technopolis |group

September 2021

Strategic Priorities Fund

Baseline and Interim Process Evaluation – Technical Report (V3)

September 2021

Strategic Priorities Fund

Baseline and Interim Process Evaluation – Technical Report (V3)

Table of Contents

Tables

Figures

Appendix A   Evaluation Questions

The following table presents the 6 main evaluation questions and 29 sub-questions that the study should address. These were developed for the study by UKRI, with the SPF objectives and long-term impacts in mind.

Table 1   Evaluation questions

Key evaluation questions	Sub evaluation questions
1. To what extent, and how, is the SPF **working and being delivered as intended**?	1.1. What, in practice, is felt to be working more or less well regarding the **delivery of the Fund** (or programmes) by UKRI and the SPF Oversight Board, and why? 1.2. In allocating SPF funding to specific programmes, how did UKRI **use/interpret the overarching objectives** of the SPF to identify which programmes were of the highest priority? Was this approach to funding research and innovation a success in terms of maximising the fund's impact? 1.3. (To what extent) did the allocation of funding between Waves 1 and 2, and the **timing**, affect the ability to deliver the best quantity and quality of programmes for the SPF portfolio? 1.4. What is the range of **reported experiences** of researchers, innovators and other delivery partners in delivering SPF-funded programmes and projects? 1.5. What were the **challenges, facilitators and barriers** to implementing and delivering the SPF and its component programmes, if any? 1.6. What potential **lessons** are there for future waves / similar funds?
2. To what extent (and how) has the SPF supported an **increase in high quality MIDRI**?	2.1. To what extent, and how, has the SPF increased the efficacy of the funding system and the effectiveness of the peer-review process to **better assess MIDRI bids**? 2.2. To what extent, and how, has the SPF **de-risked the process** of preparing and submitting MIDRI proposals for the research and innovation community? 2.3. To what extent, and how, has the SPF encouraged **further MIDRI projects and programmes**, and a shift in research institutions towards this type of activity?
3. To what extent, and how, has the SPF improved the **link between UKRI's investments and cross-departmental research and innovation priorities and opportunities**?	3.1. To what extent, and how, has the SPF improved join up across Departments to establish **consensus on key Government priorities** for R&D? 3.2. To what extent, and how, has the SPF increased **understanding of Government priorities** among research and innovation funders? 3.3. To what extent, and how, has the SPF increased investments in **projects which further the objectives of government departments** and facilitated more effective alignment between R&D strategies? 3.4. To what extent, and how, has the SPF improved the ability of the R&D funding system to deliver cross-Government R&D priorities through **enabling PSREs to bid** for open competitions funded through the SPF?
4. To what extent, and how, has the SPF ensured that the research and innovation system is **able to respond to strategic priorities and opportunities**?	4.1. To what extent, and how, has the SPF increased high-quality **R&D in areas where gaps currently exist**? 4.2. To what extent, and how, has the SPF increased engagement with research and innovation communities to **identify emerging priorities**, and provided a sufficient investment to **address these opportunities**? 4.3. To what extent, and how, has the SPF improved: (i) the funding route for high quality **medium scale programmes**? and (ii) the agility of the funding system to **respond to emerging opportunities**?

Key evaluation questions	Sub evaluation questions	Sub evaluation questions
5. To what extent, and how, has the SPF delivered **economic, knowledge and societal impact**?	5.1. What has been the wider, overall **economic impact** of the SPF, including the economic value of non-market impacts?	5.1.1. To what extent, and how, has the SPF succeeded in increasing **long-term investment in research and development**, including the leveraging of third-party investment? How much has materialised? If not, why not? 5.1.2. To what extent, and how, have SPF programmes resulted in the creation of **high skilled jobs, improved skills**, or increased the overall number of jobs? 5.1.3. To what extent, and how, has the SPF driven improvements in **business performance**, turnover and productivity?
	5.2. What has been the wider, overall impact of the SPF on **the state of knowledge**, both in the UK and internationally?	5.2.1. To what extent has the SPF driven the creation of **new knowledge**, such as new research publications, Intellectual Property (IP), Technology-Readiness-Level (TRL) and Manufacturing-Readiness-Level (MRL) advancement, process and conceptual innovation, etc.? 5.2.2. What specific **disciplines have collaborated** through, or as a result of, the SPF, and to what end? What does this imply about the extent to which the SPF has supported or enabled high-quality MIDRI? 5.2.3. To what extent has the SPF fostered **new approaches to collaboration** across the UKRI Research Councils, Other Government Departments (OGDs) and PSREs?
	5.3. What has been the wider, overall **societal impact** of the SPF?	5.3.1. To what extent, and how, has the SPF **impacted the environment, public health and wellbeing**? 5.3.2. To what extent (and how) have SPF programmes fostered **more equal, diverse and inclusive research environments**?**
6. Based on the overall, estimated impact of the SPF – considering those impacts which can be given market and nonmarket values – compared to the overall cost of delivering the SPF, to what extent does the SPF represent **value for money**?	6.1. To what extent does the SPF and its programmes represent value for money given overall impact on knowledge, economy and society **relative to the size of the investment**? 6.2. To what extent does the SPF represent value for money **compared to other possible alternative ways** of achieving the same impacts?	

** Note that this is not an explicit objective of the SPF, but part of the vision of UKRI ("We will work with partners to shape a dynamic, diverse and inclusive system of research and innovation in the UK")

Appendix B   Methodology

The approach being employed by the evaluation was set out in the Evaluation Framework (January 2021). The current phase (baseline and interim process evaluation) was based on seven main groups of data collection and analysis activities (see Figure 1), with activities taking place between February and June 2021. Further details of each of these evaluation methods are provided in the sub-sections that follow. A list of contributors is also provided at the end.

Figure 1   Evaluation methods

	Documents/Groups
Programme monitoring & evaluation	• Gap analysis to assess likely available evidence of relevance • Guidance and support to programmes to improve alignment / reduce duplication of effort (workshop with 90+ SPF programme / M&E leads to introduce data collection plans and give guidance on key indicators for programme evaluations – see Technical Report Appendix C) • [A meta-evaluation is also planned to assess and incorporate evidence from programme evaluations. This will first take place at the interim stage, when first findings should be available from many of the programme evaluations]
Programme documentation & secondary data	• The SPF business case • Gateway to Research • Fund management information • Researchfish • Programme bids and assessments • Fame • Programme/project data • Pitchbook
Bibliometric analysis	• Bibliometrics (outputs and impact) • Altmetrics (impact beyond the scientific community) • Forward tracing (uptake of research in innovation/policy) • Network analysis / collaborations
Programme Lead Consultation	• Collection of basic programme information (details of partner organisations, advisory boards, Directors & Champions, contact details for stakeholders, list of grants awarded) from all programmes • Information template completed by all programmes • Interviews with 50 programme leads / co-leads (covering all programmes)
Stakeholder consultation	• Survey of government CSAs (42% response rate) • Survey of SPF Programme Advisory Board members (47% response) • Interviews with 12 wider stakeholders (GO Science, UKRI, SPF Board, Authors of unsuccessful programme bids, BEIS PSRE non-participants)
Longitudinal case studies	• Eight in-depth case studies • Each focused on a Government R&I priority / challenge that has been identified and is being addressed by a particular programme • Developed based on desk research and 57 interviews (with programme leads, partners and participants) • [Case studies will be updated and extended in future phases based on new evidence, allowing them to develop their examination of the outputs and outcomes of the Fund further]
Literature review	• Rapid Evidence Assessment: • Of recent literature about which mechanisms and processes are, or could be, used by funding organisations to support MIDRI, plus key rationales for supporting MIDRI research • Of examples of mechanisms and processes used in programmes from the UK and abroad, to describe the key rationales for supporting MIDRI

A total **~200 stakeholders have been consulted during this phase of evaluation via interviews and surveys**, including for the development of 8 in-depth case studies.

B.1   Programme monitoring and evaluation

The Fund-level evaluation is expected to draw upon (and not duplicate) the programme-level monitoring and evaluation activities, where appropriate. As such we are employing a three-part process to maximise the use of this evidence base. This consists of:

1. A gap analysis to assess the evidence that will be available from programme evaluations of relevance to addressing Fund-level evaluation objectives and questions.

2. Further guidance and support to programmes to improve the alignment of Fund and Programme evaluation activities and ensure evidence from each can feed into the other.

3. A meta-evaluation to assess and incorporate relevant programme-level evidence within the Fund evaluation (in addition to secondary data analysis of centrally held outcome monitoring data).

1. Gap analysis

A preliminary analysis was undertaken during the planning phase, based on the Fund and Programme monitoring and evaluation plans (where these are available).

This suggested that the programme-level evaluations (as planned) would mainly provide evidence to support the Fund-level evaluation question on the delivery of economic, knowledge and societal impacts, plus some reflections on programme-level processes (which would support some elements of the Fund-level process question). In addition, it suggested that much of this evidence will only be available (in the form of interim or final evaluation reports) in time for the final phase of the Fund-level evaluation, not for the interim evaluation.

These early findings influenced the design of the evaluation framework and our thinking about the best approach to the Fund evaluation. In particular, we introduced a new activity (see below) to provide further steer and guidance to SPF programmes on how the Fund- and programme-level evaluations can best support each other. It will then be necessary to update the gap analysis at the start of the next phase of the study (interim impact), to take account of the further work and discussions had around the scope, focus and timing of the evaluations.

This should include a first rapid assessment of programme level evaluations at the beginning of next phase (or at least ~8 months ahead of delivery of the Interim report (which is due in December 2022) and before the fieldwork starts, to decide on time how they could be used and if changes in the methodology are needed to address potential gaps.

2. Further guidance and support

Based on the findings of the preliminary gap analysis, we proposed a series of actions to be undertaken in order to ensure that the Fund- and programme-level monitoring and evaluation activities best support each other, reducing duplication of effort and maximising the evidence available to both Fund and programme-level evaluations.

Timelines. As indicated by the preliminary gap analysis, the timing of individual programme evaluations (and their interim and final deliverables) is not currently clear in all programme M&E plans. Where milestone dates are given, these tend not to align well with the timeline of the Fund evaluation and the requirement to draw on programme level evidence at each phase.

We therefore suggested that:

- UKRI (with the support of the study team) work with programme (M&E) leads to confirm the timelines for all programme evaluations, including the expected date at which interim and final process / impact evaluation reports (as applicable) will be available.

- Further discussion is had between UKRI and the study team around the timings of the Fund and programme evaluations. We suggested that the Fund interim impact evaluation is delayed by 6-12 months, to increase the number of Programme interim impact evaluations that will have concluded by this point. The exact timing should be confirmed once further clarity has been obtained on programme evaluation timing (as per point above).

Alignment. The preliminary gap analysis has shown that programmes were required to consider and address Fund evaluation objectives and questions in the planning of their own evaluation activities. However, the requirements on questions to address were somewhat unclear (with multiple lists of objectives, questions and indicators presented). At the same time, many of the questions themselves were worded with the Fund-level evaluation in mind (which may prove difficult to interpret for programme-level evidence collection). As a consequence, the programme M&E plans go further in developing their evaluation questions and indicators in relation to programme-specific objectives and programme delivery, while less is said about how the planned activities might address the main objectives of the Fund and questions around the delivery of the Fund.

We therefore suggested that the study team worked with the UKRI evaluation team to define a clearer (and simpler) set of guidance and requirements for programmes, in relation to their alignment with, and support to, the Fund evaluation. This would include:

- Detailing key exercises that will be undertaken by the Fund-level evaluation (e.g. relating to bibliometrics) that might usefully feed into programme-level evaluations and not require duplication of effort.

- Providing programme (M&E) leads with a clear (and shorter) list of key questions and indicators that programmes might provide evidence against for the Fund-level evaluation through their own evaluation activity. Importantly, this will be one consolidated list that is worded to be relevant to the programme-level context.

Guidance and support. To help implement the above recommendations, we also suggested that the study team hosts one or more workshops with programme (M&E) leads to set out and explain the above points and to provide further guidance and support as necessary, including on the ongoing plans for the Fund-level evaluation.

This workshop was held on 16th March 2021 and attended by ~90 SPF programme and M&E leads (briefing material was also circulated to all programmes, regardless of attendance). The event was used to introduce the Fund evaluation (the questions it was to address, its plans for interactions with programmes, the phases and timing of the study, and overall plans for data collection). The study team then set out plans for engagement with programme leads and partners during the baseline and interim impact evaluation phase specifically, explaining what input would be requested from whom and when.

The session concluded with the study team providing additio**nal guidance to programmes on the questions / indicators** that all programmes might usefully provide evidence against (as part of their evaluation activities), which would support the Fund-level evaluation. This is shown in **Appendix C** of the current document

3. Meta-evaluation

For the interim and final impact evaluations we will undertake a meta-evaluation exercise to draw upon the findings of the individual programme evaluations. Where possible we will look to use quantifiable metrics, which may be collected in a standard way across programmes, and should therefore be possible to aggregate across the portfolio. However, there will also be a need to draw on qualitative assessments.

The list of indicators presented in the Evaluation Framework included evidence that will be sought from programme evaluations. This covers various achievements and benefits (e.g. advances in understanding, uptake of outputs by government, new and improved policies, products and services that are developed with SPF support, and wider societal impacts), where the extent and type of evidence will be very programme-specific.

In these areas (concerning the wider benefits and impacts of SPF-funded projects), the Fund evaluation team will then need to establish an analytical framework to collate, categorise and assess the evidence presented (see example below). This will include a qualitative assessment of the strength of evidence presented towards achieving different benefits and impacts (based on a subjective analysis by the multiple members of the evaluation team).

Figure 2   Indicative analytical framework for meta-evaluation

Type of benefit:					
Programme	Assessment of extent of benefit realization, including quantification / monetisation of benefit	Example of benefit	Method employed	Caveats and weaknesses	Strength of evidence

We will develop the meta-analysis framework in the interim impact phase, based on an updated gap analysis. The framework will then be deployed for this phase of the evaluation (based on programme evidence available at that time, e.g. from programme interim impact evaluation reports). We will then update and extend the meta-evaluation at the final evaluation stage, based on additional reporting, including final process and impact evaluation reports from the majority of programmes.

