of the key process differences that have underpinned impacts across ISCF waves. The anticipated schedule for submission of the Challenge-level evaluation reports has been presented earlier in this report (see Table 2). The review of Challenge-level reports will comprise two sub-tasks as set out below.

### Coding of evidence

For each Challenge-level evaluation report, we will code evidence within the report against our evaluation questions. For process evaluation reports, evidence will be mapped against the process evaluation themes

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<sup>60</sup> In selecting interviewees for these scoping interviews, we will be careful to avoid duplication with the key informant interviews conducted during phase 4 of the evaluation and described further below.

and questions (see Section 5.2). For impact evaluation reports, evidence will be mapped against the impact evaluation themes and questions (see Section 5.3). Coding will be performed separately by two reviewers using qualitative analysis software such as Nvivo.

While the focus of this phase will be to collate evidence as presented in Challenge-level evaluation reports, we will also, to the extent that they are available at the time of undertaking this phase, seek to incorporate the findings of Challenge-level benefits realisations plans. Here, as with the review of Challenge-level evaluation reports, our approach will be to systematically map evidence collected against key benefits indicators to our evaluation questions. Where the data is available, the findings of this review will be incorporated into our wave-level analysis, rather than reported on separately.

For the non-Challenge aspects of Wave 1, it is not anticipated that these programmes will produce Challenge-level evaluation reports in the same format as other ISCF Challenges. As such, our ability to incorporate these aspects into this step will depend upon the provisions of suitable monitoring and/or evaluation reports or data for these non-Challenge aspects. Rather than seeking to obtain data on all wave 1a projects, we envision focusing on a small number of key projects, or groups of projects, determined in agreement with UKRI. For example, we anticipate that our analysis may include the Creative Industries Cluster (funded as part of wave 1a), where we know there is an evaluation ongoing that can feed into our analysis.

**Box 8: Approach to amalgamating data from Challenge-level reports into Fund-level impact**

The extraction of quantitative data from Challenge-level evaluation reports will initially be conducted on a report-by-report basis. Following the extraction of data on each individual Challenge, we will then explore the possibility of amalgamating data from across the Challenges in order to develop a Fund-level picture of impact. This will involve identifying data that are of sufficient comparability and quality to be compared across Challenges, as well as identifying those data that cannot be reasonably compared. In cases of the former, we will attempt to amalgamate the data into a Fund-level assessment, while also specifying appropriate clarifications and caveats. In the case of the latter, while data from the Challenges will be considered as part of our contribution analysis, it will be presented as part of a more composite picture of Challenge-specific impacts

**Step 4: Thematic analysis of evidence, including contribution analysis**

Following the systematic collection of evidence (both qualitative and quantitative) from the Challenge-level reports, we will then undertake thematic analysis of the evidence in order to generate insights against our process and impact evaluation questions. As part of our analysis of the evidence, we will also undertake contribution analysis in which we will compare insights and observations against the ToC and look at the strength of evidence across the different elements, as well as evidence concerning the assumptions between them. Contribution analysis will be supported by three internal workshops, one per wave, during which the evaluation team will consider the key ‘contribution story’ for each wave. The internal workshops will also consider any alternative theories that could explain any observed impacts, and the implications for the respective contribution stories. During this phase, we will also consider where our review of Challenge-level

findings has highlighted evidence gaps and how future data collection and analysis could address these in subsequent stages of the evaluation.

### Step 5: Workshops with Challenge-level evaluators

To test, validate and refine the emerging findings from our analysis, we will host three workshops with Challenge-level evaluators (one per wave). In each workshop, representatives of the evaluation teams of each Challenge within the wave will be brought together to review and discuss the key findings. These workshops will serve to both validate the findings from the review of Challenge-level reports (both process and impact), and to facilitate the sharing of learning between the Fund-level and Challenge-level evaluations.<sup>61</sup> While structured broadly around the themes of the evaluation framework, it is anticipated that each workshop's discussions will focus on the most significant findings of the contribution analysis pertaining to each individual wave. Other key focus points for the workshops will be to explore the contextual factors that have influenced Challenges, both barriers and enablers, in delivering intended outcomes and impacts (thereby building upon the consideration of *potential* contextual factors at the baseline stage), and to review gaps in the Challenge-level evidence. An indicative set of topics for discussion during the workshops is provided in Box 9 below. The structure of the workshop participation (i.e. by wave) is set out in Table 20. In the case of the wave 1 workshop, workshop discussions will also aim to consider the differences (if any) between the impact of investments established through a challenge-led approach and those programmes based on more traditional approaches to R&I funding. To this end, the wave 1 workshop will invite representatives from the non-Challenge aspects of wave 1. These representatives will be individuals with roles related to the monitoring and evaluation of each programme. For wave 1a, they will likely be representatives from a few selected projects.

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<sup>61</sup> By validate, we mean that we will seek the views of Challenge-level evaluation teams from that wave regarding our emerging key findings, i.e. that these key findings present a picture that broadly aligns with their own evaluation findings. This validation process will include evaluation teams from all Challenges, with Frontier Economics being one of the teams represented in some cases.

**Box 9: Outline format for workshops with Challenge-level evaluators**

**Outline format for workshop sessions (c.4 hours in total – indicative timings for sessions provided below)**

Introductions and discussion of aims of workshop (10 min)

Introduction to the evaluation and key emerging findings of the review of Challenge-level evaluation reports (30 min)

Breakout 1: Knowledge and innovation (30 min)

*Note: breakout sessions will be organised by thematic area/sector as far as possible to facilitate shared understanding*

Comfort break (5 min)

Breakout 2: Capacity and investment (30min)

Breakout 3: Networks and collaboration (30 mins)

Comfort break (10 min)

Sharing observations in plenary and discussion (30 min)

Plenary discussion of barriers and enablers experienced by Challenges delivering intended outcomes and impacts, including key influencing factors (30 mins)

Comfort break (5 min)

Plenary discussion of role of evidence gaps from Challenge-level evaluations and implications for Fund-level data collection (30 mins)

Thanks and close

**Table 20: Coverage of the Challenge-level evaluation teams across the workshops**

Workshop	Challenges covered
Wave 1	Robotics and Artificial Intelligence in Extreme Environments Medicines Manufacturing Faraday Battery Self Driving Vehicles National Satellite Test Facility Next Generation Aero Materials Creative Industries Clusters Selected representatives from other wave 1 a projects
Wave 2	Data to Early Diagnosis and Precision Medicine Next Generation Services Quantum Technologies Healthy Ageing Prospering from the Energy Evolution Transforming Construction Transforming Food Production Audience of the Future
Wave 3	Accelerating Detection of Disease Commercialising Quantum Technologies Digital Security by Design Manufacturing Made Smarter Industrial Decarbonisation Transforming Foundation Industries Smart Sustainable Plastic Packaging Low Cost Nuclear Driving the Electric Revolution Future Flight

Our REA highlighted the need for evaluations to consider the systemic barriers that may inhibit a well-performing mission-oriented innovation system. Throughout our evaluation, we will incorporate consideration of the factors that prevent and enable the successful implementation of mission-oriented programmes. In reviewing and validating the key findings from our review of Challenge-level evaluation findings; for example, our wave-level workshops with Challenge-level evaluators will also consider the key barriers and enablers experienced by Challenges delivering intended outcomes and impacts.

## Step 6: Final analysis and reporting on Challenge-level findings

Based on the insights obtained through the workshops with Challenge-level evaluators, we will then revisit and refine our contribution analysis, and prepare for reporting. The output of our review of Challenge-level findings will be three summary evaluation evidence reports, one per wave. Within these reports, key evidence regarding both impacts and processes will be presented for each wave. The three wave-level reports will also consider key gaps in the Challenge-level evidence, and consider the implications of these gaps, including recommendations for the primary data collection activities to be undertaken during phase 4 of the evaluation. In the wave 1 evidence report, evaluation of programmes without a challenge-led approach, to the extent that this has been possible, will be presented within a dedicated section of the report.

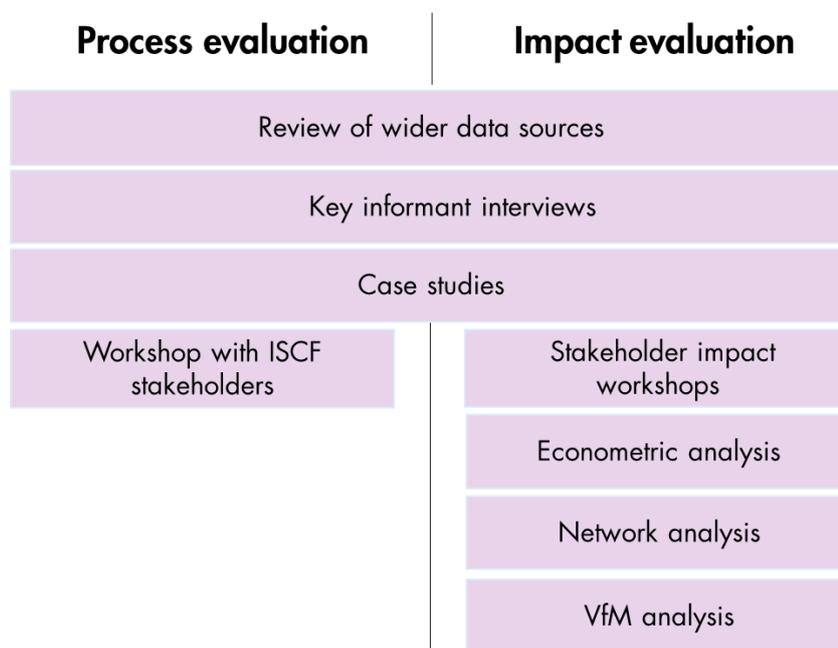
### 6.4. Phase 4: Analysis and reporting

Building on the review of Challenge-level findings, the final phase of this evaluation will focus on multi-method primary data collection. The aim of this data collection will be to address gaps in the evidence provided by the Challenge-level evaluations, while also helping to establish a stronger evidence base regarding the impacts and the contributing processes of the ISCF as a whole. During this phase, we will also review key Fund-level data of relevance to the evaluation framework.

Below, we set out the data collection methods to be used during this phase. In doing so, we focus firstly on the data collection methods for the process evaluation and secondly on the data collection steps for impact evaluation. While presented separately below, it is important to recognise that the methodological steps taken for the process and impact evaluations will in some cases be interlinked. For example, key informant interviews, conducted primarily to inform the process evaluation, will also be used to address impact evaluation questions in areas where it is felt that interviewee perspectives will help to address key data gaps. Another key way in which our process and impact evaluation methods will be linked will be the development of case studies. Focused on key examples of impacts that have been enabled by the ISCF's mission-oriented approach, these case studies will be explored from both a process and an impact perspective. Areas where process and impact methods overlap are described in the sections that follow. These overlaps are also visualised in Figure 4 below.

Because many of our data collection methods will be applied in parallel, rather than in sequence, we have described each method in turn rather than as a series of sequential steps. However, where one data collection method will draw upon another – for example, a workshop that will review evidence collected from other data collection activities – this has been highlighted within the relevant method description.

Figure 4: Overlap between phase 4 process evaluation and impact evaluation data collection methods



## 6.5. Process evaluation

### 6.5.1. Review of wider data sources

As part of our process evaluation, we will also review wider data sources. This will include selected data compiled by UKRI/IUK, together with other non-UKRI data sources, that are of particular relevance to our process evaluation framework. Here, our focus will not be to conduct original data analysis, but rather to review data already collated where that data can provide direct insights for our evaluation questions. While the specific data that we review will be determined closer to the time, including in light of any new forms of data that may become available, at this stage, we anticipate that our review of wider data will focus on the following data sources: Challenge Director quarterly reviews; quarterly portfolio performance and monitoring reports; IUK project monitoring; and the NAO report on UKRI's management of the ISCF. The relevance of each of these data sources to our evaluation framework has been set out in the evaluation framework tables presented in Chapter 5 and is summarised in Table 21 below. Data collected from these sources will be mapped to our evaluation questions. The collected data will help to inform our approach to other aspects of the evaluation, for example key informant interviews.

**Table 21: Relevant wider data sources for the process evaluation**

Data source	Process evaluation themes to which data is relevant	Evaluation question(s) to which data is relevant
UKRI/IUK collated data		
Challenge Director quarterly reviews	Strategy	All evaluation questions
Quarterly portfolio performance and monitoring reports	Strategy	All evaluation questions
	Delivery	All evaluation questions
	Wider engagement	All evaluation questions
IUK project monitoring/Research Council monitoring <sup>62</sup>	Delivery	All evaluation questions
Steering board review	Strategy	How has the ISCF governance and set-up supported and enabled delivery of the ISCF? (e.g. how effective has the ISCF steering board been in decision making? How have the performance and monitoring board analysed the portfolio's performance and the individual Challenge governance set-up with senior responsible officer, Challenge programme board and advisory board)? How have these boards done this effectively?
UKRI risk appetite framework for ISCF	Delivery	All evaluation questions
IUK data (EDI survey)	Cross-cutting	How did the ISCF ensure diversity among participants, especially in regard to gender and ethnicity?
		How, if at all, did the ISCF promote equal opportunities?
ISCF core data	Cross-cutting	How, if at all, did the ISCF contribute to tackling regional inequalities?
		How balanced was the ISCF in selecting the industry it targets (e.g. achieving the balance between selecting small and micro companies and larger companies)?
UKRI evidence on place impact of ISCF	Cross-cutting	How, if at all, did the ISCF contribute to tackling regional inequalities?
Other data sources		
NAO report on UKRI's management of the ISCF (2021)	Strategy	All evaluation questions
	Delivery	All evaluation questions
	Wider engagement	All evaluation questions
	Cross-cutting	How, if at all, did the ISCF contribute to tackling regional inequalities?
		What were the unexpected facilitators or barriers to implementing and delivering the ISCF, if any, e.g. recruitment of Challenge Directors?