B.2 Desk review of programme documentation and secondary data

B.2.1 Desk review

The evaluation is making use of **existing information and data held by UKRI and the SPF** team wherever possible. At this stage, we have identified and used the following key sources to support the interim process evaluation and early assessment of impact:

- SPF Business Case
- SPF Fund and Programme M&E plans
- Government department Areas of Research Interest documents
- Successful and unsuccessful programme proposals
- Guidance to programme bid assessment panel and minutes of the assessment
- A GO Science overview and reflections on the Wave 2 process to identify priorities (including list of priorities programme ideas)
- A GO Science governance framework, suggesting where to include stakeholders, particularly government representatives, in the governance structures of programmes

In addition, programme leads have provided additional information on individual SPF programmes, via two templates (which are discussed in Appendix B.4). A series of programme-level evaluation reports (baseline/interim/final impact and process evaluations, as applicable) are also expected to become available over time (starting in the next phase of the evaluation).

Beyond these items, the evaluation is making use of two main **secondary data sources**: Gateway to Research and Researchfish. The former provides information on grants awarded (including through SPF programmes), such as the grant value and participating organisations. The latter is used to collect information on outputs, outcomes and impacts that have arisen from research funded by UKRI Research Councils. More specifically, Researchfish contains information on:

- Artistic and Creative Product
- Collaboration outcome
- Dissemination outcome
- Further Funding
- Impact Summary
- Intellectual Property
- Key Findings
- Policy Influence outcome
- Product Intervention outcome
- Publication
- Research Database and Model
- Research Material
- Software and Technical Product
- Spin Out

Researchfish is an incredibly valuable source of information for activities, outputs and outcomes emerging from grants. However, because of the qualitative nature the data, it is difficult to extract "hard" indicators from this source beyond basic counts of types of outputs and outcomes. As such, Researchfish is used primarily by evaluators as an additional source of qualitative data (e.g. to identify examples of further funding or collaboration for case studies).

B.2.2 Measuring UKRI spend in priority areas

Analysing UKRI spend in priority areas required mining the entire GtR database to compare investments made historically in the areas of interest (using a classification algorithm applied to grant abstracts). Given the scope of the exercise (and diversity of areas covered by SPF), we have focused the analysis on the eight areas that correspond to the eight longitudinal case studies selected for this evaluation, which provide a good spread in terms of themes covered, partners involved and Waves.

In order to draw comparisons with a benchmark (UKRI), the analysis focuses on the value of grants in competitive calls. Not all SPF programmes have launched competitive calls (up to 2020) or planned to do so. Further iterations of the analysis could draw comparisons with the total value of the SPF programmes and UKRI data up to 2023, when most SPF programmes are expected to conclude.

A total of eight priority areas have been identified by the Government Office of Science together with departmental Chief Scientific Advisers:

1. Cybersecurity

2. Productivity

3. Space weather

4. Time infrastructure / measuring time

5. Bacterial plant diseases

6. Modern slavery

7. Mental health and adolescence

8. Air quality

Firstly, the analysis of SPF's coverage of these areas required the classification of individual SPF-funded grants. This was achieved by using TextRazor, a Natural Language Processing (NLP) service. TextRazor offers out of the box classification models based on publicly available taxonomies such as Wikipedia[1], DBPedia[2] and Wikidata[3]. Its classification service is based on a proprietary knowledge graph[4] in combination with machine learning algorithms that assigns topics from the taxonomies of interest to any form of textual data.

In this analysis, the text data consisted of the abstracts of SPF grants that were available in GtR. A total of 504 SPF grants were covered by GtR as of late May 2021. All of these were classified based on Wikidata topics after which these initial results were filtered down to relevant topics only. The allocation of relevant topics per priority areas is summarised in Table 2. Most priority areas were sufficiently captured by a single Wikidata topic, with the exception of "Adolescence and mental health" which was captured by cross referencing the separate topics of "mental health" and "adolescence".

Table 2   Allocation of topics per priority area

Priority area	Topic (with Wikidata code)
Cybersecurity	Computer security (Q3510521)
(Research on) Productivity	Productivity (Q2111958)

---

[1] Wikipedia is a free online encyclopaedia, created and edited by volunteers around the world and hosted by the Wikimedia Foundation., see: https://www.wikipedia.org

[2] DBPedia is a project aiming to extract structured content from the information created in Wikipedia, see: https://www.dbpedia.org

[3] Wikidata is a collaboratively edited multilingual knowledge graph hosted by the Wikimedia Foundation, see: https://www.wikidata.org

[4] "Knowledge graphs (KGs) organise data from multiple sources, capture information about entities of interest in a given domain or task (like people, places or events), and forge connections between them", for more information see: https://www.turing.ac.uk/research/interest-groups/knowledge-graphs and https://www.textrazor.com/named_entity_recognition

Space weather	Space weather (Q584093)
Time Infrastructure / Measuring time	Horology (Q41767)
Bacterial plant diseases	Bacterial plant disease (Q9164481)
Modern slavery	Contemporary slavery (Q3369955)
Mental health and adolescence	Adolescence (Q131774) and mental health (Q317309)
Air quality	Air quality (Q56245086)

The initial classification of SPF grants allowed for a subsequent analysis of the key words and phrases by priority area, to be used for the classification of all remaining grants in GtR not covered by SPF (referred to as UKRI grants hereafter). To carry out this step, key words were identified using a Rapid Automatic Keyword Extraction (RAKE) algorithm.[5] RAKE follows a three-step process:

- Keywords are extracted from contiguous sequences of words that do not contain irrelevant words (such as stop words)
- A score is calculated for each word based on its frequency as well as its co-occurrence with other words. Specifically, the score is calculated as the ratio of co-occurrence to frequency

4. The RAKE score for each keyword is calculated by summing the scores of its component parts

5. Based on a combination of RAKE scores and manual inspection, a set of key words was identified per priority area, summarised in Table 3.

Table 3   Summary of key words identified per priority area

Priority area	Keywords used
Cybersecurity	Cyber security, cybersecurity, computer security
(Research on) Productivity	Productivity (restricted to ESRC grants)
Space weather	Space weather, weather in space
Time Infrastructure / Measuring time	Atomic clock, molecular clock, clock
Bacterial plant diseases	Bacteria AND plant pathogens OR plant diseases
Modern slavery	Modern slavery, slavery in the 21st century
Mental health and adolescence	Adolescent mental health, adolescence AND mental health (overall co-occurrence within abstracts)
Air quality	Air quality

---

[5] Rose, Stuart & Engel, Dave & Cramer, Nick & Cowley, Wendy. (2010). Automatic Keyword Extraction from Individual Documents. Text Mining: Applications and Theory. 1 - 20. 10.1002/9780470689646.ch1.

The identified key words were used to formulate dictionaries per priority area. For all UKRI grants (i.e. non-SPF grants available in GtR), a document-term matrix was constructed using these dictionaries. In short, a document-feature matrix tabulates the coverage of certain features, in this case priory area-specific dictionaries, across all documents, in this case non-SPF project abstracts. This process automatically performs basic text mining tasks such as converting characters to lower case, removing stop words, and stemming words (reducing terms to their word stem, base, or root) to enable more accurate text analysis.

The result of this process is an overview of the occurrence of previously identified key words across project abstracts, based on which corresponding grants were assigned to one of the priority areas. A set of random spot checks were carried out in order to ensure no grants were mislabelled. The total number of grants per priority area, for SPF and UKRI is summarised in Table 4 below.

Table 4   Number of grants per priority area - SPF compared to UKRI

Priority area	Number of SPF grants (N = 504)	Number of UKRI grants (N = 117,355)
Cybersecurity	6	743
(Research on) Productivity*	12	228*
Space weather	22	176
Time Infrastructure / Measuring time	4	237
Bacterial plant diseases	13	96
Modern slavery	9	25
Mental health and adolescence	11	165
Air quality	23	653

* Restricted to ESRC grants only

B.3   Bibliometric analysis

Bibliometrics consists in a suite of methods that help track some of the immediate research outputs of funding programmes and their projects, such as the number of peer-reviewed publications and their impact within academic circles (as measured by citations within the scientific literature).

For the current phase of evaluation, we have employed bibliometrics to assess the baseline and provide evidence of early progress in relation to the MIDRI objective of SPF, as detailed in the sub-sections below.

B.3.1   Measuring MIDRI in publications

One expected output of the Fund is an increase in high quality MIDRI projects and publications[6].

There are different approaches to measuring MIDRI using bibliometric data. The current state of development of these approaches is such that they each have their respective strengths and weaknesses, with none of them standing out as the perfect means to capture MIDRI. Science-Metrix, who will lead this work package, has however been working in this space for the past 5 years, developing state-of-the-art approaches to measuring both multi- and interdisciplinary research, which have been deployed here, with due care to account for the above limitation.

In line with our conceptual framework, the analysis of research crossing disciplinary boundaries using bibliometric data can be undertaken on at least two dimensions:

- A human dimension, capturing collaborations of researchers with different disciplinary backgrounds (an input to cross-disciplinary work, and a proxy of multidisciplinarity)

- An epistemic dimension, capturing publications that draw on knowledge from different disciplines (an output from cross-disciplinary work, and a proxy of interdisciplinarity).

Various diversity metrics can be implemented to capture the number of, intellectual distance between, or balance among the represented disciplines.[7] Within the current evaluation, disciplinary diversity amongst a publication's author list (multidisciplinarity) will be captured by adapting the Rao-Stirling diversity index to the disciplinary profiles of co-authors, while disciplinary diversity in a publication's integrated knowledge (interdisciplinarity) will be inferred by applying the Rao-Stirling index to the disciplines represented in the papers' reference list.

This means that we have computed disciplinary diversity (DD) of "SPF publications based on their author list (multidisciplinarity) and based on their reference list (interdisciplinarity). That allow us to approach MIDRI from two angles using bibliometrics. Furthermore, the above two indicators (of diversity) have been computed for different groups of papers, SPF and UKRI overall, to provide a comparison point. More information on the different measures are described below.

---

[6] Note that is one the indicators included in the Business Case. We understand however that the ultimate intent of the Fund (and assumption) is that the knowledge produce by multidisciplinary teams will lead to higher uptake of knowledge outputs and to higher societal impacts. In that venue will not restrict the analysis of uptake or societal impacts to those publications with high degree of MIDRI, but will instead test the extent to which higher degrees of MIDRI in publications led to higher results (as explained in section on econometric analysis).

[7] Leydesdorff, L., Wagner, C. S., & Bornmann, L. (2019). Interdisciplinarity as diversity in citation patterns among journals: Rao-Stirling diversity, relative variety, and the Gini coefficient. *Journal of Informetrics*, 13(1), 255–269.

B.3.1.1 Interdisciplinarity

Interdisciplinarity highlights instances where new knowledge (i.e., research publications) truly recombines *a priori* disparate knowledge (i.e., from diverse disciplines) assuming a paper's references are a reliable indication that knowledge from the cited sources has been integrated in a novel way in the research project.

Computing the **diversity of represented subfields in a publication's cited references—that is, its interdisciplinarity**—can be achieved using various diversity metrics. Most of these metrics aim to capture three underlying concepts of diversity, with varying success: variety of represented disciplines (How many are cited?), distance among integrated disciplines (How common are citations among them?), and balance showing the extent to which disciplines contributed equally to the work (How are references distributed across disciplines?). One such metric is the Rao-Stirling index, which will be implemented in this study following the work of Porter & Rafols. Using their method, each paper was assigned an interdisciplinarity score from 0 (i.e., completely following predominant citation patterns) to 1, the latter being extremely interdisciplinary (i.e., diverging completely from normal citation patterns, integrating knowledge from areas that others do not). Per their method, a paper's interdisciplinarity score is computed as:

$$Interdisciplinarity = 1 - \sum_{i,j} s_{ij} p_i p_j$$

Where p_i and p_j are the respective proportions of references in subfields i and j in a paper's reference list. The summation is taken over all cells of the subfield-by-subfield similarity matrix, accounting for all subfields in a selected taxonomy. s_{ij} is the similarity between subfields i and j and captures how close (or distant, by taking $1-s_{ij}$ as in the above formula for interdisciplinarity) the integrated subfields are in a given paper; the similarity matrix between subfields is computed relying on the subfield co-citation network in a reference set of papers. Table 5 depicts the computation for five papers in a system with three subfields (e.g. s_1 = forestry, s_2 = applied mathematics, and s_3 = optics; the similarities in the example are fictive).

Table 5   Illustration of the computation of a paper's interdisciplinarity score

Step 1: Counting the number of references per subfield for each paper

Subfield	Pub1	Pub2	Pub3	Pub4	Pub5
s_1	30	15	25	15	10
s_2	0	0	0	15	10
s_3	0	15	5	0	10

Step 2: Computing the reference vector for each paper

Subfield	Pub1	Pub2	Pub3	Pub4	Pub5
s_1	1.00	0.50	0.83	0.50	0.33
s_2	0.00	0.00	0.00	0.50	0.33
s_3	0.00	0.50	0.17	0.00	0.33

Step 3: Computing the similarity matrix between all pairs of subfield

Subfield	s_1	s_2	s_3
s_1	1.00	0.75	0.25
s_2	0.75	1.00	0.50
s_3	0.25	0.50	1.00

Step 4: Compute interdisciplinarity

	sij	Pub1				Pub2				Pub3				Pub4				Pub5			
		p_i	p_j	p_ip_j	$s_{ij}p_ip_j$	p_i	p_j	p_ip_j	$s_{ij}p_ip_j$	p_i	p_j	p_ip_j	$s_{ij}p_ip_j$	p_i	p_j	p_ip_j	$s_{ij}p_ip_j$	p_i	p_j	p_ip_j	$s_{ij}p_ip_j$
s_1s_1	1.00	1.00	1.00	1.00	1.00	0.50	0.50	0.25	0.25	0.83	0.83	0.69	0.69	0.50	0.50	0.25	0.25	0.33	0.33	0.11	0.11
s_1s_2	0.75	1.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.83	0.00	0.00	0.00	0.50	0.50	0.25	0.19	0.33	0.33	0.11	0.08
s_1s_3	0.25	1.00	0.00	0.00	0.00	0.50	0.50	0.25	0.06	0.83	0.17	0.14	0.03	0.50	0.00	0.00	0.00	0.33	0.33	0.11	0.03
s_2s_1	0.75	0.00	1.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.83	0.00	0.00	0.50	0.50	0.25	0.19	0.33	0.33	0.11	0.08
s_2s_2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.50	0.25	0.25	0.33	0.33	0.11	0.11
s_2s_3	0.50	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.17	0.00	0.00	0.50	0.00	0.00	0.00	0.33	0.33	0.11	0.06
s_3s_1	0.25	0.00	1.00	0.00	0.00	0.50	0.50	0.25	0.06	0.17	0.83	0.14	0.03	0.00	0.50	0.00	0.00	0.33	0.33	0.11	0.03
s_3s_2	0.50	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.33	0.33	0.11	0.06
s_3s_3	1.00	0.00	0.00	0.00	0.00	0.50	0.50	0.25	0.25	0.17	0.17	0.03	0.03	0.00	0.00	0.00	0.00	0.33	0.33	0.11	0.11
$\sum p_ip$				1.00	1.00			1.00	0.63			1.00	0.79			1.00	0.88			1.00	0.67
Interdisc = 1-$\sum s_{ij}p_ip_j$					0.00				0.38				0.21				0.13				0.33

Per this example, one can see that subfields 1 and 3 are the least similar (or most dissimilar), and that subfield 2 is most similar to subfield 1, while at the same time being more similar to subfield 3 than subfield 1 is to subfield 3. Thus, the combination of subfields 1 and 3 should contribute most to interdisciplinarity, followed by subfields 2 and 3, and then subfields 1 and 2.

Of course, if only one subfield is cited in a paper (either subfield 1, 2 or 3) as in publication #1, the interdisciplinarity will equal 0 (monodisciplinary paper). Publication #2 strictly cited the two most distant subfields (i.e., 1 and 3) in equal proportions. This resulted in the highest interdisciplinarity score (0.38) across the five publications shown in the example. Publication #3 also strictly cited subfield 1 and 3, but in very unequal proportions. Accordingly, its interdisciplinarity score (0.21) is lower than for publication #2 (0.38). Publication #4 strictly cited subfields 1 and 2 in equal proportions. Since they are the least distant (or most similar) subfields, its score (0.13) is lower than for publication #2 (0.38) even though they both have their references uniformly distributed across cited subfields. Finally, publication #5 is the only one to have cited all three subfields, and this in equal proportions. Due to the balanced integration of a greater variety of disciplines, it scores higher than publication #3 and #4, but not more than publication #2. This is because although publication #2 only cited two subfields instead of three, the average distance between the integrated disciplines in publication #2 is higher than in publication #4—that is, the additional subfield cited in publication #4 reduces the overall "intellectual" distance in the pool of referenced work.

In computing interdisciplinarity in this evaluation, the proximity between integrated subfields will be computed as the cosine similarity matrix between subfields, relying on the subfield co-citation network in the whole of Scopus (using peer-reviewed publications; i.e., journal articles, conference papers and reviews). The classification used to categorise publications by subfield can have an impact on the resulting interdisciplinarity scores. It is important for such a classification to offer enough granularity to enable the detection of relevant disciplinary mixes. For example, carrying out the analysis at the level of large scientific domains (e.g., natural sciences, engineering, health sciences, social sciences and humanities) would disregard significant differences in scientific culture, methods and tools within each of those domains (e.g., between biology, chemistry and physics within the natural sciences). At the other end of the spectrum, too much granularity would introduce noise in the analysis, detracting our attention from those disciplinary mixes that matter most. For example, in most cases of funders promoting cross-disciplinary work, it would appear irrelevant to know that an entomologist working on species X collaborated with an entomologist working on species Y, but it would matter to know that an entomologist working on the ecology of species X collaborated with a geneticist to study the population genetics of species X. Selecting the appropriate classification to study interdisciplinarity is not a trivial choice. Ideally, one wants to pick a structure that somewhat reflects the current division of staff in academic departments at higher education institutions. One such classification was developed by Science-Metrix[8] and was recently recognised as the most accurate journal-based classification of scientific papers.[9] In its most recent version, generalist journals publishing papers in diverse fields (e.g., *Nature, Science, PNAS, PLOS One*) were reclassified in the most appropriate category at the paper level using a machine learning algorithm. The updated classification tree now includes 174 subfields distributed across 20 fields and 5 domains. All 174 subfields will be used in computing interdisciplinarity in this study.

Because the interdisciplinarity score of a paper is in part dependent on how many references it includes, which varies across subfields due to research practices and coverage issues in Scopus, as well as across document types (e.g., reviews include more references than journal articles), the interdisciplinarity scores of individual papers will be normalised by subfield and

---

[8] Archambault, É., Beauchesne, O. H., & Caruso, J. (2011). Towards a multilingual, comprehensive and open scientific journal ontology. *Proceedings of the 13th International Conference of the ISSI,* 66–77.

[9] Klavans, R., & Boyack, K. W. (2017). Which type of citation analysis generates the most accurate taxonomy of scientific and technical knowledge? *JASIST,* 68(4), 984–998.

document type. To account for changes in the definition of subfield boundaries through time, and therefore enable a fair comparison of papers published in different years, the indicators will also be normalised by year. The normalisation process used is analogous to the one implemented on citation counts in computing the mean normalised citation score.[10] Note that the scores of papers with fewer than five references will be disregarded in the normalisation process to ensure enough of a signal is available to compute the interdisciplinarity of a paper. The normalised scores range from 0 to unbound, with the mean reference value being 1. Scores below 1 indicate papers that are less interdisciplinary than the world level in their corresponding subfield, document type and year, whereas scores above 1 mean the opposite. Two indicators aggregating the paper-level interdisciplinarity scores will be used in this study: (1) the average of the normalised interdisciplinary scores (i.e., the Interdisciplinary Index (II)), and (2) the share of papers in the 10% most interdisciplinary papers (i.e., Highly Interdisciplinary Papers (HIP$_{10\%}$)). In a random sample of publications in the low, middle and upper range of the interdisciplinary scores, a manual inspection of the papers' content suggested that the indicator properly reflected the extent of interdisciplinarity. However, those publications in the upper tail of the distribution of interdisciplinarity scores were more obviously interdisciplinary. Therefore, the analysis captures the HIP$_{10\%}$. It is also worth noting that previous analyses of multi- and interdisciplinary funding programmes (e.g., Belmont Forum, Human Frontier Science Program, Sentinel North) by Science-Metrix did reveal that they stood out, on the above metrics, from programmes without such a focus on cross-disciplinary research.

B.3.1.2 Multidisciplinarity

Multidisciplinarity highlights instances where scientists from different disciplines partnered in research, assuming that co-authorship of a paper is a reliable account of such collaboration. This should at least hold true for a project's principal investigator and his or her co-investigators, so long as they successfully worked together. If a unique subfield was assigned to each author on a publication—using, for example, the field in which a researcher graduated or the researcher's departmental affiliation, matched to the Science-Metrix classification—then the exact same approach as depicted above for interdisciplinarity could be implemented here. The former type of information (based on graduate degrees) is not available at scale for all authors in Scopus, and the second type (based on author addresses) would require a challenging harmonisation task, given existing name variants for a given department, not to mention that it would overlook some of the existing disciplinary diversity. Some departments are indeed multidisciplinary by nature, such as oceanography departments, which hire staff from biology, chemistry and physics, to name just a few disciplines. Additionally, relying on graduate degree(s) or departmental affiliation(s) would have the disadvantage of disregarding the cumulative knowledge researchers acquire over the lifespan of an academic career.

For these reasons, Science-Metrix has devised a new approach to uncover the disciplinary profiles of authors on a given paper, accounting for their cumulative experience at the time the paper was published. For each author on a publication, the first step consists in assigning the author a subfield vector,[11] per the Science-Metrix classification, in which he or she has published in the years preceding the publication of the paper being scored. This is done relying on existing data in Scopus. Accordingly, this process requires each author to have been

---

[10] Waltman, L., van Eck, N. J., van Leeuwen, T. N., Visser, M. S., & van Raan, A. F. J. (2011). Towards a new crown indicator: An empirical analysis. *Scientometrics*, 87(3), 467–481.

[11] The subfield vector simply reports the number of prior papers produced by the author in each of the 174 subfields in the Science-Metrix classification.

disambiguated in the database to identify all his or her Scopus-indexed papers. For this, Science-Metrix relies on Scopus's unique author identifiers (AUIDs), which have been shown to produce reliable evaluation findings when used on a sufficiently large pool of researchers and/or papers,[12] and we expect such thresholds to be met in this study. Some of the limitations linked to inferring the disciplinary profiles of authors using this approach can already be highlighted. First, a large portion of researchers (e.g., students, some of which later left academia) published very few Scopus-indexed publications (or even only one publication). For these researchers, the assignation of a subfield vector is based on scant data. Thus, the resulting vector may not be representative of their "true" disciplinary background. As an example, researchers with few prior publications in Scopus may be assigned subfields other than their own. This could happen if they previously provided methodological support to the research teams of their previous publications (e.g., a graduate student in computer sciences providing support to biology papers). In other cases, graduate students could have had no previous publications, in which case they would not contribute to the score even though they effectively contributed to the paper.

Compared to interdisciplinarity, where each of a paper's references are assigned a unique subfield, authors can be assigned multiple subfields in computing a paper's multidisciplinarity score. This is a key difference requiring adaptation to the Rao-Stirling diversity index. Once all authors on a paper are assigned a subfield vector, a subfield vector for the paper is created in two steps (see Table 6 for examples in a 3-subfield system). First, the authors' subfield vectors are averaged together. Then, the averaged vector is subtracted from the authors' subfield vectors, and the absolute differences are kept. Conceptually, what remains are the distances between the authors' disciplinary profiles and the average disciplinary profile of the publication. If all authors share the exact same profile (i.e., no between-author variation in disciplinary profiles), and this even if within-author variation is present as for publication #1 in Table 6, differences will be null, leaving all authors' subfield vectors empty, which is to say that the paper will score 0 on the multidisciplinary scale (i.e., to be interpreted as monodisciplinary). Otherwise, the differences will, once averaged across authors, reflect the paper's disciplinary diversity stemming from the within- and between-author disciplinary diversity (see publication #2 in Table 6). In measuring multidisciplinarity, emphasis is indeed placed on the collaborative aspect, which is the common denominator of most funding programmes promoting cross-disciplinary research. Accordingly, within-author diversity (an author active in more than one field) will not contribute to the paper's score if there is no difference across authors' disciplinary profiles or if there is only one author (all single-author papers will score 0).

This approach runs the risk of counting as monodisciplinary all papers produced by, for example, two authors, a biologist and a physicist, who always published together, resulting in the exact same subfield vector for each of them (e.g., 50% in biology and 50% in physics). This, even though they truly provided distinct disciplinary inputs to their common work. This is a key limitation of the proposed metric. In practice, however, such cases are very unlikely. Given the number of subfields in the classification used (i.e., 174), most authors will publish in many subfields over their career (so more senior authors are likely to have more variation in their subfield vectors) making it unlikely for any given paper's authors to share exactly the same subfield vector. In fact, the larger the number of authors on a paper, the more likely this method is to capture diversity even when it is marginal; with 10 authors from a biology department, this method is very likely to capture between-author variation in their disciplinary profiles. To

---

[12] Campbell, D., & Struck, B. (2019). Reliability of Scopus author identifiers (AUIDs) for research evaluation purposes at different scales. *Proceedings of 17th International Conference of the ISSI*, Vol. II, 1276–1287.

account for this risk, while still accounting for the number of authors on a publication[13] when comparing the multidisciplinary score of papers with different numbers of authors (and effective numbers of authors, see below), two versions of the indicator will be computed and compared in analysing the study results (see below).

Table 6   Illustration of the computation of a paper's subfield vector based on its authors' disciplinary profiles

Step 1: Computing the average disciplinary profile of the paper

	Publication #1				Publication #2			
	Author subfield vector			Paper's avg subfield vector	Author subfield vector			Paper's avg subfield vector
	A1	A2	A3		A1	A2	A3	
S1	0.50	0.50	0.50	=(0.50+0.50+0.50)/3 = 0.50	0.50	0.50	0.00	0.33
S2	0.50	0.50	0.50	0.50	0.50	0.50	0.00	0.33
S3	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.33

Step 2: Computing the paper's subfield vector from the differences between author subfield vectors and the paper's avg subfield vector

	Publication #1				Publication #2			
	Difference (Author subfield vector - paper's avg subfield vector)			Paper's subfield vector	Difference (Author subfield vector - paper's avg subfield vector)			Paper's subfield vector
	A1	A2	A3		A1	A2	A3	
S1	=ABS(0.50-0.50)=0.00	0.00	0.00	0.00	0.17	0.17	0.33	0.22
S2	0.00	0.00	0.00	0.00	0.17	0.17	0.33	0.22
S3	0.00	0.00	0.00	0.00	0.33	0.33	0.67	0.44

To compute the multidisciplinarity of a given paper, the Rao-Stirling index as depicted above for interdisciplinarity (Table 5) is applied to its resulting subfield vector obtained using the above procedure with author disciplinary profiles. Briefly, a paper's reference vector (obtained in step 2 for interdisciplinarity, Table 5 is substituted by its paper's subfield vector obtained in step 2 of Table 6. Contrary to a paper's reference vector, note that the sum of values across subfields for a paper's subfield vector based on authors may add up to more or less than 1 (see publication #2 in Table 6). This implies that the adapted Rao-Stirling index for multidisciplinarity is not bounded between 0 and 1 as for interdisciplinarity. Instead, it ranges from 0 to (in theory) infinity (in practice, it rarely exceeds 1).