<sup>62</sup> While listed here, it is also recognised that research council monitoring of ISCF-funded projects is not as systematic as IUK project monitoring and may therefore be less useful for our evaluation.

### 6.5.2. Key informant interviews

To inform our process evaluation, we will conduct 35 key informant interviews. Focusing on Fund-level personnel, the aim of these interviews will be to gain perspectives on how the ISCF portfolio has been delivered, the links between impacts and processes, and key lessons learned. Interviewees will be agreed in consultation with UKRI but are expected to include representatives from the ISCF steering board (BEIS, UKRI and the Research Councils), ISCF executive management, portfolio managers, programme managers and Challenge Directors, and UKRI/IUK performance and monitoring staff. An indicative breakdown of interviewees is provided in Table 22 below. In developing our list of interviewees, we will also consider individuals who have occupied these positions but subsequently moved to new roles during the lifetime of the evaluation.

Where necessary, interviews will be planned in a way to avoid duplication of work already conducted by the Challenge-level evaluations. Where Challenge Directors have already been interviewed by a Challenge-level evaluation, for example, we will first examine the insights gained from these interviews for their relevance to our evaluation questions. Where an interview with a Challenge Director has already provided useful insights in relation to our evaluation questions, we will draw on this evidence rather than duplicating efforts. Decisions in this respect will be informed primarily by our review of Challenge-level process evaluation reports undertaken in phase 3 but may also require additional communication between our evaluation team and the relevant Challenge-level evaluation team.

All key informant interviews will follow a protocol structured around the process evaluation framework. At the same time, interviews will follow a semi-structured format, thereby enabling us to focus on the aspects of the evaluation framework most relevant to the interviewees' role. For example, interviews with members of the steering committee and ISCF executive management will more likely focus on collecting data relevant to the questions under the 'strategy' theme of the evaluation framework, rather than on those pertaining to 'delivery' and 'wider engagement'. An indicative privacy notice and interview topic guide for the key informant interviews can be found in Annex H to this report. The final protocol will be revised based on the findings of phase 3 of the evaluation.

Data collected from interviews will be coded against our evaluation framework using qualitative data analysis software such as Nvivo.

**Table 22: Indicative breakdown of key informant interviews**

Stakeholder Type	Suggested number of interviewees
Members of the ISCF steering board (executive chairs of the Research Councils and IUK, and senior officials from BEIS and HM Treasury)	5
ISCF executive management (e.g. programme director, ISCF; director, ISCF governance; head of ISCF portfolio management office)	4
Wider UK government stakeholders (BEIS Industrial Strategy policy officers/ HM Treasury staff)	3
Challenge Directors	8
Programme managers	5
UKRI/IUK performance monitoring and analysis staff (e.g. ISCF benefits lead, ISCF product manager, impact and performance manager, panel members, and Challenge-level evaluation leads)	10

### 6.5.3. Case studies

As part of our process evaluation methods, we will also undertake six case studies. In each of these six case studies, different examples of high-impact contributions of the ISCF will be explored in depth in order to understand the process elements that have enabled impact, as well as potential barriers that have been faced. **Notably, these case studies will consider the same six case study examples as used for the impact evaluation (and described further below – see Section 6.6.4), with each case study being analysed from both a process and an impact perspective.**

A key underlying assumption within the ToC, is that the enabling environment generated by the investment in the ISCF – through the advances in knowledge, increased R&I capacity and improved networking it is intended to create – can be sustained over time and can catalyse impacts on society and the economy. Case studies will provide an important route to test this crucial underlying assumption of the ToC by allowing us to explore the extent to which the ISCF’s strategy, and the enabling environment it aims to achieve, have either led to, or are in the process of leading to, societal-level impacts. In selecting case studies, we will focus on examples where there is evidence that envisioned outputs and outcomes have been met. In doing so, we will seek to capture examples relevant to different impact categories (both societal and economic) within the ToC. In considering each case study from a process perspective, we will also explore the links between the outputs, outcomes and impacts considered in each example and the processes (strategy, delivery and engagement) established at the Fund-level.

The anticipated unit of analysis for these case studies will be an intermediate level between the unit of the Challenge and the individual funding award. At this early stage, we anticipate that each case study will consider a key impact (or linked set of outcomes and impacts) delivered by a particular Challenge (or potentially by more than one Challenge). In the process aspect of these case studies, the impacts and outcomes will be traced back to assess its relationship to Fund-level process as set out in the ToC.

To select our case studies, we will draw on insights from wider data collection methods used during the course of the evaluation. Primarily, this will include the review of Challenge-level findings (conducted in phase 3) and the insights of the stakeholder impact workshops (described in Section 6.6.3 below). Across these data collection processes, we will collate a longlist of potential case study examples using a matrix that applies selected qualitative criteria regarding both the types of outcomes and impact achieved, and the relationship of this impact to the ISCF intervention logic. A final set of cases studies will be determined based on a review of the matrix and in consultation with UKRI. An indicative matrix that could be used for this purpose is presented in Annex I to this report.

To inform our case study analysis, we will draw upon two research methods: desk research and interviews. Desk research will involve the analysis of key documentation relating to the selected case example. This will include detailed consideration of evidence presented in Challenge-level evaluation reports, review of project-level data for associated projects, possibly including Researchfish data and PCF data where appropriate, as well as other outputs from associated projects, including reports, websites, publications and communications materials. To help ensure access to appropriate documentation, the cooperation from both UKRI and the relevant Challenge-level evaluation teams will likely be required. Interviews (three to four per case study) will focus on gaining in-depth perspectives on the case example, from process and impact perspectives. In selecting case study interviewees, we will focus on capturing a multi-stakeholder perspective,

including a combination of programme-level, project-level and wider stakeholder personnel.<sup>63</sup> In order to effectively capture the specifics of the case study in question, it is anticipated that these interviews will follow a semi-structured format. The case studies will be written up in a structured format capturing information around our different process and impact evaluation themes as set out in Chapter 5. These case study narratives will also be coded against our evaluation questions in qualitative analysis software (e.g. Nvivo) to inform our wider analysis.

#### 6.5.4. Workshop with key ISCF stakeholders

To further inform our process evaluation, we will conduct a workshop with key ISCF stakeholders. Conducted towards the end of phase 4, the aim of this workshop will be to review key findings that have emerged from the process evaluation, test these findings with workshop participants, and explore the feasibility of recommendations for subsequent phases of the ISCF based on these findings.

Prior to conducting the workshop, the evaluation team will conduct a detailed analysis of the evidence collected through the wider data collection mechanisms – key informant interviews, case studies and review of wider data sources – used for the process evaluation. Evidence from key informant interviews and wider data sources will be thematically analysed against the evaluation questions. Key process-related findings from the case studies will also be drawn out. During this analysis step, we will also review the key findings of our phase 4 primary data collection against the process evaluation findings from the review of Challenge-level evaluation reports conducted in phase 3. Based on this analysis, the evaluation team will identify key overarching findings from the Fund-level process evaluation, which will provide the basis for workshop discussions. While the agenda for the workshop will be refined nearer the time, it is anticipated that the workshop will be structured around the process evaluation themes. An anticipated set of discussion topics is provided in Box 10.

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<sup>63</sup> From an impact perspective, interviews will seek to engage intended users and beneficiaries of the ISCF in order to understand wider perceptions of the Fund's impact.

**Box 10: Outline format for key ISCF stakeholder workshop**

**Outline format for workshop sessions (c.4.5 hours in total – indicative timings for sessions provided below)**

Introductions and discussion of aims of workshop (10min)

Introduction to the evaluation and key emerging findings of the process evaluation (30min)

Breakout 1: Strategy (30min)

Sharing observations in plenary and discussion (15min)

Comfort break (10min)

Breakout 2: Delivery (30min)

Breakout 3: Wider engagement (30 mins)

Sharing observations in plenary and discussion (30 min)

Comfort break (10 min)

Breakout 4: Cross-cutting questions (30 mins)

Sharing observations in plenary and discussion (15 min)

Plenary discussion on key learnings and recommendations for the Fund (30 min)

Thanks and close

It will be important to ensure that workshop attendees are both well-positioned to provide input on the key findings of the evaluation and also well-positioned to act on these learnings moving forward. As such, when identifying participants, the evaluation team will seek to engage personnel with direct involvement in strategic oversight, management and delivery of the ISCF, some of whom may have been interviewed during the key informant interviews. This crossover between key informant interviewees and workshop participants is not considered problematic given the differential focus of the two methods; interviews focusing on obtaining individual perspectives and the workshop focusing on developing a set of overall process evaluation findings and recommendations.<sup>64</sup> We anticipate approximately 10 to 15 participants in the workshop. The final list of participants will be refined in consultation with UKRI.

Our REA highlighted the need for evaluation of mission-oriented R&I to functions as a platform for system-level learning. The evaluation framework has therefore been designed to enable iterative learning from experiences and evolution of the ISCF. Our workshop with key ISCF stakeholders, for example, will engage key personnel involved in the management and delivery of the Fund to review and test key process evaluation findings. In doing so, the workshop will also explore the feasibility of recommendations for subsequent phases of the ISCF.

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<sup>64</sup> Given the potential for crossover, particular care will be taken to ensure that any findings derived from interviews are presented in an anonymised, non-attributable manner.

### 6.5.5. Final analysis and process evaluation reporting

In this final step of the process evaluation, we will bring together all the data collected from the research methods described above and prepare for reporting. A key step here will be to systematically map any collected data not already mapped to the evaluation questions, thereby providing the full evidence base with which to conduct the final evaluation of Fund processes. This will involve triangulating the data collected in relation to each evaluation theme and question, with key observations and learnings drawn as a result. Along with the impact evaluation findings, we will also map our evidence against the ToC and assess the extent to which processes are operating as intended, and whether the evidence supports the assumptions and pathways articulated, informing our wider contributions analysis. These findings will be presented in the form of the draft, and later final, process evaluation report. While the final format of the report will be determined later, it is anticipated that the report will be structured around the ToC process evaluation themes. Throughout the report, case studies will provide examples of the relationship between Fund processes and impacts, including key lessons learned. Dedicated sections of the report will present recommendations for the future management of the Fund and recommendations for future process evaluation of the ISCF post waves 1 to 3.

## 6.6. Impact evaluation

### 6.6.1. Review of wider data sources

As with the process evaluation, we will also seek to review selected wider data that is of direct relevance to our impact evaluation framework. Here, again, our focus will not be to conduct original data analysis, but rather to review data already collated where that data can provide direct insights for our evaluation. In Section 5.3, we have already highlighted the wider data sources, both UKRI/IUK collated data and wider data, that is of direct relevance to our evaluation questions. These include: ISCF core data; ISCF grant classifications and partner data; PCF data; Researchfish data; IUK data on EDI; ONS data; and ISC Grand Challenge metrics data.<sup>65</sup> In Table 23 below, we summarise the types of data that we will seek to analyse during this step, as well as the aspects of our evaluation framework to which this data will be most relevant.

**Table 23: Relevant wider data sources for the impact evaluation**

Type of data	Impact evaluation themes to which data is relevant	Evaluation question(s) to which data is relevant
UKRI/IUK collated data		
ISCF core data	Capacity and investment	To what extent has the ISCF increased UK businesses' investment in R&D?  How much additional public and private R&D investment has the ISCF contributed towards the R&D investment target of 2.4% GDP by 2027?

<sup>65</sup> While the ISC itself is to be wound down, the ISC metrics draw on external data sources which can potentially be used throughout the timeframe of this evaluation.

Evaluation of the Industrial Strategy Challenge Fund

		To what extent has research supported by the ISCF opened up new avenues of investment (de-risking)?
		While the ISCF is place-agnostic, to what extent have the Fund's investment and activities been widely distributed across the UK?
	Connected innovation ecosystem	To what extent has the ISCF increased MIDRI research around the Challenge areas?
		To what extent has the ISCF increased business-academic engagement on innovation activities relating to Challenge areas?
		To what extent has the ISCF increased collaboration between businesses, including increased collaboration between younger, smaller companies and larger, more established companies up the value chain?
	Connected innovation ecosystem	To what extent has the ISCF increased MIDRI research around the Challenge areas?
To what extent has the ISCF increased business-academic engagement on innovation activities relating to Challenge areas?		
To what extent has the ISCF increased collaboration between businesses, including between younger, smaller companies and larger, more established companies up the value chain?		
ISCF grant classifications and partner data (Research Councils only)	Capacity and investment	To what extent has the ISCF increased UK businesses' investment in R&D?
	Connected innovation ecosystem	To what extent has the ISCF increased MIDRI research around the Challenge areas?
		To what extent has the ISCF increased business-academic engagement on innovation activities relating to Challenge areas?
PCF data/Researchfish data	Creating knowledge and innovation pathways	What has been the contribution of the ISCF to new knowledge addressing the Challenges, both within the UK and internationally (publications)?
		What has been the contribution of the ISCF to new knowledge addressing the Challenges, both within the UK and internationally (other)? (Datasets; services; business models; outputs)
		To what extent has the ISCF advanced the readiness of new technologies, products and processes?
		To what extent has the ISCF leveraged knowledge and insights to create increased awareness and understanding among key stakeholders of new technologies and outputs addressing the Challenges?
		To what extent have ISCF outputs (technologies, products, processes, services, approaches etc.) been implemented/adopted within society?
		To what extent has the ISCF contributed to evidence-based policymaking surrounding the Challenges?
		Capacity and investment
		<b>How and to what extent has the ISCF contributed to improved infrastructure to support future R&amp;I investment?</b>

		To what extent has the ISCF contributed to the creation and retention of new businesses and high-skilled jobs?
	Connected innovation ecosystem	To what extent have institutions and clusters participating in the ISCF Challenges been recognised for their expertise within the UK and internationally?
IUK data (EDI survey)/EDI policy documentation and guidance	Capacity and investment	How has ISCF contributed to EDI?
KTN data	Creating knowledge and innovation pathways	To what extent has the ISCF leveraged knowledge and insights to create increased awareness and understanding among key stakeholders of new technologies and outputs addressing the Challenges?
UKRI evidence on place impact of ISCF	Economic impact	While the ISCF is place-agnostic, to what extent have the economic impacts of the ISCF been the widely distributed across the UK?
Other data sources		
ONS data	Capacity and investment	To what extent has the ISCF attracted additional talent and Challenge-associated skills into the UK
ISCF Grand Challenge metrics data	Societal impact	To what extent has the ISCF contributed to health and wellbeing benefits, including quality of life, life expectancy, reduced health inequalities and reduced healthcare costs?
		To what extent has the ISCF contributed environmental and sustainability benefits, including contribution to reduced emissions, progress towards net zero, and growth of the circular economy?
		To what extent has the ISCF contributed benefits to infrastructure and services including broadened access, increased resilience, and increased safety?

### 6.6.2. Key informant interviews

As described above, key informant interviews will be used primarily to inform the process aspects of this evaluation. However, some of these interviews will also be used to inform our impact evaluation. In the impact evaluation framework presented in Chapter 5, we identified a number of evaluation questions where the perspectives of key informant interviews may be particularly helpful in order to address data gaps. These evaluation questions are listed in Table 24 below:

**Table 24: Impact evaluation questions to be addressed through key informant interviews**

Impact evaluation theme	Evaluation question
Creating knowledge and innovation pathways	To what extent has the ISCF leveraged knowledge and insights to create increased awareness and understanding among key stakeholders of new technologies and outputs addressing the Challenges?
	To what extent have ISCF outputs (technologies, products, processes, services, approaches etc.) been implemented/adopted within society?
	To what extent has the ISCF contributed to evidence-based policymaking surrounding the Challenges?
	To what extent has the ISCF enhanced understanding of the effectiveness of mission-oriented R&I programmes and informed more effective policymaking for mission-oriented goals?
Capacity and investment	To what extent has the ISCF increased overseas investment in R&D in the UK?
	To what extent has research supported by the ISCF opened up new avenues of investment (de-risking)?
	While the ISCF is place-agnostic, to what extent have the Fund's investment and activities been widely distributed across the UK?
	How and to what extent has the ISCF contributed to improved infrastructure to support future R&I investment?
	To what extent has the ISCF attracted additional talent and Challenge-associated skills into the UK?
	How has the ISCF contributed to EDI?
	To what extent has the ISCF contributed to the creation and retention of new businesses and high-skilled jobs?
Connected innovation ecosystem	To what extent has the ISCF increased business-academic engagement on innovation activities relating to Challenge areas?
	To what extent has the ISCF increased collaboration between businesses, including between younger, smaller companies and larger, more established companies up the value chain?
	To what extent have institutions and clusters participating in the ISCF Challenges been recognised for their expertise, within the UK and internationally?

An indicative privacy notice and interview topic guide for the key informant interviews can be found in Annex H to this report.

### 6.6.3. Stakeholder impact workshops

To further develop our understanding of the ISCF's impacts, we will hold five stakeholder impact workshops. Structured according to the same five clusters as the expert baselining workshops conducted in

phase 2 (see Section 6.2.3), these workshops will engage both internal and external stakeholders in consideration of the key impacts of the ISCF within each area. The workshops will provide insights relating to each of the key societal impact themes within the ToC (impact on health and wellbeing; impact on environment and sustainability; impact on infrastructure and services), with some workshops providing insights relating to more than one impact theme (see Table 25 below).

To prepare for these workshops, the evaluation team will conduct a detailed analysis of the evidence collected for the impact evaluation. In addition to reviewing the outputs of the phase 3 review of Challenge-level findings, this will include reviewing the insights emerging from other data collection already undertaken in phase 4, including, potentially, key informant interviews, the review of wider data sources, and the econometric and network analysis. Evidence already collected during phase 4 will once again be mapped against the evaluation questions, thereby further developing the evaluation evidence base. Having analysed the data collected, the evaluation team will then examine the evidence relating to each of the five thematic workshops clusters. This analysis will provide a clearer sense of what is known and not known about the impacts of the ISCF within each cluster area. This will then provide the basis for the design of the workshops, wherein we will test emerging findings and explore potential gaps. We envisage that these gaps will particularly be around the longer-term or more indirect impacts of ISCF. Anticipated key topics for the workshops, which will be refined nearer the time, are provided in Box 11 below.

**Table 25: Coverage of the Challenges across the impact workshops**

Workshop focus	Relevance to societal impact theme	Challenges covered
Health and healthcare sector	Health and wellbeing	Medicines Manufacturing Data to Early Diagnosis and Precision Medicine Healthy Ageing Accelerating Detection of Disease
Energy sector	Environment and sustainability/infrastructure and services	Prospering From the Energy Revolution Low Cost Nuclear Industrial Decarbonisation
Manufacturing and sustainability	Environment and sustainability/infrastructure and services	Transforming Food Production Smart Sustainable Plastic Packaging Transforming Construction Manufacturing Made Mmarter Transforming Foundation Industries
Transport and space sector	Infrastructure and services/ environment and sustainability	Self Driving Vehicles National Satellite Test Facility Future Flight Driving the Electric Revolution Next Generation Aero Materials Faraday Battery
IT and data sector	Infrastructure and services	Next Generation Services Digital Security by Design Quantum Technologies Commercialising Quantum Technologies Robotics and Artificial Intelligence in Extreme Environments Audience of the Future Creative Industries Clusters <sup>66</sup>

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<sup>66</sup> Note, this is technically not one of the ISCF Challenges and was funded through wave 1a support. However, we are aware that there is likely to be an evaluation of this portfolio and feel it would be relevant to include this part of the Fund. It may be feasible to also include key stakeholders from other aspects of the wave 1a portfolio. We will discuss this with the ISCF evaluation working group at the start of the baselining phase.

## Box 11: Anticipated topics for impact workshops

### Outline format for workshop sessions (c.4.5 hours in total – indicative timings for sessions provided below)

Introductions and discussion of aims of workshop (10min)

Introduction to the evaluation and key emerging findings of the impact evaluation (30 min)

Breakout 1: Impact of the ISCF on knowledge and innovation (30 mins)

*Note: breakout sessions will be organised by thematic area/sector as far as possible to facilitate shared understanding*

Sharing observations in plenary and discussion (30min)

Comfort break (10 min)

Breakout 2: Impact of the ISCF on capacity and investment (30min)

Breakout 3: Impact of the ISCF on networks and collaboration (30min)

Sharing observations in plenary and discussion (40min)

Comfort break (10min)

Plenary discussion on the overall impact of the ISCF on the economy and society and contribution of the ISCF within the thematic area. How have changes in knowledge, capacity and networks facilitated these impacts? (45min)

Thanks and close

As with the baseline workshops held in phase 2, we anticipate engaging a mix of internal and external stakeholders in these workshops, including relevant Challenge Directors, a sample of award holders, relevant government bodies, academic experts within the thematic area, and representatives from key relevant sector organisations. A key focus of the workshops will be the engagement of intended beneficiaries of the ISCF in order to understand wider perceptions of the Fund's impact. We anticipate approximately 15 to 20 participants in each workshop. Lists of participants will be refined in discussion with UKRI, building on those set out for the baselining phase.

### 6.6.4. Case studies

The impact evaluation will also be informed by six case studies. As described above (see Section 6.5.3), these case studies will be the same as those conducted for the process evaluation. In each case study, examples of ISCF impacts will be explored from both a process and impact perspective.

As noted in Section 6.5.3, in selecting case studies, we will focus on examples where there is evidence that envisioned outputs and outcomes, as outlined in the ToC, have been met. The selected cases will then be used to explore the extent to which these outputs and outcomes (and the enabling environment they create) have either led to, or are in the process of leading to, broader societal impacts. In this way, the case studies will test the assumption that the enabling environment generated by the ISCF investment can catalyse impacts on society and the economy. Our approach to the selection of case studies and the research methods we will use have already been described in Section 6.5.3.

In analysing the case studies from an impact perspective, we will seek to engage intended users and beneficiaries of the ISCF in order to understand wider perceptions of the Fund's impact.

As highlighted by our REA, the literature on the evaluation of mission-oriented R&I highlights the need for recognition of the complexity of the potential impacts that may occur as a result of mission-oriented programmes. The effects of mission-oriented programmes may occur at different stages along the impact chain as envisioned by a ToC. These impacts may also be non-linear, with feedback loops, adaptation and learning occurring across the different parts of the impact chain. The incorporation of case studies into our impact evaluation methods will provide an opportunity to explore in more detail the complex ways in which the ISCF has contributed to impacts. Here, alongside our broader data collection against indicators, case studies will consider how different types of outputs and outcomes have related to and informed one another, as well as how (if at all) different types of output/outcome have contributed to broader societal-level impacts.

#### 6.6.5. Econometric analysis

Econometric analysis will be conducted to understand the impact of the Fund on business performance. The approach will use data-linking to compare how businesses engaged by the Fund (the 'treatment group') perform compared with an objective counterfactual ('control group') of observationally similar businesses. Outcomes include key business performance indicators such as headcount employment, business turnover, business survival and a proxy for productivity (turnover per worker).

The econometric analysis will seek to go beyond a simple aggregation of the business impact evidence gathered by individual Challenges, and explore instead the impact of the ISCF both as a whole, and potentially at other levels of disaggregation such as the Grand Challenges.

The results of the analysis will be a key input into the economic evaluation (see Section 6.6.7). The econometrics is therefore concerned with estimating key outcome additionality measures of the ISCF programme. Based on the logic model developed for the programme (see Section 3), the analysis will provide particular evidence relating to the 'impact on the economy', including 'growth of UK businesses' and 'increased productivity'.

## Box 12: Discussion of sources and methods for the econometric analysis

The choice of outcome metrics is based on the information available in the key administrative data source, the Business Structure Database (BSD, see below), and reflects our confidence based on past experience that it is feasible and practical to estimate business-level impacts using this source of data. We also chose these as key outcomes to measure the economic impact of the ISCF.

In principle, similar methods can be used to look at intermediate outcomes of the ISCF, in particular around knowledge and innovation pathways, such as the impact on business innovation activities and innovation outputs like patents. Some studies (e.g. Raschid et al. 2020) have used Orbis, a commercial dataset collected by Bureau van Dijk, which gathers firm-level patent statistics to explore the impact of policy interventions on innovation performance. At present we do not have access to Orbis, though if access can be provided we can in principle include this within the data matching and linking process (see below) to include patenting both as an outcome of interest and as a potential control variable in any econometric matching model. We also note that, in general, patents are seen as a highly imperfect measure of innovation impacts, in part because not all innovation is patentable, and in part because patents can sometimes be defensively filed for very minor innovation that is not really consistent with the transformative change the ISCF is seeking to promote (see e.g. Carlino and Kerr 2015).

An alternative approach is to use additional business-level microdata to explore innovation-related activities and outcomes, in particular the UK Innovation Survey (UKIS). The most recent iteration of the UKIS, published in 2020, looks at data between 2016 and 2018 with a sample of around 14,000 businesses. We do not, however, recommend conducting a data linking exercise and business-level analysis using UKIS: the relatively small sample sizes mean that the number of businesses we observe in the survey in any given wave that have received support from the ISCF is likely to be quite low, meaning any microeconomic analysis is unlikely to have sufficient statistical power. Another data source to consider would be R&D tax credits, as collected by HMRC. This gives a continuous measure of innovation activity, and due to the tax incentives, should be complete for qualifying innovation activities. However, using the data would be subject to an application process for HMRC granting access. This typically requires the research to be closely aligned with HMRC functions, which is unlikely to be the case for this evaluation.

Other outcomes of potential interest relate to productivity. As stated above, turnover is an imperfect measure of productivity, as firms may use differing levels of inputs in relation to producing the same amount of output. The obvious further data source to consider in this context would be the Annual Business Survey (ABS), which covers around 73,000 businesses per annum. However, only firms of 250 or more employees are captured longitudinally, which limits the scope of analysis and feasible sample sizes. We also considered using Annual Survey of Hours and Earnings (ASHE), a randomised sample of 1 per cent of employees through their workplaces, to explore whether there is any move toward higher-paid jobs. However, there is scope for considerable measurement error with this approach, as the randomly sampled individual in this data may be a poor proxy for firm-level pay. Only very large firms would have enough workers sampled in ASHE to give a reliable measure of firm-level pay, so this data is unlikely to be useful in this context.