To ensure that the disciplinary profiles of a paper's authors are adequately captured, multidisciplinarity is only computed for papers with at least two effective authors (i.e., authors with an assigned subfield vector). For a score to be computed, the effective number of authors must also represent at least 20% of the real number of authors. A multidisciplinarity score is not computed for any paper not matching these two conditions. Single-author publications are by default monodisciplinary papers.

Once the raw multidisciplinarity scores are computed, they are normalised in two ways: once using the same approach as detailed above for interdisciplinarity (i.e., normalised by the average score of papers falling in the same subfield, document type and year) to obtain multidisciplinarity I, and once by grouping publications together according to their subfield and

---

[13] As stated earlier, the collaborative dimension is of interest.

document type, and then creating a non-linear model with the following formula (this will lead to multidisciplinarity II, see below):

Where:

Multidisciplinarity$_{s,d}$ = The expected score of a paper in subfield s and document type d, accounting for the publication year, the number of effective authors and the difference from the real number of authors.

e = effective number of authors;

d = difference between real number of authors and effective number; and

y = year.

The use of an equation of the third degree for number of effective authors and year was justified by the non-linear relationship between these variables and multidisciplinarity, as well as by the variation in observed patterns across subfields and years; higher-degree equations would have resulted in too much overfitting. In many cases, at least two inflection points were needed to properly fit the data (see example using effective number of authors in ecology, Figure 3); multidisciplinarity increases up to a certain point, after which it can decrease before stabilising.

Figure 3   Median multidisciplinarity (prior to normalisation) for papers with a given effective number of authors
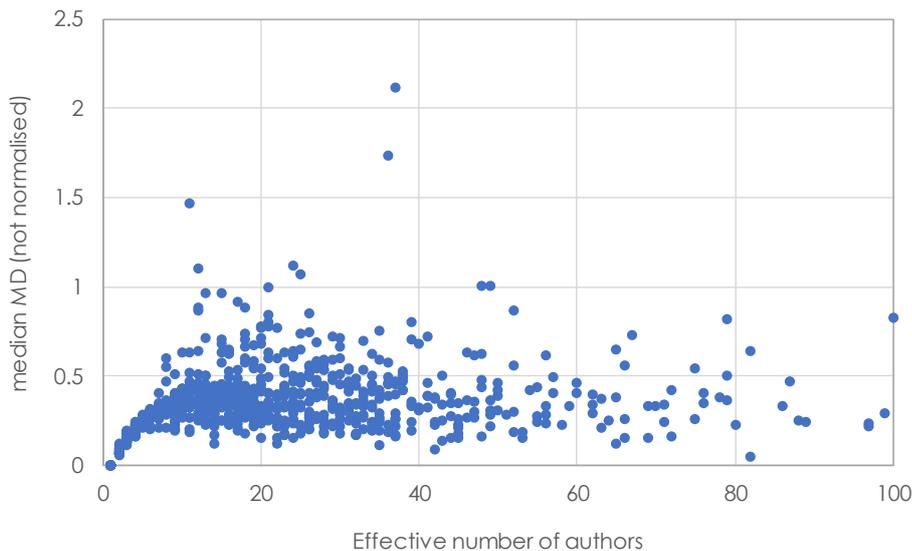
Past a certain point of effective number of authors, few data points exist to properly estimate expected values from the regression. For this reason, for a small share of publications with the largest numbers of effective authors (less than 1%), the expected score is computed using a lower number of effective authors (i.e., the number for the paper at the 99th percentile of the number of effective authors). By calculating the difference between the observed and the expected multidisciplinarity scores of papers, the residuals (i.e., ε in the above regression model) are obtained, which is equivalent to the variation in the multidisciplinarity that is not explained by the variables in the model. To obtain the second set of normalised multidisciplinarity scores (i.e., multidisciplinarity II), the minimum residual is subtracted from the residuals (to make the distribution of residuals strictly positive), and the translated scores are divided by the median of the residuals (which has itself been translated).

Similar to multidisciplinarity I, multidisciplinarity II below 1 indicates less multidisciplinarity than expected, whereas a score above 1 means the opposite. Conceptually, the first normalisation controls for the differences in authorship traditions across subfields and document types, as well as for changes in the extent of multidisciplinarity over time (enabling a fair comparison of papers in different periods). The second normalisation controls for the number of effective authors, the difference between the number of real and effective authors, as well as for subfield, document type and years.

In the end, both multidisciplinarity I and II can be aggregated in a similar manner to interdisciplinarity using (1) the average of the normalised scores (i.e., Multidisciplinary Index I and II (MI-I and MI-II)), and (2) the share of papers in the 10% most multidisciplinary papers (i.e., Highly Multidisciplinary Papers (HMP$_{10\%}$-I and HMP$_{10\%}$-II)).

B.3.1.3   Measuring MIDRI for SPF

The bibliometric indicators reported are based on 242 peer reviewed publications from 2018 to 2020 that have already been reported in GtR (or acknowledged by authors as supported by SPF). These publications were reported by 7 % of all SPF projects awarded to date (N = 754); this is most likely due to the recent start date (in 2018) of most SPF projects rather than underreporting in GtR or papers' acknowledgements; though this latter factor may still be at play. The small share of represented projects among reported publications implies the SPF results in this report are most likely not representative of the full programme yet.

Comparator groups were selected from four publication sets as adequate benchmarking references against which to measure the performance of SPF papers:

- UK papers (all publications with at least one UK-based author).
- UKRI papers (all UK publications with funding from a UKRI council, identified in GtR and Scopus acknowledgements).
- Prior publications from SPF researchers (papers authored by SPF researchers and published prior the first year of any of the SPF projects in which the researcher has participated. In the aggregate, this group includes papers published between 2006 and 2019).
- Parallel publications from SPF researchers (papers authored by SPF researchers after their first year in any SPF project, that has not been identified as an SPF paper in GtR and Scopus). These are presumed to be publications associated with concurrent projects by SPF-funded researchers. They include, in the aggregate, papers published between 2018 and 2020. Note that the parallel papers group may include SPF papers not correctly identified as such in GtR or in Scopus acknowledgments.

The indicators were computed for 2 periods (2006-17, 2018-20).

Limitations and caveats

We identified two potential concerns related to the data used to compute the indicators reported here.

1. Many SPF projects have not yet been linked to publications. This should be expected, given that most of them are still too recent to accumulate a considerable number of publications; it is also possible that some of their publications are just not yet reported in GtR. The extent of this potential issue may become clear in the future iterations of this project.

2. It is possible that GtR does not provide a comprehensive list of all researchers involved in each SPF project. For instance, 201 of the SPF projects listed only one researcher in

GtR (40 % of the 512 SPF projects in GtR), what may indicate that the list of researchers used in this report is incomplete.

3. We also note that there might be unknown cofounding factors making it so that researchers from highly cross-disciplinary projects also tend to be more systematic in updating their GtR profiles.

4. For the interim and final report, this problem of attribution may be alleviated by using multivariate analysis and by improving the classification of papers by SPF researchers into the groups of SPF, prior and parallel publications.

B.3.2   Intersectoral collaboration

We have also measured the extent to which researchers in the UK (and through SPF) collaborate in publications with authors affiliated to Universities, Government Departments, PSREs and Industry.

The data set used is similar to the one described above (and based the 242 peer-reviewed publications from 2018 to 2020 that have already been reported as SPF-supported on the Gateway to Research website (GtR) or in the paper's funding acknowledgments.

As above the indicators are calculated for four comparator groups and computed for two periods (2006-17, 2018-20).

The first two limitations listed above should be considered when analysing this data.

B.3.3   Additional indicators

At this baseline stage, we have also collected data on

- Share of publications cited in patents, as baseline information to track uptake of (codified) knowledge on innovations
- Share of women authorships, as a proxy for Equality, Diversity and Inclusion (which is included in the Business Case as an indicator of interest).

B.4   Programme lead consultation

We plan to consult all programme leads at each phase of the evaluation (baseline, interim and final). In each case, this will comprise the completion of template (survey) to provide factual information and headline views, plus further consultation (through interviews or workshops). During the current phase of evaluation, we have employed a three step process:

1. Initial request for basic information. All programme leads were asked to provide a list of grants awarded by their programme so far, as well as the details of various stakeholders involved in programme governance (programme leads and co-leads, government department partners, Directors, Champions and Advisory Board members). A return was provided by all programmes, with subsequent interviews (see below) seeking to clarify any gaps in the information provided.

2. A programme information template. A second request went out to all programme leads to provide factual information on their programme and its implementation, as well as high-level views and perceptions on several key areas relating to Fund objectives. This asked, for instance, about the extent of involvement of different types of organisation in the programme bidding and implementation processes, as well as overall views on the added value of SPF. A return was provided by all programmes and the results are summarised in Appendix F.1. Subsequent interviews (see below) sought to clarify any gaps in the information provided, as well as build on this initial input and pursue areas in more depth through discussion.

3. Interviews. Finally, all programme leads and co-leads were invited to participate in a semi-structured interview about their programme and experiences. The topic guide for these interviews sought to explore the programme bid, the value added of SPF in each of three areas (relating to the Fund objectives), notable achievements within the programme and early indications of change more widely, as well as any lesson learned. At least one individual was interviewed for each programme, with multiple leads and co-leads consulted in some cases.

Table 7   Response rate to programme lead consultation activities

Approach	Response*
Initial request for basic information (grants awarded, contact information)	33 returns
Programme information template	33 returns
Interviews with programme leads / co-leads	59 interviews, covering 33 programmes

* Note that while there are 34 programmes in the SPF portfolio, the Clean Air Future Challenges programme in wave 2 is a continuation of the Clean Air Analysis and Solutions Programme in Wave 1, with a single management and governance structure, and so these programmes have been treated as one.

At the interim and final phase, a series of workshops are planned with programme leads (seven workshops per phase, organised by SPF Theme), in addition to a smaller number of interviews (which will focus on case study programmes).

B.5 Stakeholder consultation

B.5.1 Surveys

The evaluation has run two short survey consultation exercises, one targeted at members of the Government CSA network and the other addressed to members of individual SPF Programme Advisory Groups (where these exist).

All ~24 **Government CSAs** were approached through the GO-Science weekly newsletter with a request to participate in a short online survey. This questionnaire addressed topics including: awareness and involvement in SPF (bids and implementation); the SPFs role in the identification of cross-departmental priorities; views / perceptions on SPF R&I outputs (knowledge, solutions, tools); views and perceptions of improved evidence for policy; and early examples of access / uptake by government.

Due to a low response, the survey remained open for several months, with further reminders being sent through the CSA newsletter and made at CSA meetings. In total, 12 (50%) of the CSAs replied. We have recommended actions that the evaluation can take in future iterations to try to further improve this level of engagement for the next stages of the evaluation.

The results from the survey are presented in Appendix F.2.

Programme Advisory Group members. All programmes were asked to provide details of their advisory group members (where these bodies existed). Across the portfolio of 34 programmes, 25 have an advisory board in place, while a further 6 plan to establish one in due course (leaving 3 programmes without such a body). We were provided with details of the members of 22 of the bodies currently in existence, which together contain 270 members.

Where individuals were being consulted through other means (e.g. the CSA survey), they were removed from this list. Those with no missing email address were also removed. The remainder were approached with a request to complete an online survey about the role and activities within the advisory group, their experiences of the SPF programme and views on added value in relation to SPF objectives. The survey remained live for 1 month, with a reminder sent before the deadline. In total 89 responses were received from the 190 individuals targeted, representing a very good response rate of 47%.

The results from the survey are presented in Appendix F.3.

Table 8   Response rate to surveys

Group	Population targeted	Responses
Chief Scientific Advisors	24	10 (42%)
SPF Programme Advisory Board Members	190	89 (47%)

B.5.2 Stakeholder interviews

Additional interviews have been undertaken with other stakeholders. This includes additional interviews tied to the development of case studies (described in the next section), where (in addition to programme leads) we have consulted with other programme partners, government representatives, programme Directors and Champions and key participants involved in each of the programmes in focus. In addition to this, we have spoken with stakeholders from GO Science, UKRI, the SPF Board, the SPF bid selection panel, unsuccessful programme bidders and BEIS PSREs (not being covered elsewhere).

B.6　Longitudinal case studies

The Fund evaluation is developing **eight case studies**, iteratively, over the three phases of the evaluation. These will focus on Fund-level objectives and evaluation questions, and in particular Objective 2 ("Ensure that UKRI's investments link up effectively with cross-departmental research and innovation priorities and opportunities"). The case studies have been selected using a purpose sampling approach described below.

Each case will have as a starting point a Government R&I priority / challenge that has been identified (and is being addressed) by a particular programme, and will explore the extent to which (and how and why / why not) the nature of the SPF and its key characteristics have: (i) enabled UKRI investments to align with and help address this priority and create impact; (ii) enabled focus in an area where a gap existed; and (iii) enabled the achievement of impact.

It is important to note that at this (baseline) stage the case studies focus mainly on the programme origins, early development, design and activities to date, while evidence on the outputs, outcomes and impacts of the programmes is more limited because of the relatively early stage of programme implementation. This evidence is expected to build over time, and the impacts and achievements of programmes will be the main focus of later iterations of case study development, as part of the interim (2022) and final (2024/25) phases of evaluation.

B.6.1　Case study scope

The **purpose** of the case studies is to explore in more depth the extent to which (a selection of) programmes have made progress towards SPF outputs, outcomes and impacts, in particular (but not exclusively) with respect to Objective 2 (Links with government priorities). The case studies also covered, when relevant results with respect to MIDRI (in particular the intersectoral and/or cross-council nature of the programme and the activities developed to ensure intersectoral and/or cross-council collaboration and knowledge exchange; and the scale of the support, and its agility.

The analysis also covers outcomes identify in the Theory of Change, including improved awareness and understanding of national research efforts and state of the art amongst Government departments, increasing R&D spend that aligns with Government R&I priorities, and strengthening linkages and communications mechanisms / structures between and across partner organisations (including new ways of working and collaborating).