## Anticipated approach

We plan to conduct a combination of propensity score matching (PSM) and difference-in-difference (DiD) analysis as our main econometric approach. These quasi-experimental methods, based on linked business administrative data sources (such as the ONS Business Structure Database, BSD), have been used in recent evaluation work to understand the impact of innovation-related interventions on business performance (Frontier Economics 2017, Vanino, Becker and Roper 2018), and are now becoming an increasingly established part of the toolkit for evaluation. The approach is also in line with methods identified in our REA which used PSM and DiD to assess the impact of mission-oriented research grants on researchers' performance, measured in terms of publications and citations (see the box below). The approach comprises several steps which we summarise below.

### Step 1: Obtain data on the businesses supported by the ISCF

The econometric analysis will require us to link data on businesses supported by the ISCF programme with administrative data on business performance. We therefore need to gather this data in order to define the 'treatment group'. Early discussions with ISCF stakeholders suggest that this will require a combination of data collected directly from the individual Challenges, supplemented with data that may be available centrally (for example, businesses that received CR&D funding as part of a Challenge fund).

Primarily, we will require information on the businesses that received support from the ISCF programme. However, we are aware that data is also held on unsuccessful applicants which may be useful in determining a potential control group during the econometric analysis (see Step 5). We will explore further the potential of using these data in the next stage of the study.

In our REA, we highlighted the econometric approaches used in Shimada et al (2017) to assess the impact of mission-oriented research grants on researchers' performance. This approach is very similar to our proposed methodology for the ISCF outlined below. Shimada et al (2017) use a *difference-in-differences* technique to compare the performance of researchers who received a grant (the 'treatment group') with that of researchers who did not (the 'control group'). Whilst the outcome variables of interest in the research (publications and citations) are different to the business outcomes we are assessing for the ISCF, the use of the DiD technique is very similar. A key aspect of the approach in Shimada et al (2017) is the method used to identify the 'control group' through *propensity score matching*. This involves assessing each researcher's probability of being awarded a mission-oriented research grant, based on certain characteristics. Each researcher receiving a grant can then be matched to one or more researchers who did not receive a grant but share the same characteristics. Our methodology follows the same type of approach to analyse the ISCF business outcomes, as described in Step 5 of our method below.

While the use of business-level microdata for policy evaluation is now well-established, one limitation is that the approach seeks to identify the impact on supported organisations but cannot identify the wider spillover or sectoral-level impacts that are an important part of the ISCF. Evidence for these effects may be seen in Challenge-level evaluations and established through case studies and key informant interviews conducted for the Fund-level evaluation.

Another quantitative approach that could provide some insights here, is to analyse business data at the sector/industry level rather than the firm level. This requires identification of the sectors most 'treated' by the ISCF and comparing trends (either pre- and post-ISCF and/or comparing with 'control' sectors that are not heavily influenced by the ISCF) at sector level in outcomes of interest. These could include turnover, GVA and productivity (gathered from aggregation of the BSD and sector-level data published by ONS), or innovation outcomes measured in the UKIS.

At this stage, it is not possible to be definitive on the feasibility of this approach. In particular, we would need to assess whether it is possible to identify treated sectors on the basis of information about the firms supported by the ISCF. By aggregating information on firms that are supported and linking them with BSD, we can construct measures such as the proportion of firms in given standard industrial classification (SIC) codes – the current standard definition used to define business sectors – that are supported by the ISCF. We can then use both trend and DiD approaches to assess quantitatively whether sectors more heavily influenced by the ISCF perform better in terms of innovation or business outcomes. Alternatively, treated sectors can be identified *ex ante* using SIC-based definitions of the sectors intended to be influenced by particular sectors, which are set out in some evaluation frameworks.

To the extent that a set of treated sectors can be identified and agreed on, in principle sector-level analysis can be conducted, though interpretation would need to be done with care. The diversity of sectors influenced by different Challenge funds means that it is not necessarily possible to consider 'non-treated' sectors as a reliable counterfactual for sector-level performance absent the funds. In addition, sectors are likely to benefit from other investment (public and private) which will affect performance. Finally, the approach may not capture spillovers *across* sectors.

At this stage, we do not have a clear definition of what we mean by ‘support’, and further definition and clarification of this will only be possible once we have access to at least some data. Given that we are seeking to evaluate the impact on business performance, we suggest that support, or ‘treatment’, should be interpreted as relatively intensive forms of business support provided by the Challenges, for example:

- Participation in a CR&D or other R&I funding programme delivered by a Challenge
- Making use of scale-up or other similar facilities and infrastructure funded by a Challenge
- Receiving significant bespoke advice or support to promote innovation and business growth

However, it would in general be useful to know about all forms of business engagement that Challenges have conducted, even if ‘lighter-touch’ (e.g. businesses that attend events), as this may help to construct different definitions of treatment and to identify potential control groups. Depending on the completeness of the data we can obtain, we may only be able to conduct the analysis for a particular type of support offered through the ISCF, such as CR&D funding.

Ideally, the treatment data should be organised by episode of support rather than by individual organisation. For example, if a firm was part of a CR&D project and then used scale-up facilities, we would like to have these recorded as two separate episodes of support.

Table 26 below summarises the information we would ideally collect for the econometric analysis. We also indicate whether the information is ‘essential’, or ‘helpful’ in that it would improve the quality of any econometric analysis, but not critical to the analysis being possible.

**Table 26: Information requirements for econometric analysis**

Information required	Essential or helpful?
<b>Information regarding the business</b>	
Company name	Essential
Company address including postcode	Helpful
Company reference number (key linking variable)	Essential
Key contact point relating to the support (name and role)	Helpful
The department/branch engaged	Helpful
Business demographic information such as employment, turnover, etc. at the time they were engaged by the Challenge	Helpful
<b>Information regarding the support provided</b>	
Start date (at least year)	Essential
End date (at least year)	Essential
Type of support provided	Helpful
Value of support provided to the business (where relevant, in cash and/or estimated in kind)	Helpful

## Step 2: Clean data and develop a treatment dataset

The data received from each Challenge (and central ISCF sources) will need to be compiled into a single treatment dataset which will contain information on each episode of business support provided by each Challenge. A possible ‘variable list’ could look like this:

- Business name
- Business address

- Company House Reference Number (CRN)
- Challenge name
- Business turnover (continuous or coded)
- Business employment (continuous or coded)
- .... (other business demographic variables)
- Type of support (coded into groups)
- Year/date support began
- Year/date support ended
- ... (other variables describing the support provided, e.g. value, scale, quality)

If it is not possible to obtain ‘treatment-level’ data from some Challenges, the dataset could be compiled at the company-/Challenge-level with the ‘type of support’ variable coded to allow ‘multiple episodes’ of support as an option.

However, it will be critical for the analysis to separately identify businesses’ engagement with each individual Challenge (i.e. there could be multiple observations of each firm in the treatment dataset).

### Step 3: Link treatment dataset with the Business Structure Database

We propose to use the BSD as the key administrative dataset to provide data on business performance and demographics.<sup>67</sup>

Linking the treatment dataset with the BSD will generate an analytical dataset on which we can conduct the econometric analysis.

The BSD contains data on all businesses above either PAYE or VAT thresholds. However, it will exclude very small businesses (usually sole enterprises). It captures the vast majority of business employment and activity.

Among other characteristics, the BSD includes firm-level information on:

- Turnover

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<sup>67</sup> See [http://doc.ukdataservice.ac.uk/doc/6697/mrdoc/pdf/6697\\_user\\_guide.pdf](http://doc.ukdataservice.ac.uk/doc/6697/mrdoc/pdf/6697_user_guide.pdf) for key documentation. Access to microlevel data can be attained for eligible research projects through a Secure Datalab, though access outside of the Datalab is possible and Frontier Economics has the necessary approvals to access the data from their offices. Applications for projects using the secure data must be made to ONS and be approved by a Research Accreditation Panel. Approval is based on clarity that secure microdata is required for the work, that the researchers involved have the necessary training and expertise in handling secure data, that there is a public interest in the findings, and that the findings will be made available. Based on past experience, we do not envisage any issues with approval for this project. We will make applications for the work well in advance of phase 4 to ensure time necessary for project approval to be granted, and work closely with UKRI in developing the project application approval. See <https://www.ukdataservice.ac.uk/get-data/how-to-access/accessecurelab.aspx>

- Employment (headcount figure)
- Legal status (whether the business is a company, sole proprietor, partnership, public organisation or non-profit-making body)
- Ownership (immediately and/or ultimately foreign-owned)
- Location (postcode sector)
- Industry (five-digit SIC codes)
- Year of birth

The BSD is a secure dataset and can only be accessed via secure data settings including the ONS Secure Research Service and institutions with agreed access rights from secure data environments in offices. Remote access from home is also possible. Researchers using BSD need to have approved researcher status with ONS and pass a training exercise. Frontier Economics have agreements in place with ONS to access the secure data from their London office and for researchers to access the data from home via secure networks. We also have more than 20 researchers with approved clearance to use secure data.

Ahead of this stage, we will need to apply to ONS for permission to access BSD. This requires us to complete an application which will then be approved by a quarterly panel that meets to review new applications. We will work with ONS and the ISCF team to ensure this application meets all the criteria needed for project approval.

Linking the treatment dataset with the BSD will primarily rely on CRN as the linking variable. This is a unique Companies House identifier which matches the firm supported by the ISCF to the data on that firm's performance in the BSD.

Linking via the CRN is normally done by the ONS, with a linked dataset made available to the research team. Recent experience suggests that successful match rates in excess of 90 per cent should be expected, assuming that CRNs are captured correctly. Where CRNs are missing, or the match is unsuccessful, ONS can also conduct 'fuzzy matching' on the basis of the company name and address. Success rates for such matching are normally substantially lower. In addition, while CRN matching is done by ONS at no cost, there is normally a charge associated with fuzzy matching. We will therefore review the need for this on the basis of CRN availability and match rate.<sup>68</sup>

The CRN will identify the business with an 'enterprise' in the BSD. An enterprise is the smallest combination of organisational units producing goods or services, which benefits from a certain degree of autonomy in decision-making. This is the definition of a business that has been used in past econometric analysis of business performance.

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<sup>68</sup> Approval of projects using secure data requires estimation of any data linking costs to be made and approved in advance. We will therefore work with UKRI and the individual Challenges to obtain the firm-level data for linking in advance to estimate the number of firms where CRNs are available and the number where fuzzy matching will be required.

Based on past work with BSD, our understanding is that the information on business outcomes is normally lagged by around one year, given various delays in updating the underlying datasets which feed into the BSD. This means, for example, that the dataset labelled BSD 2020 will likely contain information on a businesses' employment and turnover for 2019. We therefore need to adjust this when linking the BSD with the treatment dataset. Where we observe a firm that is supported in 2019, for example, we will want to associate that support with the 2020 BSD dataset.

#### Step 4: Develop an analytical dataset

Having linked the support dataset provided by the ISCF with the BSD, we then need to shape the data into an analytical dataset on which descriptive and econometric analysis can be conducted.

This involves:

- Developing a set of firm-level characteristics based on BSD variables (e.g. measures of size, geography, sector). These will be used to match treatment and control businesses (see Step 5). We will conduct exploratory analysis to assess the best way to define these variables, needing to balance parsimony (in order to keep the dataset manageably large for feasible implementation of the econometrics) with enough precision in the definition of business characteristics to be confident that the matching process will identify a robust control group.<sup>69</sup>
- Developing a set of outcome variables based on the BSD. We envisage this to include: survival (a binary variable indicating whether the firm is active in a given year),<sup>70</sup> employment (headcount metric) and turnover.<sup>71</sup> A crude productivity metric (turnover per employee) can also be defined.
- Developing a set of treatment indicators based on the treatment set. These will be binary variables taking a value of 1 in years where the firm receives a certain treatment.

We will explore options for defining these treatment indicators based on the data received. At the simplest level, the indicator will simply reflect whether or not the firm received any form of support from any Challenge in that year. Depending on the information available about the period of support (e.g. when a

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<sup>69</sup> We will include data from other sources to supplement the BSD and define additional characteristics, in particular to help increase the information we observe about firms which might relate both to whether or not they are supported by the ISCF and their outcomes. This will help validate the critical Conditional Independence Assumption required for the PSM approach to be valid (see below). This could include: receipt of support from other public funding mechanisms, and whether firms are known to be R&D active proxied by their inclusion in the Business Enterprise Research and Development (BERD) sampling frame.

<sup>70</sup> It is essential to understand whether treatment impacts on survival in order to be able to analyse precisely the impact on turnover and employment. These outcomes are, by definition, only observed for firms that remain in business, implying that estimating the impact of treatment on turnover or employment also needs to condition on survival. However, if treatment affects survival, the selection of surviving treated firms is different from the selection of surviving non-treated firms. Hence, even if treatment is essentially random conditional on observed characteristics (that is, the conditional independence assumption holds), random assignment will not hold conditional on survival. See further discussion in Frontier Economics (2017), *op cit*.

<sup>71</sup> Note that turnover and employment *after* treatment are outcomes, whereas turnover and employment *before or in the year of* treatment are treated as firm-level characteristics for the analysis.

CR&D project began and ended) we may assign treatment only to the first year of support, or for treatments which last many years, we may assign treatment in every year.

More complex treatment indicators may vary by the type of support, or whether support was received from a particular Challenge (e.g. if we wanted to segment the analysis by Grand Challenge, we could set the indicator to 1 only if the firm received support from particular groups of Challenges). Measures of ‘intensity’ of support can be constructed based on the value of support (for financial support) or to reflect businesses in receipt of support from multiple Challenge funds.

The analytical dataset is therefore a panel dataset comprising firm-year observations of characteristics, treatment status and outcomes.

At this stage, we would suggest conducting preliminary descriptive analysis to better understand the nature of the data and inform the specific design and approach of the econometrics. This will complement any network analysis we conduct (see Section 6.6.6). Possible questions we will take to the data include:

- How did the number of businesses supported change over time? How does this break down along key business demographics such as size, region and sector?
- How did the type of support provided change over time?
- How does the profile of businesses supported by the ISCF (by size, region, sector, etc.) compare with the wider UK business population? Are there differences within sector?

We will also conduct data cleaning. Based on past experience, we recommend:

- Excluding businesses reporting zero employment or turnover in any year observed, as this indicates misreported information
- Excluding businesses in the top percentile of employment or turnover values, or over a data-driven threshold, given difficulties in matching very large businesses
- Excluding certain sectors such as public administration and households as employers (as these are outside the private sector) and other SICs which are rarely treated
- Excluding businesses which appear to cycle through periods of activity and inactivity as these are likely anomalous patterns in the data.

We will provide justification for any proposed data cleaning and consider carefully the implications for the analysis, documenting the number of excluded businesses and their characteristics.

### Step 5: Conduct econometric analysis

The econometrics aims to identify the impact of ISCF support on business outcomes. To do this credibly, we need to identify a robust counterfactual for business performance in the absence of ISCF support.

The most conceptually appealing approach is to compare outcomes for businesses who receive support (the treatment group) with businesses who did not (the control group), treating the latter as a counterfactual. However, businesses do not receive support at random: they select into applying for support, and those who receive support are further selected from those applying (where support is assigned competitively). Given these hurdles, it is highly unlikely that simply looking at outcomes for non-supported businesses alone

would provide a suitable counterfactual: they will differ systematically from supported businesses in a number of ways.

We therefore adopt a PSM approach (see Rosenbaum and Rubin 1983). This involves:

- Modelling the likelihood that a firm with a given set of characteristics is treated – the propensity score. This is normally done through a matching model. In most cases where we have binary treatment variables this is done using Probit or Logit equations, with a set of control variables derived from the firm-level characteristics in the analytical dataset. The model will be run separately for each treatment indicator and each treatment year. The matching model takes the form:

$$P(T_{it} = 1) = \alpha + \beta'X_{it} + \varepsilon_{it}$$

where the dependent variable is the probability that firm  $I$  is treated (receives ISCF support) in year  $t$ , and  $X$  is a set of firm-level variables expected to affect the probability of treatment.

- Matching all treated businesses to one or more control businesses based on the propensity score. A range of econometric approaches to matching exist and, as part of sensitivity testing, we will explore whether our conclusions are affected by different approaches. Past experience suggests that a ‘radius matching’ approach, which treats all control businesses with a propensity score within a narrow bandwidth of the score for a given treated businesses as part of the control group, is effective.
- Computing the average outcome for the treatment and matched control groups. The difference between them gives the Average Treatment Effect on Treated Businesses (ATT).
- Netting off the average difference between the treatment and control groups at baseline (pre-treatment) to give the DiD estimate of the impact of ISCF support on the outcome

The outcomes of interest from the evaluation metrics that can feasibly be measured with the available data are survival, turnover, employment and productivity a certain number of years after treatment. How many years it is possible to estimate will depend on the sample sizes available. We expect (see below) to conduct the econometric analysis in 2024, by which time outcome data should be observable up to 2022 or 2023. Assuming that the earliest year in which any firm was treated by the ISCF was 2016, we could in principle observe outcomes up to six or seven years after treatment. However, in practice, the number of businesses treated in 2016 is likely to be low, and more robust estimates are only likely to be available for shorter post-treatment periods. For example, if we are interested in the impact of ISCF support on employment two years later, we can look at outcomes in 2018 for those treated in 2016, outcomes in 2019 for those treated in 2017, and so on. This increases the sample sizes available for analysis (see Figure 5 below) because we have many years of treatment data we can use. In addition, when looking at longer post-treatment periods, we will only be able to identify the effects for the earliest Challenges to be established, which may not be representative of the wider Fund (see Table 1).

Figure 5: Relationship between treatment year and outcome year in terms of post-treatment periods we can measure using econometric analysis

		Outcome year						
		2017	2018	2019	2020	2021	2022	2023
Treatment year	2016	t+1	t+2	t+3	t+4	t+5	t+6	t+7
	2017		t+1	t+2	t+3	t+4	t+5	t+6
	2018			t+1	t+2	t+3	t+4	t+5
	2019				t+1	t+2	t+3	t+4
	2021					t+1	t+2	t+3
	2021						t+1	t+2
	2022							t+1
	2023							

Note: t represents the year of treatment and e.g. t+1 represents 1 year after treatment.

**Box 13: Approach to dealing with key econometric challenges**

*Ensuring comparability of treatment and control groups*

We will conduct statistical ‘balancing’ tests of whether the control group is observationally equivalent to the treatment group. This is a key assumption of the PSM approach, known as the conditional independence assumption (CIA). This states that, for businesses with a given propensity score, the expected outcomes without treatment would be the same. By testing whether there are statistically significant differences between the treatment and control groups in terms of any of the variables used to match the two groups, we can go some way to confirming that the CIA is maintained.

However, it is only possible to test the CIA based on observable information about businesses. We will conduct a ‘bounding’ test based on Rosenbaum (2002) to assess how far unobserved selection effects may be an issue in our findings. This is a statistical robustness check which tests how much unobserved selection we would need to assume to eliminate any significant treatment effects estimated in the model. Assuming that any unobserved selection effects are positive (e.g. factors such as firms’ willingness to grow positively affect both seeking support from the ISCF and subsequent business performance), we can ask questions such as ‘would any positive, significant impacts of ISCF support still be significant if there were unobserved factors that increase the odds of receiving support by a factor of 2, 3, ...?’ While the test does not test for the presence of these effects (which, by definition, are unknown) it gives us evidence on how sensitive positive findings are to unobserved selection.

We will conduct visual testing of the common trends assumption necessary for DiD analysis. This says that trends in the outcome variables of interest before treatment should be the same for the treatment and control groups. While formal tests of this assumption cannot be carried out, we can visually inspect the data to assess whether or not the assumption appears to be valid.

*Accounting for possible spillovers to non-beneficiaries*

To the extent that benefits of the ISCF spillover to firms that are not directly supported, business outcomes for the control group may be positively affected by ISCF. Assuming that the spillovers are positive, this would bias down the econometric estimates of ISCF impact. While it is unlikely that we can ‘adjust’ findings for this, we can triangulate with other evidence of spillovers from the Challenge-level and Fund-level evaluations to qualitatively assess the importance of this bias in helping incorporate the econometric results into the wider contribution analysis.

#### *Accounting for possible survival biases*

As highlighted above (see footnote 59), we include firm survival as an outcome metric primarily to ensure that we can fully interpret any evidence on the impact of the ISCF on business turnover and employment. Frontier Economics (2017) note that where a programme positively affects business survival, there are potential biases in the interpretation of wider business impacts. The *sign* of the bias is unclear. One possibility is that programmes like the ISCF help productive, fast-growing firms overcome early barriers to survival (e.g. by helping them access finance). As a result, the sample of firms that we observe to survive in the data includes some fast-growing firms which, absent the ISCF, would not have survived. This leads to a *positive* bias in any employment or turnover effects. Alternatively, it may be that programmes like the ISCF can temporarily 'prop up' slower-growing firms that otherwise would have not survived. This leads to a *negative* bias in any effects.

Because the scale and sign of any survival biases is not clear ex ante, our approach includes:

- Conducting exploratory regression analysis to assess where survival biases are likely to be larger or smaller, by regressing survival outcomes on a set of firm-level covariates interacted with treatment indicators. Based on this, we will propose any stratification or initial selection of business types to take to the full analysis where we expect survival bias to be minimal (for example, focusing the analysis on older, more established firms where survival rates are likely to be high even absent the ISCF) and outline trade-offs of such stratification (for example, we may fail to capture impacts on younger firms that could be a key part of the ISCF treatment group)
- Testing for the presence of survival effects using the econometric methods outlined above, implementing any stratification suggested by the exploratory analysis. If we find no effect, we can be confident that any turnover and employment effects are not subject to survival bias
- Where we do find survival effects, triangulating with other evidence gathered from elsewhere in the ISCF and Challenge-level evaluations to qualitatively assess whether survival biases are likely to be positive or negative (for example, evidence that ISCF has helped overcome barriers to young firms accessing finance would support the positive selection hypothesis, suggesting that the scale of employment or turnover effects identified in the econometrics should be adjusted downwards before the figures are used in the economic evaluation)

#### *Accounting for possible displacement effects*

By comparing business outcomes for observably similar treatment and control groups, the aim is to give credible and robust estimates of additional impact of the ISCF. One risk is around displacement: if supported firms can attract resources (in particular labour) from unsupported firms, then treatment effects observed in the econometric analysis could simply reflect this phenomenon, but not necessarily represent net additional economic output.

As we outline in Section 6.6.7 below, it is probably inaccurate to simply presume that any employment benefits in the treatment group benefitting from the ISCF support simply represents displacement of activity rather than net new jobs, or higher-quality jobs, given the economic benefits of moving resources to more productive uses, potential regional benefits and the potential for spare economic capacity, particularly post-Covid. Equally, however, a presumption of zero displacement is also probably inaccurate. We will therefore triangulate with other findings from the ISCF and Challenge-level evaluations to consider the potential scale of displacement in quantitative (for example, drawing on any survey data conducted at the Challenge-level that attempts to quantify displacement effects) or qualitative terms. As with other factors

discussed here, we will then assess whether, on balance, econometric findings ought to be adjusted to account for the possible presence of displacement.

#### *Accounting for other support policies*

It is likely that many of the firms receiving support from the ISCF are also in simultaneous receipt of other public funding or have benefitted from past support from other programmes. As a result, interpreting a positive treatment effect as the 'impact of ISCF' may overstate the additionality of the ISCF.

As far as possible we will match into our analytical dataset information on other funding received by the firm from public sources. We anticipate as a minimum that this will include datasets available from UKRI on firms receiving funding grants, though we will also explore other databases that may be available (e.g. from devolved administrations). The critical factor is whether the information can be linked, via CRN, to our analytical dataset, and whether available databases are robust and complete. By merging information on other support received into our dataset, we can construct measures of other support received to include in the econometric specification (ranging from simple dummy variables reflecting whether a firm has received support within a certain period before their interaction with the ISCF, to more complex measures of the value of support, depending on the quality of data available).

We anticipate that we will not have complete support histories available for each firm from all public funding sources. As a result (assuming these other investments also have positive effects on survival, employment and turnover), there is still likely to be a degree of positive bias in our econometric findings which we will consider in interpreting the results for use in the wider evaluation.

#### Step 6: Express impacts in terms of GVA

For the economic evaluation, we will require estimates of the impact of the ISCF on GVA. However, GVA is not observed in the BSD.

We will therefore derive a set of multipliers to convert turnover to GVA. These will be derived by sector (SIC) and year, based on published ONS estimates of GVA and turnover by sector from the Annual Business Survey.<sup>72</sup> We will match these into the analytical dataset to convert firm-level turnover to estimated GVA. While these will be imperfect, as the multiplier will not vary within a sector/year combination, in our view this represents the most pragmatic approach.

#### Timing

We propose to conduct the econometric analysis in 2024 as part of phase 4 of the evaluation. This will allow the maximum time to elapse for post-treatment outcomes to be observed. We will continue to scope, test and validate our approach before then.

However, we will likely need to collect final treatment datasets from individual Challenges at different times – either in their final year, or in the three to six months before we conduct the analysis, whichever is earlier.

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<sup>72</sup>See

<https://www.ons.gov.uk/businessindustryandtrade/business/businessservices/bulletins/nonfinancialbusinesseconomy/ukandregionalannualbusinesssurvey/2018revisedresults> for the current data.

### 6.6.6. Network analysis

Building on the data used to conduct the econometric analysis, we will also carry out a network analysis of the ISCF. Network analysis looks at data from the perspective of the connections between entities and draws insights from the structure of those links. In the case of the ISCF, it can be used to investigate the links between organisations engaged, and the individual Challenges. The network analysis will complement descriptive statistical analysis conducted as part of the econometric work (see Section 6.6.5). It goes beyond analysis of business impacts to look at wider networks (e.g. academic and third sector) enabled and supported by the ISCF.

From the perspective of the logic model, this analysis will provide particular evidence on the ‘connected innovation ecosystem’ strand of outputs, short-term outcomes and long-term outcomes.

We will consider two approaches to investigate interactions supported by the ISCF:

- Visualisation of the network
- Statistical analysis of the structure of connections, network analysis can help investigate how organisations interact via the Challenges

We note that the network analysis will yield descriptive evidence of networks and connections that exist within the ISCF. However, it will not by itself provide causal evidence of whether or not these networks are fully additional as a result of the ISCF. Additional insights from the Challenge-level evaluations and case studies will be needed, and triangulated with the network analysis to arrive at overall conclusions about how the ISCF has contributed to these outputs and outcomes.