Over time, the case studies will play an important role within the overall evaluation, helping to understand what has worked well / less well in the delivery of programmes to address the Fund's ambitions, highlight issues and challenges, and provide examples of successes and achievements that demonstrate the added value of the Fund, compared with business as usual (BAU).

Each case study will follow a standard structure, and look to address a **series of questions**, which are outlined in the template below. The first three sections of this structure (the programme origins, early development, design and activities to date) are the main focus of the current (baseline) versions of the case studies. Evidence for the subsequent sections (on the outputs, outcomes and impacts of the programmes) is more limited at present because of the early stage of programme implementation. These later sections will be further developed over time and will be the main focus of later iterations of the case studies.

Figure 4   Case Study Structure

Section	Scope (questions in parenthesis refer to evaluation sub-questions)

Introduction and context	• Summary of the focus of the case study
	  – The programme (objectives, budget, lead and partner Councils / PSREs)
	  – The Government R&I priority / challenge and government department partners

Programme origins and idea development	• What was the process for developing the programme idea?
	  – How did different organisations (Councils, OGDs, PSREs) engage with each other to discuss and design the programme (Q3.4)?
	  – How do these aspects compare with business as usual (BAU) i.e. before SPF?
	• What is the nature of **the priority / gap in knowledge** that has been identified?
	  – How was this identified and used to inform the design of the programme?
	  – Did the process set up via SPF support the identification of this priority (Q3.1)? How?
	• How did Fund objectives and bid guidance / criteria influence the proposal? (Q1.2) (e.g. focus, partners, activities, target groups)

Programme design and activities	• How is the programme designed to address the identified priority (Q3.3)?
	  – Is the programme designed to bringing a multi- and inter- disciplinarity perspective (MIDRI) to address the priority (Q2)? How is a MIDRI perspective being embedded in the programme and its activities?
	• What **activities** have been funded?
	• What has been the **role of different organisations** (Councils, OGDs, PSREs) in the governance, management and delivery of the programme (Q3.4)?
	  – Have specific mechanisms / approaches been deployed for partners to work together?
	  – How do these aspects compare with BAU?
	• Has the programme shifted its priorities over time to reflect **changing needs and opportunities** (Q4.3)? How?

***Programme outputs and uptake**	• **What has resulted from the R&I** (Q 4.1)? • How has this been collated and disseminated? • How have relevant users been identified / engaged?
***Programme outcomes and impact - R&I to address priorities**	• To what extent / how have the R**&I outputs been taken up and deployed** (and by whom)? • Have they helped to address the originally identified priority / challenge? What is the scale of the contribution? (Q4.1) • What have been the implications of this (Q5)? • How do these aspects compare with BAU?

***Programme outcomes and impact - intersectoral collaboration**	• How has the **experience of the programme** been viewed by the different partners (Q1.4)?
	  – What has worked well / less well in the design and delivery of the programme (Q1.4)?
	  – What have been important **enablers** or facilitators for success (Q1.5)?
	  – What **barriers** have been identified / overcome (Q1.5)?
	  – What has been learnt (Q1.6)?
	• How have **relationships**, communication mechanisms / structures and ways of working changed between programme partners (Q3.2)?
	• How has understanding of Government R&I priorities improved amongst Council partners (Q3.2)?

	• How has understanding of research efforts and evidence improved amongst Government Department partners (Q3.2)?
	• Have further potential **opportunities** for R&I to address Government priorities been identified (Q3.2)?
	• Have there been sustained effects (collaborations / interactions) amongst SPF partners, outside of SPF?
	• Is there evidence of a wider ecosystem change (i.e. with effects materialising beyond the SPF partners), e.g. through new coordination structures or new "MIDRI-rich" programmes?
Conclusions	• Based on the evidence available in the case study so far, to what extent and how has the nature of the SPF and its key characteristics: – Enabled UKRI investments to align with and help address identified priorities – Enabled focus in an area where a gap existed – Enabled the achievement of impact (across all the impact categories) • What other conclusions can be drawn about the contribution of the programme to Fund objectives?
Sources	• List of documentation, interviews, etc.

* Early evidence for some parts of these sections is limited at this baseline stage. However, these areas are still explored, in order to provide preliminary results and insights, where available.

B.6.2   Case study selection

Across Waves 1 and 2 there were 32 programmes (out of 34) that self-assessed at the bid stage as addressing SPF Objective 2. All but two of these programmes also involved one or more Government Department partners in their bid. From these, the evaluation team selected 9 programmes to case study (one case study will explore the two 'Clean Air' programmes together). Beyond addressing Objective 2 and involving government department partners, this sample of programmes has been chosen using a purpose sampling approach to achieve good coverage across other relevant dimensions (government departments, Councils, PSREs, Waves, programme size, etc.).

Table 9   Selection of programmes to case study

Wave	Programme	Lead	Partner Council / BEIS PSRE	Government partner	Budget (£m)	M&E Scope
2	Policy and Evidence Centre for Modern Slavery and Human Rights	AHRC	ESRC	Home Office	10	5
1	Bacterial Plant Diseases (originally UK Animal and Plant Health)	BBSRC	NERC	DEFRA and Scottish Gov.	17.7	1
1	Transforming Productivity Research	ESRC	EPSRC, MRC	DHSC, DWP and BEIS	8.9	1
1	Ensuring the Security of Digital Technologies at the Periphery	EPSRC	AHRC, ESRC, IUK	DCMS and Home Office	30.6	6
1&2	Clean Air: Analysis and Solutions & Future Challenges	NERC & Met Office	IUK, ESRC, EPSRC, MRC and STFC & NPL	Defra, Scottish Gov, Welsh Gov, DHSC and DfT	41.6	3
2	Adolescence, Mental Health and the Developing Mind	MRC	AHRC and ESRC	DfE, DCMS and Welsh Gov.	35	5
2	National Timing Centre	NPL	IUK	MoD, BEIS and DfT	30.3	5
2	Space Weather Innovation, Measurement Modelling & Risk	STFC	NERC & Met Office	BEIS, MoD and DfT	20	2

B.6.3   Case study approach

The case studies will follow a **longitudinal design**, involving data collection at three distinct points in time (baseline, interim and final evaluation). This enables us to provide early evidence, as well as to illustrate the dynamic aspects of the programmes and change over time.

The first iteration (at the baseline / interim process stage) focuses on providing an in-depth description of the programmes and their origins, as well as any early learnings and preliminary outputs / outcomes (where relevant). We will provide a first cross-analysis as part of the final report from this phase, comparing and contrasting the cases and drawing insights on each of the dimensions covered, plus any unexpected themes emerging.

The case studies will be mini-studies in their own right, but also draw upon evidence emerging from other evaluation activities (e.g. survey responses and programme evaluation evidence) when this becomes available. The current drafts are based on desk research, plus interviews with a number of key stakeholders (lead and partner organisations, programme Directors and Champions where these are in place, and key programme participants working on particular projects or work-packages around dissemination and uptake activities). Individual interviewees are detailed at the end of each case.

B.7   Literature review

A literature review has been undertaken to inform evaluation of the Fund. It focuses on describing the main rationales for investing public funding in Multi- and Interdisciplinary Research and Innovation (MIDRI) and analysing the mechanisms and processes used by international funders to support MIDRI in a selection of international programmes.

The review is presented in Appendix D and includes further details of the approach employed.

B.8 Interviewees

In total, 119 interviews have been undertaken with a wide range of stakeholders during the current phase of evaluation. This includes:

- 5 members of the SPF Board or Working Group
- 3 members of the SPF bid selection panels
- 59 programme leads / co-leads
- 8 programme partners from Councils
- 2 programme partners from PSREs
- 14 programme partners from government departments and agencies
- 9 programme partners from other organisations
- 6 programme Directors
- 2 programme Champions
- 3 programme participants
- 3 representatives from BEIS PSREs not otherwise covered
- 5 individuals from Councils that had submitted an unsuccessful programme bid to SPF

Note that a small number of individuals were interviewed more than once, for different roles / programmes. Note also that another 96 individuals were consulted through survey.

Appendix C   Guidance for programme monitoring & evaluation

This appendix presents a list of questions / indicators that all programmes might provide evidence against (as part of their evaluation activities), which would support the Fund-level evaluation. We have focused on those questions and indicators that need to be answered at the programme level, but which will support the answering of Fund-level evaluation questions.

We have drawn selectively on the original long list of questions / indicators requested of programmes in the SPF M&E plan, but kept only those elements that are appropriate and relevant to the Fund evaluation and which cannot be addressed through other means. These questions / indicators are marked in blue text in the tables below.

Additional questions / indicators have then been added which directly relate to Fund-level evaluation questions, as well as selected indicators from the Fund evaluation framework.

This guidance document was circulated to all SPF programmes and their M&E leads and then presented and discussed at a workshop run by the Fund evaluation team in March 2021.

C.1   Process Evaluation

To support **EQ1** (To what extent, and how, is the SPF working and being delivered as intended?):

Source	Question
• Views of researchers and innovators	• What, in practice, is felt to be working more or less well regarding the delivery of the programme, and why? • What is the range of reported experiences of researchers and innovators in delivering SPF-funded projects? • What were the challenges, facilitators and barriers to implementing and delivering projects, if any? • What potential lessons are there for future similar activities?
Programme-level view	• Is the programme working as intended? • Is the programme being delivered as intended? • Are targets for inputs and outputs being met? • Is the programme on course to deliver intended impacts? • What were the challenges, facilitators and barriers to implementing and delivering the SPF and its component programmes, if any? • Were there any unexpected barriers or facilitators to desired impacts? • What potential lessons are there for future waves / similar funds?

C.2   Impact Evaluation

1.1.1   Obj 1: Increase in high quality MIDRI

To support **EQ2** (To what extent / how has the SPF supported an increase in high quality MIDRI?):

Source	Question
• Views of researchers and innovators	• To what extent has the programme improved the effectiveness of the peer-review process to better assess MIDRI bids?
	• To what extent has the programme de-risked the process of preparing and submitting proposals for the R&I community?
	• To what extent has confidence increased to apply for MIDRI funding (within/beyond SPF)
	• To what extent do barriers remain to MIDRI applications (plus identification of

	barriers)?
	• How successful have MIDRI collaborations been?
Programme-level view	• To what extent has the programme produced high quality MIDRI *[A qualitative assessment only. A quantitative exercise will be conducted as part of the Fund evaluation]* • Number and type of collaborations, before, during and after SPF allocations

1.1.2 Obj 2: Alignment with cross-departmental R&I priorities

To support **EQ3** (To what extent, and how, has the SPF improved the link between UKRI's investments and cross-departmental research and innovation priorities and opportunities?):

Source	Question
• Views of researchers & innovators	• To what extent has the programme increased understanding of Government priorities amongst researchers and innovators?

1.1.3 Obj 3: Responding to strategic priorities and opportunities

To support **EQ4** (To what extent, and how, has the SPF ensured that the research and innovation system is able to respond to strategic priorities and opportunities?):

Source	Question
• Views of researchers and innovators	• Awareness and understanding of SPF (and its objectives) amongst applicants and wider research community
	• Extent to which programme addresses an important gap
	• Extent of engagement / involvement of researchers and innovators in SPF programme development and design

1.1.4 R&I ouputs, outcomes and impacts

To support **EQ5** (What has been the economic and social impact from research findings, new products, processes or services generated by the SPF?):

R&I Outputs

Source	Question
Programme-level view	• Number of outputs produced through programme. This should include, as a minimum: – Number of new or enhanced products, processes or services – Research databases and models developed – Number of patents published – Number of patents granted – Number of trademarks and / or copyrights (e.g. software) – Number of spin-offs – Number and value of licences – Number of project participants reporting improved skills as a result of SPF participation – Number of projects reporting TRL/MRL/CRL advancement – Funding leveraged by projects and project participants – Count of IP (including count of IP non-exclusively licensed to multiple organisations, rather than exclusively sold to one) – Additional employment due to the programme – Research infrastructure enabled

	• Examples of discoveries or advances in understanding

R&I Outcomes

Source	Question
Programme-level view	• Count of new / improved public policies building on knowledge, solutions and / or tools developed with SPF support • Examples of new / improved public policies, building on knowledge, solutions and / or tools developed with SPF support • Estimation of value of benefits
	• Count of new / improved public services building on knowledge, solutions and / or tools developed with SPF support • Examples of new / improved public services, building on knowledge, solutions and / or tools developed with SPF support • Estimation of value of benefits
	• Count of new / improved products and services building on knowledge, solutions and / or tools developed with SPF support • Examples of new / improved products and services, building on knowledge, solutions and / or tools developed with SPF support • Estimation of value of benefits
	• Number of high-skilled jobs created amongst participants • Increased high-skilled jobs created beyond participants
	• Turnover growth amongst participants (by sector) • Productivity growth amongst participants (by sector)

R&I Impacts

Source	Question
Programme-level view	• Examples of impacts on the environment, public-health and well-being • Estimate of value of impacts on the environment, public-health and well-being
	• To what extent has the investment delivered a discernible impact on knowledge creation, the economy and society?
Evaluation conclusions	• What have the observed changes been (resulting from the programme), compared to what was already in place?
	• Are there interim outcomes from the programme that provide an indication of future impact, and to what extent are these attributable to SPF funding?
	• Have any outcomes occurred from the programme which were not originally intended, and how significant are they?

Appendix D   Literature review

D.1   Summary

This literature review has been developed to inform the Strategic Priorities Research Fund programmes and the ongoing evaluation of the Fund. It contains two main parts. Firstly, it describes the main rationales for investing public funding in Multi- and Interdisciplinary Research and Innovation (MIDRI) (section 2)., Secondly, it analyses the mechanisms and processes used by international funders to support MIDRI in a selection of international programmes (section 3).

- MIDRI has is believed to have the potential to deliver benefits to both the scientific community and wider society and has attracted increasing attention from policymakers and funding organisations in recent years. The review identifies two main types of rationales underpinning decisions to support MIDRI: The advancement of knowledge – e.g., with new scientific knowledge often created in emerging fields, spanning the boundaries of existing science, and complex scientific problems often requiring inputs from multiple perspectives

- Addressing societal challenges – with such issues rarely conforming to disciplinary boundaries and with multiple perspectives required to address them effectively

For the analysis of international practice, we identified 15 relevant programmes / initiatives, which we mapped against key characteristics, and reviewed six of them in more depth.