### Data requirements

The data required to conduct network analysis is similar to the data required on businesses for the econometric analysis (see Section 6.6.5). However, we would also require similar data about academics, third and public sector organisations engaged by the Challenges. Relative to the information required to conduct econometrics, it is also generally more important to have information about the individuals engaged, where possible, as well as the organisations. This is because, in principle, we can consider networks of people as well as networks of organisations. Put simply, it may be that we identify that two Challenges are working with the same higher education institution (HEI) or even the same department within it, but this might not necessarily reflect a ‘connection’ between the Challenges via this HEI if the people involved are very distant. The more information we know about the individuals involved, therefore, the more confident we can be that links between organisations that connect via the Challenges are genuine.

Table 27 below summarises additional information we may therefore want to collect on top of the data needed for the econometrics to support the network analysis.

**Table 27: Information requirements for network analysis**

Information required	Essential or helpful?
<b>Information regarding academia</b>	
The institution engaged	Essential
The department within the institution engaged	Essential
The specific academic(s) engaged	Helpful

Information regarding public and third sector organisations	
The name of the organisation, department, etc.	Essential
The name of the individual(s) engaged	Helpful

As with the econometrics, information on the nature of support provided is also required. Where relevant, the value of the support may provide a way to quantify the ‘strength’ of any links in the network and therefore prove particularly helpful for the network analysis.

### Visualisation of the network

As a starting point, the ISCF can be visualised onto a network. An exemplar of a visualisation is shown in Figure 6 below, to represent the sort of diagram that can be produced.

**Figure 6: Example visualisation of a network**



Visualisation of the network can take a number of forms.

A first approach would be to explore connections between Challenges. This involves representing each Challenge as a ‘node’, and drawing up weighted links between pairs of Challenges, where the weight on the links is the number of organisations that have been involved in both Challenges (or, potentially, the value of support where this is observable). This will provide a visualisation of which Challenges are most closely connected to each other, based on the organisations they support. With 24 Challenges corresponding to 24 nodes, this would be a relatively simple visualisation, clearly setting out the collaborative relationships between Challenges.

This approach is particularly useful to inform thinking about relationships between Challenges and whether natural ‘segments’ of closely connected Challenges are forming. In principle, we may expect these to relate to the higher-level Grand Challenges (e.g. Challenges that most closely relate to the Future of Mobility Grand Challenge might be expected to be closely connected). In practice, we may observe other groupings

or clusters forming based on common connections to organisations engaged. This could inform case study selection, and can also be useful evidence for those individual Challenges to ensure they are aware of, and fully exploiting, possible synergies with other Challenges.

A second approach would be to explore connections between organisations supported by Challenges based on common connections to individual Challenges. If organisations (and/or individuals within them) are engaged with multiple common Challenges, there may be stronger connections between them (regardless of whether or not those common engagements are part of formal collaborative projects). This would set out the collaborative relationships between participants and help identify organisations that play central roles in the ISCF network.

Due to the large number of organisations involved, this visualisation could become very intricate, so it would be particularly important to compliment the visualisation with statistical analysis (see below).

Finally, a hybrid approach generates a network with nodes of both Challenges and organisations, where organisations are linked to Challenges if they were involved with them. The weight on the links could represent the financial value of the organisation's participation in the Challenge. This would be the most disaggregated visualisation of the network, and would show the most information. However, it may be more difficult to interpret visually. Supporting statistics would therefore be important.

Any of these visualisations could be explored separately for organisation type. For example, it would be possible to explore whether the 'clusters' of related Challenges look the same where we consider common business beneficiaries and common academic beneficiaries.

The visualisations could also be done at different points in time to assess whether connections between Challenges and/or organisations change – for example, as new waves of Challenges begin to deliver activities, or as Challenges mature.

### Statistical analysis of networks

We can undertake a statistical analysis of the network data. This will go beyond a straightforward visual inspection of the networks to provide a more rigorous interpretation and analysis. The precise scope of any analysis will need to be developed further based on data provided by the Challenges and the central ISCF team. However, relevant concepts from network analysis that could be explored include:

- **Connectivity:** can be measured by the average number of connections of each node (average degree) or as the minimum number of nodes that need to be removed from the network to separate the remaining nodes into isolated subgraphs. In looking at the network of Challenges, for example, connectivity can provide a measure of how cohesive and interrelated the 24 Challenges are within the ISCF.
- **Centrality:** measures the most important nodes in the network. One measure of centrality is the 'betweenness' centrality, which measures the number of times a node occurs along the shortest path between two other nodes. Centrality can provide us with an indication of which Challenges have had most interaction with other Challenges, or which organisations have the most connections with others via the Challenges.

- Community detection: examines whether the nodes of the network can be grouped into sets of nodes such that each set is densely connected internally. Community detection can be useful to examine whether some Challenges appeal to the same types of organisations, and provides a statistical approach to identifying closely related sets of Challenges or organisations.
- Clustering: examines the extent to which nodes in the network cluster together. Given that one node is linked to two other nodes, it measures the probability that those two other nodes are also linked together. As with community detection, clustering can be helpful to examine whether some Challenges have attracted the same types of organisation.
- Network distance: provides a measure of the ‘cohesiveness’ of the network. One measure of network distance is the network diameter, which measures the distance between the two most distant nodes in the network. Network distance can be used to identify which Challenges are relatively isolated, and attract a distinct type of organisation, which can be complemented with qualitative insights to understand whether or not this is intended.

Any of these measures could be compared over time to assess trend evolution in the ISCF network.

## Timing

We anticipate that a final network analysis would be conducted in phase 4 to sit alongside the econometric analysis. However, it would be possible to conduct earlier analysis, as part of the baselining (phase 2) and interim evaluation (phase 3), both to act as a proof of concept, and to provide earlier insights which might inform Fund-wide thinking at an earlier stage. This could include identifying clusters of Challenges that are unanticipated to help ensure possible synergies are being explored. The final evaluation analysis (phase 4) will also draw on the earlier network analysis to give some indications of how the ISCF network has changed overtime.

### 6.6.7. VfM analysis

The purpose of an economic VfM assessment is to understand how the benefits that can be attributed to the ISCF compare with the costs of the programme. This analysis will be undertaken consistent with the principles outlined in the latest Green Book appraisal and evaluation guidance.<sup>73</sup>

In this section we set out how the principles of economic valuation approaches apply to the specific context of the ISCF and the implications for taking the analysis forward. This is intended to provide an initial framework for our approach, which will be further refined in light of emerging evidence and findings over the course of the evaluation. The overall valuation of the costs and benefits will require a mixed-methods approach, monetising impacts where possible, while also drawing on broader evidence from across the wider evaluation, and reflecting the areas of uncertainty.

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<sup>73</sup> <https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-government>

We first set out the broad types of costs and benefits that are relevant to the ISCF programme. We then outline five key principles for economic valuation assessment from the Green Book and how, at this stage, we understand them to apply to the evaluation of the ISCF programme.

## Types of costs and benefits

Our analysis will focus on two aspects: capturing the costs and benefits from each Challenge Fund (as determined by the individual Challenge-level evaluations); and determining the extent to which costs and benefits are enhanced as a result of the operation of the ISCF as a coordinated programme.

There are six broad categories of costs of the ISCF programme that are described in Table 28 below. We anticipate that information on these costs will be available from a combination of the individual Challenges and the central ISCF.

**Table 28: Costs of the ISCF programme**

Cost	Description
Programme administrative costs	Costs of running and operating the ISCF programme as a whole, incurred principally by UKRI
Challenge administrative costs	Costs of operating individual Challenges, such as staffing, resources and overheads, incurred by each Challenge
Capital investments	Costs incurred by Challenges through investment in physical capital and facilities
Training and skills investments	Costs incurred by Challenges through investment in training and skills of their staff
R&D costs	Cost from direct support provided to R&D, such as investment in collaborative R&D projects
Private investment costs	Costs occurred by businesses, academics and other organisations working with the Challenges as a result of the ISCF

Based on the logic model and review of Fund documents, there are six broad types of benefits from the ISCF programme, as outlined below. These require careful consideration under Green Book approaches to determine which effects are relevant to include within the analysis.<sup>74</sup> As shown in Table 29, it is also important to consider potential disbenefits or other unintended consequences, such as the displacement of economic activity that becomes obsolete as a result of new innovations.

**Table 29: Benefits (and disbenefits) of the ISCF programme**

Benefit	Description
Productivity	Increases in the productive capacity of the UK economy as a result of the ISCF, such as increased output per worker  There may be specific productivity benefits from the ISCF programme as a whole beyond the individual Challenge funds, such as through knowledge spillovers across the programme.

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<sup>74</sup> It should be noted that there have been updates in appraisal guidance during the period of the ISCF programme, with the latest Green Book guidance published in December 2020. Therefore, there may be differences in the methodology used for assessing VfM for this evaluation compared to earlier appraisals of each wave of the ISCF. For example, the new Green Book guidance places greater emphasis on analysing regional effects than previous guidance.

Competitive expansion	Businesses and organisations supported by the ISCF may expand relative to their competitors in the UK or abroad. This may be productivity-enhancing if it resources transfer from a less to more productive sector of the economy, but will otherwise have no net effect under standard Green Book assumptions.
Multipliers	Expansion of economic activity from supply chains and induced effects  These effects may be included if the economy is not otherwise at full employment or if there are regional impacts, but are otherwise assumed to net out across the economy under standard Green Book assumptions.
Regional effects	Increases in economic activity in regions where the ISCF supported activities take place  The distribution of these effects should be considered under the latest Green Book guidance where a policy has specific regional objectives or differential regional impacts are expected. It is also important to consider the substitution or displacement of activity across regions.
Adoption of new technologies and associated benefits	Economic, social and environmental benefits from the use of technologies and approaches developed with the support of the ISCF  These benefits should be considered only where adoption is increased as a result of the ISCF relative to what otherwise would have occurred, e.g. adoption is brought forward, or quality is increased.
Displacement disbenefits	Costs associated with the adoption of new technologies, due to previous approaches becoming obsolete  These are normally assumed to be reabsorbed within the economy but can be subject to significant time lags, especially if the economy is not at full employment.

## Economic evaluation principles

In this section we outline key principles for the economic evaluation of the ISCF programme.

### Box 14: Definitions of key principles

**Opportunity cost:** reflects that in the absence of a given policy intervention, the resources, goods or services used could have been put to an alternative use.

**Employment and productivity effects:** enhancement in economic output per worker and employment across the economy.

**Economic transfers:** the transfer of resources from one part of society to another (e.g. through subsidies or taxation) which are generally excluded from economic valuation assessments.

**Environmental, social and health effects:** wider benefits to society which may require non-market valuation approaches.

**Time and time preferences:** capturing the full lifetime of costs and benefits and reflecting that people generally prefer value now rather than later.

#### *Opportunity cost*

The concept of opportunity cost reflects that, in the absence of a given policy intervention, the resources, goods or services used could have been put to an alternative use.

For the ISCF programme, there is an opportunity cost that had the programme not been taken forward, the public and private sector resources invested could have been put to some alternative use. This relates to consideration of the appropriate counterfactual in which the ISCF has not taken place, against which the

impacts of the programme should be compared for the evaluation. It is possible the public investment may crowd out investment that would otherwise have been made by the private sector, which is instead displaced by public funds – or it may crowd in private investment by increasing the private returns to investment.

Our conceptual approach to the counterfactual is that the next best alternative to the ISCF could have been a similar level of public investment in R&D but not through a coordinated mission-oriented programme. This approach allows us to consider the additional benefits of the ISCF as a programme of coordinated investment above and beyond what could have been achieved as a set of disconnected individual Challenge funds. For private investment, the counterfactual depends on the alternative opportunities available to investors. These issues can be explored empirically, with the econometric and network analyses described in Sections 6.6.5 and 6.6.6, for example providing some evidence on the economic returns to the Fund as a whole based on microeconomic analysis. However, this analysis will provide only a partial picture (in particular limited to direct business impacts), and will need to be supplemented with evidence gathered from individual Challenge-level evaluations, case study analysis and key informant interviews. We may also be able to draw on the wider evidence base around the returns to investments in R&I to provide intelligence on whether the returns to funding delivered via the ISCF appear to differ (Frontier 2014).

#### *Employment and productivity effects*

Productivity effects for the economic valuation are enhancements in the level of economic output for a given level of inputs. For example, increased output (or GVA) per worker, which can be assumed to be measured through changes in wages. There are several channels through which the ISCF programme may lead to productivity effects that require consideration in the economic valuation:

- Movement of workers into high-value productive sectors of the economy from less productive sectors
- Clustering or agglomeration effects from bringing organisations together where there is cross-fertilisation of knowledge and ideas
- Knowledge spillovers from the wider dissipation of knowledge and innovation generated through R&D across the economy

In addition, the investment of public funding through the ISCF may also leverage private investment in R&D that further enhances these mechanisms. However, the net effect of this leveraged funding depends on how the private funds would otherwise have been used in the absence of the ISCF (the counterfactual), which may be challenging to evidence.

Our evaluation will focus on the extent to which the productivity effects are enhanced through knowledge spillovers and network effects from the operation of the ISCF as a combined programme of support,<sup>75</sup> while

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<sup>75</sup> The approaches to evidencing these productivity effects will be further refined over the course of the evaluation, drawing on insights from emerging research such as that of The Productivity Institute [www.alliancembs.manchester.ac.uk/research/productivity/](http://www.alliancembs.manchester.ac.uk/research/productivity/)

also drawing on the insights from individual Challenge fund evaluations. The econometric analysis will also enable us to carry out some (relatively crude) estimation of productivity effects at the Fund-wide level.

Employment effects through job creation require careful consideration. The standard assumption under Green Book approaches is that across the economy these impacts will cancel out by moving people from one job to another if the economy is at full employment. However, there are important exceptions to this approach that are relevant to the ISCF:

- As noted above, employment may be transferred to a more productive sector, increasing productivity
- Employment may be transferred from one geographic area or group of society to another, leading to distributional impacts. Analysis of these geographic, social or equality distributional impacts is likely to be important for a programme of the scale of the ISCF, consistent with the latest Green Book guidance on place-based and equality impacts.<sup>76</sup>
- The assumption of full employment may not hold. This is especially relevant following economic shocks at the national level (as has occurred with the Covid-19 outbreak) or locally (for example, due to the decline of a locally important industry or sector)

#### *Economic transfers*

Economic transfers are the transfer of resources from one group to another. For example, R&D subsidies developed through the ISCF transfer costs of R&D from the private sector to the public sector. These costs are ignored for the purposes of economic valuation because there is no net change in cost for society as a whole.

However, it is important to consider transfers where they may have a distributional impact from making one group of society better or worse off. This can be assessed through an analysis of the recipients of transfer, such as which groups receive R&D subsidies.

#### *Environmental, social and health effects*

As set out in our Fund-level logic model, and further confirmed by the logic models for individual Challenge funds, there are a number of environmental, social and health impacts that the Challenges aim to contribute to. These benefits come from the use of technologies and approaches in society that the ISCF helps to support. The contribution of the ISCF may come in a number of forms, for example speeding up the pace of adoption of technologies which generate such social impacts, or making the technologies more effective and therefore enhancing the scale of impact.

Evidencing the contribution of the ISCF as a whole to these goals will largely come from the Challenge-level evaluations, supplemented with additional case studies and key informant interviews. Our review of Challenge-level evaluation frameworks identified the potential to monetise these wider impacts within the evaluations, but also that there may be challenges with attributing impacts to the ISCF. For example, two

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<sup>76</sup> See Annex 2 and Annex 3 of the Green Book on placed based and distributional analyses respectively.

of the Challenge-level evaluation frameworks available at the time of this report identify the potential for improved health outcomes from the adoption of technologies that the Challenges aim to enable: the Medicines Manufacturing Challenge and the Robotics and Artificial Intelligence in Extreme Environments Challenge. However, both evaluation frameworks note it may be difficult to evidence the extent to which these health benefits are brought forward, or additional relative to what might have been achieved with imported technology in the absence of the ISCF. Similarly, five of the Challenge-level evaluation frameworks<sup>77</sup> identify the potential for improved environmental outcomes. Whilst many of these outcomes can be measured, such as in terms of reduced carbon emissions, the evaluation frameworks again note challenges in determining the additionality of these benefits relative to what might have been achieved with imported technologies absent the ISCF.

Our approach to evidencing these environmental, social and health effects will draw on the evidence available from each Challenge-level evaluation and follow Green Book best practice. Our analysis will prioritise those outcomes for which this evidence base is most robust, as opposed to attempting to capture all possible types of outcomes. Where feasible to attribute impact, non-market valuation approaches will be followed. For example, carbon valuation approaches can be used to estimate climate impacts and Quality Adjusted Life Years (QALYs) can be used to estimate health impacts. Where it has not been feasible to attribute monetised impacts within the Challenge-level evaluations, we will draw on the relevant quantitative and qualitative insights with a mixed-methods approach. This will integrate the evidence on the contribution of the ISCF from Challenge-level evaluations with the qualitative insights and wider contribution analysis conducted within our programme-level evaluation. This approach will provide insights on the nature and plausible order of magnitude of key non-market benefits, alongside those benefits that can be monetised. Green Book approaches such as ‘tipping point’ analysis will then be explored to assess what assumptions would need to be made for the overall benefits to at least outweigh the costs where attribution is uncertain.

## Time

The treatment of time is important for economic valuation in two key respects:

- Policy choices often have consequences and impacts for a number of years. It is important to consider the full lifetime of economic costs and benefits to provide a complete assessment of these impacts.
- When costs and benefits occur matters, with the general principles that people prefer value now rather than later. These time preferences need to be accounted for, using standard discounting methods to provide a ‘net social present value’ of the time-adjusted benefits relative to the costs.

These considerations are important for the ISCF due to the length of the programme and long-term nature of the economic and social benefits that mission-oriented R&D seeks to achieve.

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<sup>77</sup> These Challenges are: Faraday Battery, Future Flight, Prospering from the Energy Revolution, Smart Sustainable Plastic Packaging, and Transforming Construction.

We anticipate that the majority of the direct public sector costs of the programme (see the table above) will have occurred within the evaluation period. However, some private sector costs, such as investment made by R&D collaborators, may incur in part within the evaluation period but also in the longer-term through related research and investments.

The benefits from the ISCF may start within the evaluation period but in most cases are likely to be longer-term in nature. For example, productivity effects as a result of new technologies or innovations accrue over a number of years, and environmental, social and health effects are inherently long-term and may be realised over a number of decades (such as contributions to bringing greenhouse gas emissions to net zero by 2050). The economic valuation will need to consider the potential lifetime of these benefits as far as they can be attributed to the ISCF.

To the extent that evidence about future anticipated impacts is collected within any Challenge-level evaluations, we may be able to produce scenario estimates, or ‘what if’ modelling, based on the available evidence, about longer-term impacts.

Where any assets invested in through the ISCF have a lifetime beyond the timeframe of the analysis, this residual value should be included. For example, if facilities invested in by Challenge funds might have very long lifespans that can be captured in this way. We will draw on the evidence from individual Challenge fund evaluations for any such effects.

#### 6.6.8. Final analysis and impact evaluation reporting

In this step, we will bring together the data collected from across the impact evaluation methods and prepare our final impact evaluation report. Reiterating the analysis and synthesis steps taken undertaken in phase 3 of the evaluation, a key aim of this step will be to map the collected data to the evaluation questions in order to assess the contribution of the ISCF in relation to the outputs, outcomes and impacts envisioned within the ToC. Here, building on the wave-level ‘contribution stories’ developed in phase 3, we will use data through our primary research methods to build a broader, overarching contribution story for the Fund as a whole. Once again, in analysing the evidence, we will also be careful to consider possible alternative explanations for any observed impacts. Our overarching impact findings will be presented in the draft, and subsequently, the final impact evaluation report. While the final format of the report will be determined later, is anticipated that the report will be structured around the impact evaluation themes, with case studies presented throughout. As with the process evaluation report, dedicated sections will present recommendations for the future management of the Fund and recommendations for future impact evaluation of the ISCF post waves 1–3.

## 6.7. Proposed plan for longer term evaluation

As specified in the theory of change, the ISCF is expected to have longer-term impacts that may take 10 or more years to emerge post-award, and so are expected to materialise after this evaluation is completed. As indicated in the ITT, we propose to develop a plan for a follow-on evaluation of the longer-term impacts of the ISCF post-programme as part of our work.

A key aspect of our approach to assessing the longer-term evaluation needs will be assessing the gaps in available evidence as part of our contribution analysis. We will do this in both phase 3 and phase 4 of the evaluation, however, in phase 4 we will have a particular focus on identifying any key gaps in findings or data to inform additional data collection that might be needed to answer the evaluation questions on the impact of the ISCF as part of a longer-term evaluation. We anticipate that gaps will particularly be around the longer-term or more indirect impacts of the ISCF, such as the impact on society. During this phase, we will set out a plan of how a future evaluation would look, based on the evidence gaps identified and how these could be addressed, and taking into account both the methods and data collection strategy that may be needed to ensure suitable evidence is in place to inform that subsequent evaluation.

Our proposed strategy for evaluation post-ISCF programme will be written up as part of the draft final report for the present evaluation. The strategy will include our proposed approach, evaluation questions, methods and data collection tools. We plan to hold a workshop with the evaluation working group after this draft report is shared, to discuss the proposed evaluation approach and any refinements needed, as well as the feasibility of any data collection requirements. The input from that workshop will be incorporated into the final round of edits of the final evaluation report for the study, producing a clear plan for future evaluation needs of the ISCF and how these can be addressed.

## 7. Evaluation deliverables

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### 7.1. Overview of evaluation deliverables

This chapter sets out the key deliverables and anticipated delivery dates for each phase of this evaluation. Beginning with the delivery of this draft evaluation framework report, the key deliverables for the evaluation span the baselining report (phase 2), wave-level summary evaluation evidence reports (phase 3), and process and impact evaluation reports (phase 4). The delivery of these outputs will be accompanied by presentations to key ISCF stakeholder groups, including, at different stages, the ISCF evaluation working group, the NPIF evaluation oversight board and the ISCF steering board. More details on the specific points at which we will engage with these groups are presented in the next chapter.

**Table 30: Evaluation deliverables and dates**

Phase	Deliverable	Delivery date
1 – Evaluation framework development	Draft evaluation framework report (this report)	March 2021
	Final evaluation framework report	April 2021
2 – Baseline measurement	Draft baseline report	November 2021
	Final baseline report	December 2021
3 – Review of Challenge-level evaluation findings	Draft wave 1 (1a and 1b) summary evaluation evidence report	May 2022
	Final wave 1 (1a and 1b) summary evaluation evidence report	June 2022
	Draft wave 2 summary evaluation evidence report	May 2023
	Final wave 2 summary evaluation evidence report	June 2023
	Draft wave 3 summary evaluation evidence report	February 2024
	Final wave 3 summary evaluation evidence report	March 2024
4 – Analysis and reporting	Draft process evaluation report	September 2024
	Final process evaluation report	October 2024
	Draft impact evaluation report	November 2024

	Final impact evaluation report	December 2024
	External presentation to support the final learning event	December 2024
	Strategy for evaluation post ISCF waves 1–3	December 2024

## 7.2. Quality assurance of deliverables

RAND Europe is an ISO 9001:2015 certified organisation and committed to maintaining high quality standards in delivering its work. A key process used to manage the quality of RAND Europe’s research deliverables is its internal Quality Assurance (QA) process. QA involves rigorous peer review of all research outputs. The overarching philosophy of the QA process for research deliverables is to improve quality through the introduction of additional points of view. The QA process involves researchers who are external to the core project team reviewing the project team’s work, both on an on-going basis, and before any project deliverables are presented to the client.<sup>78</sup> This QA process will be followed for all outputs delivered to UKRI as part of this evaluation.

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<sup>78</sup> A formal description of RAND quality standards can be found at: <https://www.rand.org/standards/index.html>

## 8. Ways of working

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### 8.1. Overview

Successful implementation of the evaluation plan as set out in Chapters 5 and 6 will require engagement with a wide range of stakeholders, both internal to and external, in the ISCF programme. In this chapter, we outline our approach to working with key stakeholder groups. The first section describes our approach to working with stakeholders with a direct role in the oversight over the ISCF evaluation. The second section describes our approach to working with Challenge-level evaluation teams. The third section presents a stakeholder mapping table outlining envisioned ways of working with wider evaluation stakeholders, including those with whom we anticipate engaging as part of our data collection activities.

### 8.2. How we will work with key evaluation stakeholders

During the course of delivering this evaluation, we anticipate direct engagement with four key ISCF/UKRI stakeholder groups, both as part of the day-to-day oversight of the evaluation and the sign-off of key deliverables. These four groups are as follows: the ISCF evaluation team, the ISCF evaluation working group, the NPIF evaluation oversight board, the ISCF steering board. In Table 31 below, we set out our understanding of the composition and role of each of these stakeholder groups within the ISCF evaluation and our planned ways of working.

**Table 31: The role of key evaluation stakeholders and our planned approach to engagement**

Key evaluation oversight stakeholder	Our understanding of its composition and role within the evaluation	Planned ways of working
ISCF evaluation team	<p>Comprised of the ISCF evaluation lead, the ISCF evaluation analyst and the IUK evaluation lead specialist</p> <p>The core team is responsible for day-to-day oversight of the evaluation and liaison with the RAND Europe/Frontier Economics evaluation team</p>	<p>Regular communication, including weekly meetings during periods of intense activity</p> <p>Ad hoc emails as required</p> <p>Maintenance of an up-to-date evaluation plan and risks register and agree and record any changes and key decisions</p> <p>Early identification and discussion of emerging risks and implementation issues</p>
Evaluation working group	Comprised of representatives from the ISCF PMO, UKRI analysis, UKRI	Engagement at key points for input, guidance and feedback

	<p>strategy, BEIS analysis and HM Treasury who are involved in the ISCF</p> <p>The working group has been established to provides strategic guidance to the ISCF evaluation</p>	Initial review of all deliverables
NPIF evaluation oversight board	<p>Comprised of the UKRI head of evaluation, leads for all NPIF UKRI-backed funds, and BEIS analysis</p> <p>The board oversees the evaluation of UKRI projects funded through NPIF funds</p>	<p>Sign-off on all deliverables</p> <p>Half-yearly presentations of the key findings and messages to date to support the NPIF evaluation oversight board</p>
ISCF steering board	<p>Comprised of leadership from UKRI Research Councils, IUK, BEIS and other government departments</p> <p>The steering board provides overarching strategic leadership for the ISCF</p>	Sign-off on key deliverables: baseline report, wave-level summary evaluation evidence reports, process evaluation report, impact evaluation report

### 8.3. How we will work with Challenge-level evaluation teams

Effective engagement with Challenge-level evaluation teams will be key to the successful delivery of our Fund-level evaluation of the ISCF. While true of the evaluation as a whole, this will be particularly the case in respect to the review of Challenge-level evaluation findings conducted during phase 3. During preparation of this evaluation framework report, working together with the ISCF evaluation team, we have established contact with each of the evaluation teams thus far commissioned at the Challenge-level, in order to make them aware of the aims and approach of the Fund-level evaluation, and to highlight our expectations regarding communication with the Challenge-level evaluations. In Table 32 below, we set out the key ways in which we anticipate engagement with Challenge-level evaluation teams during each phase.