We find that those six programmes address MIDRI along four key dimensions:

- **Strategic rationale**: MIDRI is supported for a variety of reasons, ranging from an ambition to enable breakthroughs and creating national capabilities in future areas of importance, to contributing to the solution of societal challenges and creating economic growth.

- **Priority-setting:** Two main mechanisms for setting thematic priorities were found: Allowing applicants to define themes which live up to the programmes goals; or deriving thematic priorities from government policy or through pollical decisions and budget allocations.

  Internal reviews of the programmes show that priority-setting should balance the responsiveness to changing political priorities against the need for a sufficiently long-term strategic perspective to enable societal impact to be created.

- **Call and selection:** Selection processes were adapted in a number of ways to accommodate MIDRI, including through eligibility criteria, through networking support, tailored assessment criteria, and adaptation of review panel guidelines and membership.

  The examples reviewed show that there are multiple ways of supporting or encouraging MIDRI throughout the programming process.

- **Monitoring and evaluation**: The evaluation record is less than complete. Several of the programmes are still in the early implementation phase and where evaluations do exist, they don't always focus on effectiveness and impact at the programme level. The evaluations used very different methods. Some draw heavily on bibliometric analysis, while others had a stronger emphasis on qualitative methods, with surveys addressing process questions and case studies demonstrating interaction and impact.

  In terms of effectiveness, the programmes showed several types of effects including improved collaboration and scientific productivity, enhanced interaction with research users as well as potential for societal impact.

D.1.1   Implications for the SPF and the SPF evaluation

The evidence collected through this literature review serves a dual purpose: to inform ongoing programmes, and to inform the SPF process evaluation.

It is difficult to draw direct comparisons between SPF and the programmes / initiatives reviewed, given their different objectives and configurations, but the review can serve as a source of evidence for ongoing SPF programmes on the mechanisms put in place internationally to assess, support, and monitor MIDRI across different types of programmes. For instance, the examples reveal that funders have used elements from across the entire programming process to supporting and encouraging MIDRI within their respective schemes. Key examples, which could be considered for SPF programmes include:

- Stating very clearly what are the requirements for MIDRI to ensure meaningful (as opposed to merely nominal) cross-disciplinary and -sectoral collaboration within the funded R&I projects, e.g., requiring all disciplines to be involved from the start in innovative parts of the project.
- Providing additional support to facilitate the building of such collaborative relationships, either as part of the programme or by connecting to other supports
- Setting up assessment processes, panels and criteria defined in a way that is consistent with a desire to fund MIDRI research

For the evaluation of SPF more specifically, the literature review has several potential implications:

- The review can help shape some of the conclusions and recommendations emerging from our process evaluation (which in turn could serve to inform the current implementation of the programmes as well as further iterations of the Fund)
- Additionally, we find that the mix of methods included in the SPF evaluation framework and being employed through the current evaluation cover the methodological approaches followed across the six programmes.

D.2 Introduction

This literature review describes the main rationales for investing public R&I funding in Multi- and Interdisciplinary Research and Innovation (MIDRI) and the mechanisms and processes used by funding organisations to do so. By analysing international practice, the review seeks to draw lessons and inform the wider SPF fund-level evaluation.

After outlining the scope and methodology used in this introductory section, the document goes on to describe the main rationales for supporting MIDRI (Section 2) and to analyse international examples of how MIDRI is supported by funding organisations (Section 3), before drawing conclusions and implications for the wider evaluation (Section 4).

D.2.1 Scope of the review

The main focus of this paper is public support for MIDRI, and more specifically the mechanisms and processes used. This includes targeted MIDRI programmes, as well as other measures to encourage MIDRI applications to non-MIDRI-targeted programmes and/or to ensure MIDRI-applications are not disadvantaged in competition.

'Mechanisms and processes used by funding organisations' primarily refers to support provided through competitively awarded grants by national or international funding bodies for specific projects or activities. Thus, the review primarily focuses on how MIDRI can be supported through programme design and implementation, including programmes which aim to fund MIDRI ('prospective point of view') and/or which do, in fact, fund MIDRI R&I ('activity point of view').

D.2.2 Definition of MIDRI

For the purpose of this review, we have adopted an **inclusive definition of MIDRI**, covering the spectrum from the multidisciplinary to the more integrated interdisciplinary approaches, and cross-sector collaboration relevant to policy-related research.

There are no universally agreed definitions for the terms 'multidisciplinary' and 'interdisciplinary', or related terms such as 'transdisciplinary', but it is common to draw a distinction between multidisciplinary R&I (with more loosely associated (uni-)disciplinary components that are brought together post-hoc) and interdisciplinary R&I (where disciplinary perspectives are more closely integrated from the outset to develop a common approach).[14] The table below lists a set of influential definitions from the literature.

---

[14] See for example, Krogh et al. (2019) *Interdisciplinary research: constructing a level playing field*, Research Council of Norway's International Advisory Board

Table 10 MIDRI definitions

Term	Definition
Multidisciplinary	"Theory, methods, and interpretive standards of the different disciplines are employed. Interpretation of the results from different disciplines typically occurs post hoc, often from the perspective of one discipline that may emerge as dominant within the project." (Rossini & Porter, 1979)
Interdisciplinary	"Approaches integrate separate disciplinary data, methods, tools, concepts, and theories in order to create a holistic view or common understanding of a complex issue, question, or problem" (Wagner et al., 2011, p. 16)
Transdisciplinary	"Trans-sector, problem-oriented research involving a wider range of stakeholders in society" (Klein, 2008, p. S117)

Source: Adapted from Davé et al (2016), p. 13

D.2.3   *Methodology*

This review is based on recent literature about which mechanisms and processes are, or could be, used by funding organisations to support MIDRI R&I, as well as key rationales for supporting MIDRI research, followed by a review of examples of mechanisms and processes used in programmes from the UK and internationally. It follows a Rapid Evidence Assessment approach.[15]

For the exercise, we have used a dual search strategy. The starting point was the Landscape Review of Interdisciplinary Research conducted for Research England in 2016 and other sources known to be relevant for the study.[16] Secondly, we have completed a targeted keyword search for recent publications. The search is designed to complement what is already included in the Landscape Review by covering i) recent publications (since 2016), and ii) publications focussed on the funding of MIDRI research. Google Scholar is preferred to alternatives (e.g. Scopus and Web of Science) as it has a better coverage of non-academic literature, which is likely to be of interest. We identified 54 articles which meet the search criteria. These have been reviewed based on the scope described above to determine which are included and excluded. D.6.2 details our search methods and results. A list of key references is provided in Section D.6.

The selection of programmes for the second part of this review (section D.4) covers both MIDRI-specific and non-MIDRI programmes and aims to illustrate a variety of mechanisms and processes used to cater for MIDRI. The selection process that was employed is described further in Appendix B, while full details of the selected schemes are provided in D.7 and then drawn upon (including with specific examples) in the main text.

---

[15] A Rapid Evidence Assessment (REA) is a method to undertake a review of literature in a subject area in a shorter period of time than a systematic review (which tends to be more exhaustive). Additionally, the focus of a REA is narrower (in comparison with a systematic review) , and concessions are made on the breadth or depth of studies included. Magenta Book, 2020.

[16] Davé et al. (2016). *Landscape review of interdisciplinary research in the UK*. Report to HEFCE and RCUK by Technopolis and the Science Policy Research Unit (SPRU), University of Sussex.

D.3   Rationale for supporting MIDRI

MIDRI is believed to have the potential to deliver benefits to both the scientific community and wider society and has attracted increasing attention from policymakers and funding organisations in recent years.[17]

Despite the broad consensus that MIDRI is important to support, it can be difficult to accommodate within established funding schemes. Many funding bodies are organised according to established disciplinary boundaries and MIDRI often does not fit neatly within the remit of any one funder or programme.

Similarly, where the review process used to evaluate competing proposals are defined according to (mono-)disciplinary standards, this can place MIDRI proposals at a disadvantage. Many researchers perceive MIDRI to be 'risky' and less likely to be funded and may therefore be dissuaded from pursuing a career focussed on MIDRI.[7] Funders who wish to support MIDRI – and achieve the associated benefits – therefore have good reasons to adjust programme mechanisms to better accommodate MIDRI, or to design new programmes dedicated to MIDRI.

The main rationales for public funding bodies to invest in MIDRI identified in the literature converge around two main types:

- **Advancement of knowledge:** Complex scientific problems often require inputs from multiple perspectives from inside and outside of academia to be addressed effectively.[18] MIDRI, it is argued, has the potential to be intellectually transformational, enabling new ways of thinking and conducting research.[19] A number of studies have found evidence,[20] that new scientific knowledge is often created in emerging fields spanning the boundaries of existing disciplines,[21] and is closely related to novelty in science.[22] Support for MIDRI is seen as an essential element in the pursuit of new and breakthrough knowledge,[23] to promote scientific excellence, and to be able to compete globally.[24]

- **Addressing societal challenges:** R&I policy is increasingly concerned with the contribution of R&I to addressing the challenges facing society. Such issues rarely conform to disciplinary boundaries and multiple perspectives are required to address them effectively. MIDRI is therefore widely seen as well placed to take up these challenges, in several contexts:

---

[17] Gleed, A., & Marchant, D. (2016). Interdisciplinarity: Survey Report for the Global Research Council 2016 annual meeting. Global Research Council (Vol. 44). Global Research Council.

[18] Gibbons M, Limoges C, Nowotny H, Schwartzman S, Scott P, Trow M (1994). The new production of knowledge: The dynamics of science and research in contemporary societies. London: Sage

[19] Mcleish, T., & Strang, V. (2014). Leading Interdisciplinary Research: Transforming the Academic Landscape. Stimulus Paper, The Leadership Foundation for Higher Education.

[20] E.g., Rodgers Hollingsworth (2007) is based on an analysis of 291 major discoveries, Huang et al. (2016) looks at how the US (NSF) and China (NSFC) supports 'Big Data', and Davé et al. (2016) analyses a survey of researchers and funders in the UK. Other well-known essays make this point in more conceptually (e.g., Nurse review, Gibbons et al. (1994)).

[21] e.g. Huang, Y., Zhang, Y., Youtie, J., Porter, A. L., & Wang, X. (2016). How does national scientific funding support emerging interdisciplinary research: A comparison of big data research in the US and China. PLoS ONE, 11(5), 1–20

[22] Davé (2016), Op Cit, p. 23.

[23] J. Rogers Hollingsworth. (2007). High Cognitive Complexity and the Making of Major Scientific Discoveries. In A. Sales & M. Fournier (Eds.), Knowledge, Communication, and Creativity (pp. 129–155). Sage Publications.

[24] Nurse, P. (2015). Ensuring a successful UK research endeavour - A Review of the UK Research Councils. BIS/15/625.

- Contributing to solutions for complex societal challenges, such as climate change and food shortages[25]
- Contributing innovation and economic growth[26]
- Supporting the ability of government to carry out its functions effectively
- MIDRI is more likely to create societal impact, as evidenced by impact case studies submitted as part of the Research Excellence Framework (REF) in the UK.[27]

Although not the main focus here, it is worth noting that research organisations and individual researchers can have a variety of incentives and motivations to engage in MIDRI, beyond what is intended by government sponsors. For example, institutions may pursue MIDRI in order to fulfil their strategic goals or access new funding streams,[28] whereas individual researchers may choose to do so for reasons of personal preference or intellectual curiosity.[29]

D.4 Supporting MIDRI in practice

D.4.1 Introduction to programme examples and selection

This section reviews a selection of international programmes to show examples of international practice in supporting MIDRI.

Programmes vary greatly across countries and funding organisations in terms of their structure and scope as well as the terminology used to describe them. Strategic programmes also tend to come about in response to specific challenges or gaps within the national funding systems and are therefore rarely directly comparable.

The aim of the task has therefore been to find programmes with a similar profile to the UKRI Strategic Priorities Fund (SPF), using the following main criteria:

5. Programmes which support MIDRI either directly / explicitly (i.e. they are set up to support MIDRI), or indirectly (they are set up in way that could be conductive to MIDRI)

6. Programmes which support MIDRI in order to address complex problems or challenges

7. Programmes with a similar intent to the SPF, i.e. to support R&I in alignment with government priorities and strategic opportunities

8. Programmes with a scale and level of ambition comparable to SPF

9. An additional consideration has been the availability of evaluations or other activities to measure effectiveness of the programme or approach

It has not been possible, within the scope of this short exercise, to undertake a comprehensive mapping of all potentially relevant international programmes. However, using a purposive selection strategy, we have reviewed the portfolio of major international funding bodies to identify programmes with a similar profile as the SPF.

---

[25] See e.g. Institute of Medicine. (2005). Facilitating Interdisciplinary Research. Washington, DC: The National Academies Press. https://doi.org/10.17226/11153

[26] E.g. evidence suggests that MIDRI is more likely to be cited in patent applications (Elsevier 2015).

[27] Krogh et al. (op cit)

[28] Davé, A., Melin, G., Swenning, A.-K., Berglund, E., Javorka, Z., & Arnold, E. (2018). Case Study Review of Interdisciplinary Research in Norway. Technopolis Group, February 2018.

[29] Davé (2016) Op. Cit.

As part of this search, we have consulted the project team's external advisors, Professor Veronica J. Strang (Executive Director of the Institute of Advanced Study, Durham University) and Professor Catherine Lyall (University of Edinburgh) for advice on relevant programme to consider.

As shown in Table 11 below, we identified 15 programmes from 11 advanced R&I countries,[30] which aim to support MIDRI directly or indirectly. They are scored against the selection criteria mentioned above, based on an assessment of whether the criterion is fully met ($\sqrt{}\sqrt{}$), partially met ($\sqrt{}$) or not met at all (no tick). The last column in the table also shows that different programmes approach MIDRI in different ways.

---

[30] Australia, Austria, Canada, Denmark, Finland, France, Germany, the Netherlands, Switzerland, and the USA.

Table 11   Long list of programmes

Selection criteria					Funder	Programme title	Budget	MIDRI relevance
1	2	3	4	5				
√√	√		√	√√	Swiss National Science Foundation (SNSF)	Sinergia – interdisciplinary, collaborative and breakthrough	**£35m / yr** (2020 call) (CHF 40m)	Sinergia promotes the interdisciplinary collaboration of two to four research groups that propose breakthrough research.
√√	√√	√	√	(√)	SSHRC on behalf of Canadian granting agencies	New Frontiers in Research Fund	**£34m / yr** £170m over 5 years ($275m CAD)	The fund invests $275 million over 5 years from 2018-19, to fund international, interdisciplinary, fast-breaking and high-risk research. The Transformation stream is designed to support large-scale, Canadian-led interdisciplinary research projects that address a major challenge with the potential to realize real and lasting change (high reward). The challenge may be fundamental, leading to a scientific breakthrough, or applied, with a social, economic, environmental or health impact.
√	√√	√√	√√	(√√)	NSF	Science, Engineering and Education for Sustainability NSF-Wide Investment (SEES)	Up to **$1bn / yr**	To advance science, engineering, and education to inform the societal actions needed for environmental and economic sustainability and sustainable human well-being… a portfolio of activities that highlights NSF's unique role in helping society address the challenge(s) of achieving sustainability.
√	√√	√√	√	√√	Academy of Finland	Strategic Research Council	**£50m / yr** (2021 budget)	The funding granted by the Strategic Research Council is intended for extensive, multidisciplinary research consortia that carry out research with an emphasis on active interaction and engagement with users and beneficiaries of research.
√	√	√√	√√	√	Innovation Fund Denmark	Grand Solutions	**£130m / yr** (2020 budget)	Aimed at collaborative projects based on excellent research focused on solutions of considerable societal value. Based on societal and business challenges, opportunities and innovation needs, Innovation Fund Denmark wants to enable cross-disciplinary investments in knowledge institutions and companies – private as well as public.
√	√√	√√	√√		NWO (The Netherlands)	Knowledge and Innovation Covenant	**£90m / year**	The Knowledge and Innovation Covenant (KIC) 2020-2023 focusses on societal challenges by means of mission-driven research. An integral approach is needed to tackle these challenges, in which researchers from the humanities, natural sciences and social sciences work together and coherently approach a problem from the perspective of their different disciplines. Successful innovations will only come about if technological and social innovation go hand in hand.
√	√√	√	√	√	Australia Research Council	Linkage Program schemes / Special Research Initiatives	**£38m / yr** (combined budget for two initiatives launched in 2020)	The ARC's Linkage funding schemes aim to encourage and extend cooperative approaches to research and improve the use of research outcomes by strengthening links within Australia's innovation system and internationally. The Special Research Initiatives (SRI) scheme provides funding for new and emerging fields of research and builds capacity in strategically important areas. The ARC currently funds several SRIs

					Organisation	Scheme	Budget	Description
								in a wide range of research areas… Funding may also be used to develop networks and initiate collaborations that would be unlikely to occur otherwise and to disseminate the outcomes of the collaborative activities funded under the scheme.
√	√√	√√	√√		Research Council of Norway	Collaborative Project to meet Societal and Industry-related Challenges	**£110m / yr** (2020 call)	Collaborative and Knowledge-building Projects are to develop new knowledge and generate research competence needed by society or the business sector to address important societal challenges. The projects are to encourage and support collaboration between research organisations and stakeholders from outside the research sector that represent the societal and/or industry needs.
√√	√		√		Research Council of Norway (RCN)	Large-scale Interdisciplinary Researcher Project	£1-2m per project (part of £100m 'FRIPRO' portfolio)	Support for researchers from different subject areas to work together to generate new knowledge that would not be possible to obtain without interdisciplinary cooperation.
√	√√		√		Wellcome Trust	Collaborative Awards in Science	**£49m / yr** (2018 expenditure)	We encourage interdisciplinary research collaborations, although they are not essential.
√	√	√√			ANR (France)	Strategic priorities within Generic Call for proposals	Unknown	As part of its efforts to clarify its programmes, the agency has also included a component specifically addressing the French state's strategic priorities and those arising from national plans to strengthen research in specific areas in response to present-day scientific and societal challenges. Specifically, these challenges are artificial intelligence (AI), social sciences and humanities, quantum technologies, antimicrobial resistance, autism in neurodevelopmental disorders, and translational research on rare diseases.
√√	√				Wellcome Trust / Cambridge University	Junior Interdisciplinary Fellowships	**<£5m / yr** (part of £5m award over 5 years from Wellcome)	The scheme is aimed at post-doctoral candidates with backgrounds in the physical sciences who wish to gain experience in the application of their research to solve problems in the basic biological and biomedical sciences.
√√	√				Nordforsk	Interdisciplinary research projects	**£10m / yr** (2019 call) (NOK 120m)	The call is specifically aimed at genuinely interdisciplinary projects that combine disciplines which are far removed from one another and rarely collaborate, or that pursue an original research question requiring the exact combination of competencies from different disciplines proposed in the application.
√√	√				NSF	Unsolicited Interdisciplinary Proposals	Unknown (probably no fixed budget)	NSF also invites interdisciplinary proposals that are not targeted by a Program Solicitation. Such a proposal may be suitable for submission to and review by a single unsolicited core program, may be more appropriate for co-review by more than one program, or may extend beyond the scope of any current program
√	√√				DFG	Reinhart Koselleck Projects	**£5m / year** (estimate)	Exceptionally innovative or higher-risk projects that cannot be funded within the scope of other DFG programmes or within the framework of the applicant's own institution.

From the initial list, we selected the two programmes that seem more relevant for drawing comparisons with SPF (Finland's Strategic Research Council and the NSF's SEES portfolio) for an initial review, and after consultation with UKRI, a further four programmes from the long list were selected for closer study, all of which cover between 4 and 5 criteria listed above. Table 12 provides an overview of these selected programmes.

Table 12 Overview of programmes reviewed in more depth

Funder	Title	Type of initiative	Budget
Swiss National Science Foundation (**SNSF**)	**Sinergia** – interdisciplinary collaborative and breakthrough	Programme	£35m / year (2020 call)
SSHRC on behalf of Canadian granting agencies	New Frontiers in Research Fund (**NFRF**) • *Transformation*	Fund • *Funding instrument*	£35m / year [1] • *£91.6m (2020)*
National Science Foundation (**NSF**)	Science, Engineering and Education for Sustainability NSF-Wide Investment (**SEES**)	Portfolio of programmes	Up to $1bn / year
Academy of Finland	Strategic Research Council (**SRC**)	Funding instrument	£50m / year (2021 budget)
Innovation Fund Denmark	**Grand Solutions**	Funding instrument	£130m / year (2020 budget)
NWO (The Netherlands)	Knowledge and Innovation Covenant (**KIC**) • *Mission-oriented calls*	Funding line • *Funding instrument*	£90m / year • *£50m / year*

Source: Technopolis
Note [1]: Projected average based on announced budget of £175m over five years.

D.4.2   Strategic rationale

These international examples provide examples of different ways in which programmes can be positioned to support MIDRI. Specifically, the funders have identified different needs that they seek to address by supporting MIDRI:

- The Swiss Science Foundation seeks to promote scientific breakthroughs, and sees MIDRI as a key way of achieving this, through the combination of expertise from several applicants and disciplines (Sinergia).

- The Canadian research funders seeks to build national scientific capacity (NFRF) in areas of future strategic importance, and see a new large investment in MIDRI, cutting across the boundaries of established granting agencies, as the way to promote this development.

- Several funding bodies aim to address societal challenges (NFRF, Grand solutions, NWO mission-driven calls, SEES) and see the need to include relevant expertise from across different disciplines, including transdisciplinary research and user involvement, as a prerequisite for achieving this.

- Some agencies also aim promote innovation and economic growth (Grand Solutions, NWO mission-driven calls) and believe MIDRI is necessary to this end.

Many of these programmes are conceived to fill a gap in the current funding provision. In Finland, for example, the creation of the Strategic Research Council – combined with a reduction in core institutional funding – was not only about supporting specific strategic priorities, but also part of an effort to make the country's research institutes more responsive to the needs of 'knowledge users' more generally.

D.4.3 Priority-setting

Thematic priorities can be determined more or less explicitly, top-down through political decisions, or more bottom-up by applicants themselves. The selected programmes illustrate that both approaches exist for different sizes of programmes.

Two programmes, the Swiss Sinergia programme and the Canadian New Frontiers in Research Fund, refrain from specifying thematic priorities and leave it to applicants to propose projects that meet **scheme objectives**.

Box 1 Approaches to priority-setting based on programme objectives

- SNSF's **Sinergia** supports collaborative, interdisciplinary projects where breakthrough research is expected. Currently supported projects include material sciences, the arts, cellular biology and more.
- **NFRF's 'Transformation' stream** supports projects that are believed to have the potential for significant societal impact (NFRF) within any area or field where this can be achieved.

The remaining four programmes all have processes in place to define programmes **thematically in alignment with political priorities**, but they represent different ways of achieving this. Some of the schemes are designed with no prior specific theme in mind to accommodate changing government priorities, e.g. on an annual basis, whereas others are designed to address a specific set of government priorities over a longer time-frame.

Box 2 Approaches to priority-setting based on political priorities

Structures to support MIDRI, with an evolving set of themes

- Priorities for Denmark's **Grand Solutions** scheme are determined in the government's annual Finance Act, which specifies budget allocations for strategic research by theme. The allocation in the Finance Act takes inspiration from the 'Research 2025' catalogue, which provides a consolidated view of stakeholder priorities.
- In Finland (for **SRC**), this is done annually, whereby thematic priorities and an earmarked funding allocation for strategic research in these areas are decided politically (on an annual basis).

Programmes providing multi-annual support for government strategic priorities:

- The NSF's Science, Engineering and Education for Sustainability (**SEES**) portfolio was defined as an 'Area of National Importance' and aligned with the Federal Government's priorities, within the context of the broader policy-coordination processes, e.g. through the National Science and Technology Council (NSTC).
- The NWO's Mission-driven calls, as part of the Knowledge and Innovation Covenant (**KIC**) for the period 2020-2023, focus on topics derived from the four societal challenges and 25 missions defined in government's 'Mission-Driven Top Sector and Innovation policy'.

The call and selection process can be adapted in different ways to provide better support for MIDRI. From the international examples we find that all programmes encourage MIDRI, but some have more strictly defined **eligibility criteria** (as shown in the box below).

- The Finnish Strategic Research Council (**SRC**) requires project consortia to cover at least three research fields as defined in their classification.
- The Dutch Research Council's (**NWO**) requires proposals submitted for the mission-driven calls to be interdisciplinary, defined as a combination of natural sciences with either humanities or social science.
- The Canadian **NFRF** has established a set of 'pass/fail' criteria (related to novelty of perspective, novelty of approach, project design and the interdisciplinary nature of the project) to determine whether proposals meet the requirements, e.g. that it combines disciplines "that are not commonly combined".

Several programmes define requirements about *how* disciplines are combined. For example, the NFRF does not support proposals where an "interdisciplinary component [is] 'added on' to a more conventional project". Similarly, the Dutch Research Councils require that all disciplines are involved "from the start" and in innovative aspects of the project. One programme in NSF's SEES portfolio requires "meaningful and well-integrated contributions from multiple disciplines", while the Sinergia programme supports projects where "interdisciplinary collaboration is of high quality and adequately organised in view of the joint research objectives".

- 'Integrated': projects include natural sciences as well as either humanities or social sciences (or both)
- 'From the outset': Collaboration should be interdisciplinary, starting from the formulation of research questions.
- 'Innovative': All researchers must be involved in innovative research (e.g., humanities researchers cannot be included with the sole aim to verify conformity to ethical standards).

The **application processes** are adapted in multiple ways to accommodate MIDRI projects, with different approaches emphasising different aspects of MIDRI. For example, programmes might adopt a longer process with support for networking, in order to allow more time to build interdisciplinary teams. Inversely, they might aim to lessen the administrative burden and 'time to contract' as a way to promote business participation in transdisciplinary projects (see below).

- The Dutch Research Council (**NWO**) organises workshops ahead of mission-driven call deadlines to facilitate the development of interdisciplinary teams. (Other schemes may do something similar, but this is not explicitly stated).
- The US National Science Foundation (**NSF**), in some cases, advises (and signpost) potential applicants to apply for separate networking grants in preparation for SEES bids.

- The **SRC** uses a two-stage process, which allows the consortium leader to submit a preliminary expression of interest before building the full consortium. The initial 'Notice of Intent' stage is also used to inform the selection of external reviewers.
- **Innovation Fund Denmark** takes a different approach, aiming to minimise the length of the application process so as not to discourage participation from non-academic applicants whose rationale for participating may not be compatible with long administrative processes.

The **review of proposals** is among the elements of the call process that attracts the most attention from funders. Our sample of programmes provides examples of several concrete measures that have been taken to ensure that MIDRI proposals are considered appropriately.

Most programmes include specific guidance or assessment criteria that differ from standard programmes, often specifically addressing the interdisciplinary nature of proposals or emphasising the framing of challenges and potential societal and economic impact.

Box 6 Approach to peer review – guidance and assessment criteria

- **Sinergia** uses international peer review similarly to other academic programmes, but guidance for reviewers includes the instruction to assess "whether the interdisciplinary collaboration is of high quality and adequately organised in view of the joint research objectives".
- The Finnish **SRC** proposals are reviewed with particular emphasis on societal relevance and impact, alongside standard criteria of scientific quality.
- The **Grand Solutions** scheme prioritises proposals with potential for 'value creations' (whether in the form of new knowledge, improvement of/or new processes, systems, products or solutions to societal challenges), efficient project management and implementation of results (e.g. technology transfer).

Some programmes also adjust panel composition and membership, or create dedicated MIDRI review panels.