**Table 32: Anticipated contact with Challenge-level evaluation teams**

Phase	Anticipated contact with Challenge-level evaluation teams
2 – Baseline measurement	<p>While Challenge-level baseline reports will be provided through UKRI, direct contact with Challenge-level evaluation teams may be necessary in relation to specific data queries</p> <p>Additional data queries relating to baselining and/or collection of data for econometric, network and VfM analysis</p> <p>Informal learning workshop with Challenge-level stakeholders, including Challenge-level evaluation teams, to review findings of the phase</p>
3 – Review of Challenge-level evaluation findings	<p>While Challenge-level evaluation process and impact reports will be provided through UKRI, direct contact with Challenge-level evaluation teams may be necessary in relation to specific data queries</p> <p>Workshops with Challenge-level evaluation teams (one workshop per wave) to discuss and validate emerging findings from review of Challenge-level evaluation reports</p>

	Informal learning workshop with Challenge-level stakeholders, including Challenge-level evaluation teams, to review findings of the review of Challenge-level findings phase
4 – Analysis and reporting	<p>Additional data queries relating to collection of data for econometric, network and VfM analysis</p> <p>Informal learning workshop with Challenge-level stakeholders, including Challenge-level evaluation teams, to review findings of the analysis and reporting phase</p>

#### 8.4. Wider evaluation stakeholder map

Below, we present a stakeholder mapping table outlining envisioned ways of working with wider evaluation stakeholders. In identifying key stakeholder groups by type, the table sets out our approach to engaging each type of stakeholder both as a potential source of information to inform this evaluation and as an audience for the evaluation’s findings.

Table 33: Evaluation stakeholder map

Type of stakeholder	Programme managers	Industrial Strategy delivery	Wider delivery partners	Wider UKRI stakeholders	Scrutiny bodies	UK research and innovation landscape	Beneficiaries	Government bodies and departments	Relevant sector bodies	Evaluators and analysts
Example stakeholders	ISCF evaluation working group, ISCF steering board, NPIF evaluation oversight board, ISCF performance and monitoring board, Challenge Directors, UKRI, IUK	Industrial Strategy Challenge Council, BEIS	Research Councils, Research England, Department for Employment and Learning of Northern Ireland, Higher Education Funding Council for Wales, Scottish Funding Council (SFC), Challenge-level programme managers	Oversight of other funding programmes and strategy within UKRI	HM Treasury, NAO	Catalysts, catapults, centres of excellence, innovation and knowledge centres, networks (e.g. Local Enterprise Partnerships Network), innovation centres, university enterprise zones, the KTN, sector leaders, charity sector	Award holders at universities, start-ups, spin-offs, SMEs, enterprises,	DHSC, Department for Digital, Culture, Media and Sport, Dft, UKSA, Health Innovation, NHS Innovation, NHS Digital, Health Innovation South East Scotland	ABPI, ABHI, AMRC, TechUK, the Developers Alliance, Energy UK, CILT, Highways England, UKCAA, IfM, Build UK CIC	Challenge-level evaluation contractors, analysts in BEIS (Science and Research Analysis team)
How we will engage	Baselining workshops; key informant interviews; key ISCF stakeholder	Key informant interviews	Key informant interviews	Key informant interviews	Key informant interviews	Stakeholder impact workshops	Baselining workshops; stakeholder impact workshops	Baselining workshops; stakeholder impact workshops	Baselining workshops; stakeholder impact workshops	Workshop with Challenge-level evaluators; key informant interviews; informal

	workshop; informal Challenge-level learning workshops										Challenge-level learning workshops
Engagement objectives	Understand the structure and functioning of the ISCF	Gain insight into the barriers and facilitators to delivery of the ISCF, as well as the strategy underpinning its implementation	Gain insight into how the ISCF fits into the broader research funding landscape	Gain insight into how the ISCF fits into the broader UKRI funding landscape	Draw on learning from existing scrutiny mechanisms	Gain insight into how the ISCF fits into the broader research funding landscape	Understand benefits and challenges of the ISCF from a recipient perspective	Understand wider context and implications of the ISCF in the policy landscape	Understand the impact of the ISCF on the sectors in which it seeks to create impact	Align frameworks, methods and data formats to improve consistency. Validate evaluation findings and share learning	
Phase of engagement	Phases 1–4	Phase 1–4	Phases 1–4	Phase 4	Phase 1–4	Phase 4	Phases 2 and 4	Phases 2 and 4	Phases 2 and 4	Phases 1–4	
How we will communicate evaluation findings	Workshops; evaluation reports; meetings/presentations	Evaluation reports, briefings where relevant/desirable	Evaluation reports; summaries and commentaries	Evaluation reports, briefings where relevant/desirable	Evaluation reports	Evaluation reports; workshops; summaries and commentaries	Evaluation reports; workshops; summaries and commentaries	Evaluation reports; workshops; summaries and commentaries	Evaluation reports; workshops; summaries and commentaries	Workshops; evaluation reports; meetings/presentations	
Communication objectives	Build the evidence base regarding the delivery of the ISCF, and support learning and improvement	Inform future policy development regarding Industrial Strategy and mission-led R&I	Communicate the role of the ISCF in the broader UK research funding space	Communicate the role of the ISCF in the broader UKRI funding space	Informing review and assessment of the ISCF	Communicate the role of the ISCF in the broader UK R&I landscape, and its added value	Ensure buy-in and engagement, facilitate learning about what works in the iscf to improve delivery	Provide evidence on how the ISCF is contributing to the different sectors of the economy and government	Communicate the role of the ISCF across the sectors in which it seeks to have impact	Support mutual learning and inform future implementation and evaluation of the ISCF/other funds	

## 9. Evaluation risks

In this chapter, we present a risk register for this evaluation. The register considers the likelihood and potential impact of each identified risk, as well as the actions we will take (or have already taken) to mitigate these risks. The risk register will be monitored, and updated as necessary, over the course of the evaluation, in collaboration with the ISCF evaluation team.

**Table 34: Evaluation risks register**

Risk	Likelihood	Impact	Mitigation
<b>Planning and management</b>			
Disruption to project delivery and timelines due to Covid-19	High	Medium	We have strong technical solutions in place including Teams, WebEx and others, and experience in alternative methods such as online focus groups and discussion boards that we can use where required. In case of illness, we have a staff replacement plan if needed.
Disruption to project delivery and timelines due to delays in Challenge-level evaluations	High	High	We will maintain regular contact with UKRI and with the evaluators of the different Challenges. We will develop a log of the documents from the Challenge-level evaluations that will allow us to identify missing information and anticipate delays in data collection. Project team includes Frontier, who are leading on four ISCF evaluations giving familiarity with evaluation process and approach.
Lack of coordination between RAND Europe and Frontier, and Challenge-level evaluators	Medium	Medium	At the start of the project, we sent out an email to UKRI Challenge-level evaluation leads and the evaluating organisations introducing the ISCF evaluation team and asking for the relevant contact points for each Challenge. We have kept a log of the responses which will allow us to follow up where appropriate with the relevant individuals.
Lack of coordination between RAND Europe and Frontier Economics	Low	Medium	RAND Europe and Frontier have vast experience working together and in collaboration with other organisations. Each organisation has a designated project lead and project manager who communicate on a regular basis to ensure proper coordination. In addition, both organisations are represented in meetings with UKRI, after which there is an internal team debrief to ensure alignment in understanding of the tasks at hand.
Staff changeover at RAND Europe or Frontier throughout the lifespan of the project	Medium	Low	As the evaluation is expected to take place over the course of four years, it may be that the evaluation team at the start of the project changes.

			<p>At RAND Europe, there is a three-month notice period for researchers, which allows project teams to bring in new team members and bring them up to speed before handing over a project. We will discuss and agree any changes in key members of staff with UKRI as early as possible.</p> <p>If staff changes are required, Frontier Economics will discuss and agree these with UKRI as early as possible. The senior Frontier team will ensure a seamless transition, including facilitating detailed handover meetings to review completed work and share lessons learned. Frontier have more than 250 graduate-qualified economists, with staff allocated through a fortnightly scheduling system, led by Frontier's HR director</p>
Staff change over at UKRI throughout the lifespan of the project	Medium	Low	As the evaluation is expected to take place over the course of four years, it may be that UKRI staff change throughout this time. To ensure continuity in case of staff changeover, we hold regular meetings with the steering committee and working group, in which we provide progress updates and present findings from the evaluation. Feedback received from these meetings is documented and shared with UKRI.
<b>Methodology</b>			
Low quality/availability of data from the Challenge-level evaluations	Medium	High	We will seek to gather information from Challenge-level evaluations as early as possible and develop an internal log, which will allow us to identify gaps in the evidence. The project manager will keep track of the documents available from the Challenge-level evaluations and act as the point of contact for the contractors of the different evaluations in the request for documents. Where certain documents are unavailable from a specific Challenge-level evaluation, we will discuss with UKRI to identify the best way forward.
Duplication of efforts with Challenge-level evaluations	Low	Low	We have thoroughly reviewed evidence available to date from the Challenge-level evaluations and identified areas where Challenge-level data will serve to answer evaluation questions and where additional data may be needed. We will continue to review Challenge-level evidence as it is made available to ensure that our data collection methods are not duplicating efforts.
Evaluation indicators not fit for purpose	Low	High	We have developed the indicators based on the ToC developed together with UKRI. In addition, we have mapped the Challenge-level evaluation indicators to the ISCF evaluation framework to ensure consistency and appropriateness.
Challenge-level indicators are not relevant to Fund-level evaluation	Low	Medium	We will review Challenge-level evaluation documents as they become available from the Challenge evaluations and map indicators against the Fund-level evaluation questions with the aim of assessing the extent to which Challenge-level indicators could provide insight to the ISCF evaluation. Where Challenge-level indicators do not inform the Fund-level evaluation, we will identify appropriate data collection methods.

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Lack of flexibility in the ToC and evaluation framework	Low	High	The ToC and evaluation framework have been developed using information available to date from Challenge-level evaluations and are necessarily designed to be broad and flexible, in line with the requirements for the evaluation of a broad, complex Fund. However, not all Challenges have been or are currently being evaluated, and information from these will need to feed into the existing ToC and evaluation framework, therefore there may be scope for minor refinements and adjustments – for example, we plan to map additional potential sources of Challenge-level data into the evaluation framework as this information becomes available.
The Fund-level evaluation does not add information additional to that already available through Challenge-level evaluations	Low	High	In order to avoid the Fund-level evaluation strictly being the sum of the Challenge-level evaluations, we will seek to collect new data in order to understand the overall impact of the ISCF, including through a large number of interviews, multiple workshops with a variety of stakeholders to the programme, as well as bespoke econometric and network analyses.
Covid-19 and Brexit transition shocks make it difficult to set the framework (economic shock to sector, counterfactual difficult to identify)	High	High	The framework will need to recognise sector volatility and accommodate accordingly. For example, we may need to consider specific Covid metrics (e.g. impact of the ISCF on business survival), as well as engage with stakeholders who can provide input on the impact of Covid and Brexit, and how to factor it into the framework.
Using secure administrative data held by ONS and/or HMRC	Medium	High	We will apply to access the data as quickly as possible given lags in project approval. All analysis will be conducted in line with disclosure and access rules. Code use to extract baseline measures will be stored for future updates.
Lack of participant engagement in workshops	Low	Medium	We will be holding multiple workshops throughout the project: 1) baselining; 2) workshops with Challenge-level evaluators; 3) workshop with ISCF stakeholders; and 4) impact workshops with external stakeholders. In order to ensure participation, we will be holding more than one workshop for each type of stakeholder, with the exception of 3) workshop with ISCF stakeholders. Specifically, we will hold five baselining workshops, three workshops with Challenge-level evaluators, and five workshops with external stakeholders, giving stakeholders multiple opportunities for engagement.
Low participation in interviews	Low	Medium	We have developed an indicative list of key informant interviewees presented in this report. Each interviewee will be assigned to one of three priority groups. Interviews in the first priority group will be the first interviewees we seek to engage with, followed by second-priority and third-priority interviewees. Each stakeholder category will have at least three potential interviewees.
Wrong selection of case studies	Low	Low	Case studies will be selected in consultation with UKRI to ensure that the selection addresses the main issues and can provide the most insight. We

			have also proposed the use of a matrix to identify potentially suitable case studies over the course of the evaluation.
Incorrect inference drawn from network analysis because of low-quality input data on organisations engaged	Medium	Medium	Close working with the UKRI central team and Challenges to understand data availability. We will develop a clear template to ensure data provided are consistent and meet the needs of the analysis. We will triangulate with other evidence to draw insights.
Poor-quality counterfactual group in econometric analysis limits inference about economic impacts	Low	High	We will use as much information as possible in the business administrative data to match treatment and control groups, with careful design and planning of the matching algorithm and testing sensitivity of results to the choices made. We will conduct balancing tests to validate the selection process. Where we believe there may be biases, we will be explicit about those and where possible assess the implications for the econometric results.

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