Box 7 Approach to peer review – panel composition and membership

- For the Canadian **NFRF**, the 'merit review processes' have been adapted to promote MIDRI. This includes a three-stage assessment with external reviewers recruited specifically for each shortlisted application, a multi-disciplinary/multisectoral review panel which will rank the proposals, and a jury with broad representation to which the highest ranked proposals will be presented in person.
- For the **NWO's** mission-driven calls, it is considered vital that referees and committee members are "carefully selected and instructed", although details have yet to be specified.

D.4.5.1   Project monitoring and evaluation

Overall, monitoring and evaluation of MIDRI programmes tends to follow generic organisational rules and procedures, including reporting on financial and scientific progress during the life of the project, but some schemes have adopted MIDRI-specific features as described in the box below.

In other cases, projects are required to describe potential impact at the time of application (see above), but it is unclear to what extent this is followed up subsequently.

Box 8 Approaches to project monitoring

- **Grand Solutions** (Denmark) and **NFRF** (Canada) both include project reviews with the option for the funder to discontinue under-performing projects (once a year and at a mid-term point respectively). This potentially allows the funders to take more risk with large grants for projects in emerging, interdisciplinary fields where results are unpredictable (high-risk).
- Finland's Strategic Research Council (**SRC**) describes their approach to evaluation, stressing the need to accommodate differences in the nature and quantity of evaluation and impact. In particular, SRC policy documents note that interdisciplinary projects might produce fewer high-impact publications, and possibly have more emphasis on societal impact.[31]

D.4.5.2   Programme evaluations

The evaluation record is less than complete. Several of the programmes are still in the early implementation phase (e.g. Canada's NFRF and the Dutch KIC) and where evaluations do exist, they don't always focus on effectiveness and impact at the programme level (e.g. Denmark's Grand Solutions). These caveats aside, several evaluations are available and do offer interesting findings; the most relevant are summarised in the box below.

The evaluations used very different methods: the Sinergia evaluation drew heavily on bibliometric analysis, reflecting its more academic focus. The evaluation of Finland's Strategic Research Council had a stronger emphasis on qualitative methods, with surveys addressing process questions and case studies demonstrating interaction and impact. The evaluation of Innovation Fund Denmark had a much broader scope than the Grand Solutions scheme itself and provided a high-level expert-based view on supporting evidence including a stakeholder consultation. The findings reflect the different methods used and offer different perspectives on potential effects and overall assessment of the programmes.

Box 9 Selected evaluation findings:

- The **Sinergia** programme evaluation found that successful applicants were more likely to co-author articles with team members, but even unsuccessful applicants experienced improved productivity (publications) and interdisciplinary learning compared to non-applicants. The findings suggest that the process of preparing a collaborative proposal

---

[31] Other evidence is more mixed as to the relationship between MIDRI and citation impact. See e.g., Yegros et al. (2015), "Does Interdisciplinary Research Lead to Higher Citation Impact? The Different Effect of Proximal and Distal Interdisciplinarity." PloS ONE, 10 (8).

(combined with availability of alternative funding sources for unsuccessful proposals) has significant effects for researchers involved.[32]

- The Finnish **SRC** evaluation found that the new scheme had been successful in creating a strategic approach to challenge-driven research and thematic prioritisation. The scheme's strength was the emphasis on interaction between research and knowledge users, whereas it was found that many challenge solutions developed by the projects had yet to be taken up by relevant stakeholders. The 3-year programme duration was also considered too short to create impact.

- The **Grand Solutions** scheme was found to have an insufficient focus on long-term strategic research, and to not include enough interdisciplinary collaboration. The reviewers recommended a "new, bolder and better integrated programme" with longer term funding for a smaller number of priorities to be addressed jointly with other funding agencies.

It is worth noting that evaluations for both the SRC and the Grand Solutions scheme comment on the relative lack of a long-term strategic perspective beyond individual calls and projects (3 years in the case of the SRC). As discussed above, new priorities for the two programmes are set *annually* by policymakers, which could make this task difficult. Innovation Fund Denmark has attempted to create thematic strategies to create a longer-term perspective for changeable annual budget allocations. Other programmes might be able to address these issues, by virtue of having more autonomy to organise the response to government priorities over a period of several years (e.g., NWO, KIC 2020-2023) or alternatively have individual awards that have a longer duration (e.g., NFSF).

D.4.6   Summary

The table below summarises the main MIDRI-related programme elements discussed above.

---

[32] Appendix C.1 provides more detail on the methodology used in Sinergia review.

Table 13   Summary table

	Strategic rationale	Priority-setting	Call and selection	Monitoring and evaluation
Sinergia – interdisciplinary collaborative and breakthrough	• Dedicated to MIDRI breakthrough research	• Response-mode, no thematic priorities	• Interdisciplinarity and quality of collaboration as assessment criteria	• Programme effects on unsuccessful applicants
New Frontiers in Research Fund: Transformation	• Combines 'exploration' support to build strength and 'Transformation' to support large scale challenge-driven projects	• Funds projects with potential for significant impact in addressing societal challenges	• Mandatory Interdisciplinary design (pass/fail criterion) • Dedicated Multidisciplinary/ Multisectoral Review Panel and jury	• Mid-term review and possibility of discontinuing investment
Science, Engineering and Education for Sustainability NSF-Wide Investment (SEES)	• Programme dedicated to specific MIDRI challenge • Portfolio-approach with a range of associated schemes	• Defined as a 'Area of National Importance', in alignment with government priorities.	• Differs across portfolio • Example: "must include meaningful and well-integrated contributions from multiple disciplines"	• N/A
Strategic Research Council	• Flexible instrument to fund programme-based research on major societal challenges • Aims to support MIDRI, as well as find solutions to challenges and create economic impact	• Annual consultation process and government decision to define 3-5 priority areas to be funded	• Project teams to include at least three different research fields • Expected to include interaction with users	• Their plans are built on the presumption that multidisciplinary research may have different publication output than single discipline projects. • Emphasis on impact and interaction with users
Grand Solutions	• Flexible instrument to support societal and business challenges • Aims to enable cross-disciplinary	• 5-yearly 'catalogue' of priorities based on broad consultation. • Annual allocation of funds for about 5-10	• Separate assessments of scientific/technical quality (external) and strategic importance (internal)	• Mandatory collaboration agreement • Active follow-up; possible to terminate or

	Strategic rationale	Priority-setting	Call and selection	Monitoring and evaluation
	investments in knowledge institutions and companies	priority themes through government Finance Act	• Focus on short time to grant to encourage intersectoral projects	reward projects based on performance • Evaluation suggested "bigger and bolder" approach
Knowledge and Innovation Covenant: Mission-driven calls	• Interdisciplinarity promoted to address societal challenges	• Mission-driven calls aligned with government agenda (challenge areas and missions)	• Interdisciplinarity mandatory from 2021 • Matchmaking organised to facilitate interdisciplinary proposals • Review panel membership and guidance to reflect interdisciplinarity	• N/A

Source: Technopolis

D.5   Conclusions

D.5.1   Summary of key findings

This short literature review has described the main rationales for investing public R&I funding in Multi- and Interdisciplinary Research and Innovation (MIDRI), as well as some of the mechanisms and processes commonly used by funding organisations to do so.

The main **rationale for public investment in MIDRI** identified in the literature relates to either:

- The advancement of knowledge – e.g. with new scientific knowledge often created in emerging fields, spanning the boundaries of existing science, and complex scientific problems often requiring inputs from multiple perspectives

- Addressing societal challenges – with such issues rarely conforming to disciplinary boundaries and with multiple perspectives required to address them effectively

In both cases, this tends to be the starting point (hypothesis) rather than a proven point. For individual R&I performers there may also be other incentives and motivations, including fulfilling strategic goals, accessing funding, personal preference or intellectual curiosity.

From six programmes that were reviewed in more depth, we have seen a range of **examples of international practice in supporting MIDRI**, at all stages of programme design. We distinguished four main dimensions from the selected international examples found.

Strategic rationale - MIDRI is supported for a variety of reasons, ranging from an ambition to enable breakthroughs and create capabilities in future areas of importance, to helping solve societal challenges and creating economic growth. In some cases, this has led funders to create dedicated MIDRI programmes and schemes, while others have incorporated incentives and support for MIDRI into existing instruments. In all cases, these programmes identify MIDRI as an essential prerequisite for meeting specific strategic policy and programme objectives.

Priority-setting - Two main mechanisms for setting thematic priorities were found within the selection of programmes: Allowing applicants to define themes which live up to the programmes goals (e.g. break-through research, potential for impact); or deriving thematic priorities from government policy or through pollical decisions and budget allocations.

Call and selection - Several programmes mandate interdisciplinarity, some using detailed criteria to determine eligibility. These often emphasise that disciplinary and/or sectoral components are required to be closely integrated, i.e. interdisciplinary or transdisciplinary rather than multidisciplinary. The selection process was found to include several MIDRI-specific adjustments across the selected programmes, including the application process being longer or shorter depending on key audiences, and including support for networking and multiple stages to enable the establishment of disciplinary teams and lessen administrative burdens on applicants. The assessment process was also adjusted to MIDRI, using specific panel guidance and criteria emphasising problem-solving and impact, and by using panel composition and membership to accommodate MIDRI proposals.

Monitoring and evaluation - This is the stage of the programming process which received least attention within the programmes, partly because several have yet to reach this stage of implementation. Programmes generally appeared to follow standard M&E procedures, but two programmes allowed for the possibility to terminate underperforming projects early, an option that could conceivably enable less risk-averse project selection up front.

Evaluations were available for three of the six programmes. Each was based on different methods and, accordingly, drew different conclusions about programme effectiveness. The academically-oriented Sinergia programme was reviewed using bibliometric methods and found a positive effect on interaction and productivity among both successful and unsuccessful applications (as compared to non-participants). An international expert review of Innovation Fund Denmark drew conclusions about the strategic positioning of the Grand Solutions scheme, finding it insufficiently focussed on long-term strategic research. Finally, a recent evaluation of the Finnish SRC, based primarily on qualitative methods, identified a key strength in the support for interaction between researchers and knowledge users. The latter two evaluations both commented on the balance between short term priorities and longer term strategic perspectives.

D.5.2   Gaps and limitations

The current text reviews a selection of programmes, which have been carefully selected to provide a varied and relevant set of examples of international practice. Naturally, this cannot account for the full variety of approaches and instruments used to support MIDRI, nor can we claim that the selection is representative or typical of the wider population of programmes.

Several of the programmes were launched very recently and have not yet reached the implementation phase. This has the advantage that programme documentation is made publicly available and promoted by the programme owners, which enables a detailed description of programme rationale, design and review mechanisms. However, it also means that there is more limited evidence of the effectiveness of approaches and lessons learned.

Strategic research programmes are often conceived and designed in the context of specific national circumstances, such as the existing structure and traditions of the national R&I system and the specific political priorities within the country in question. For example, the Finnish SRC aims to support solutions for societal challenges, but it was conceived with the specific role of Finnish research institute in mind, which is obviously specific to the national context. Lessons drawn from these examples should be carefully assessed as to their relevance to the UK / SPF.

The programmes included here all offer ways to assess MIDRI, but this is most often done with a defined qualitative threshold in mind, with the aim to determine eligibility at the proposal stage. The 'MIDRI-ness' of projects is not generally considered as a criterion to assess project performance or impact (it was not assessed if levels of MIDRI or presence or absence of MIDRI made the initiative more or less effective), although one programme was found – via ex-post evaluation- to be 'insufficiently interdisciplinary' based on the composition of the consortia within funded project.

D.5.3   Implications for the SPF evaluation

The evidence collected through this literature review serves a dual purpose: to inform ongoing programmes, and to inform the SPF process evaluation.

The review can serve as a source of evidence for ongoing SPF on the mechanisms put in place internationally to assess, support, and monitor MIDRI across different types of programmes.

For instance, the examples reveal that it is relevant to look at the entire programming process (from the defining the strategic rationale and programme design to project selection process and monitoring and evaluation) to determine whether there is a comprehensive and coherent approach to supporting and encouraging MIDRI within the scheme. Key examples may include:

- Stating very clearly what are the requirements for MIDRI to ensure meaningful (as opposed to merely nominal) cross-disciplinary and -sectoral collaboration within the funded R&I projects
- Providing additional support to facilitate the building of such collaborative relationships, either as part of the programme or by connecting to other supports
- Setting up assessment processes, panels and criteria defined in a way that is consistent with a desire to fund MIDRI research

Additionally, it is worth considering whether priority-setting processes strike the right balance between being responsive to changing political priorities and the ability to provide a long-term strategic perspective and investment to bring about sustained effects.

For the evaluation of SPF more specifically, the evidence collected through this literature review would help to shape some of the conclusions and recommendations emerging from our process evaluation, which in turn could serve to inform the current implementation of the programmes as well as further iterations of the Fund. -   For instance, the examples reveal that it is relevant to look at the entire programming process to determine whether there is a comprehensive and coherent approach to supporting and encouraging MIDRI within the scheme.

Finally, the evaluation record as well as the evaluation practices have shown that the effects of MIDRI often cannot be captured fully using conventional measures of impact and examples of alternative ways of achieving this have been identified, including qualitative methods, with surveys addressing process questions and case studies demonstrating interaction and impact, and high-level expert-based view on supporting evidence including a stakeholder consultation.

We have observed that available programme evaluations all rely on different methods and, on that basis, each emphasise different types of impacts. A mixed methods approach, combining elements ranging from bibliometrics to impact case studies, therefore seems to be the best option to capture the range of different outcomes and impacts. This goes in line with the current SPF evaluation framework.

D.6   Appendix 1 – References and approach

D.6.1   List of references

- Bammer, G., O'Rourke, M., & O'Connell, D. (2020). Expertise in research integration and implementation for tackling complex problems: when is it needed, where can it be found and how can it be strengthened? *Palgrave Commun*, 6(5).

- Baptista, B. V., Fletcher, I., Maryl, M., Wciślik, P., Buchner, A., Lyall, C., … Pohl, C. (2020). *Final Report on Understandings of Interdisciplinary and Transdisciplinary Research and Factors of Success and Failure*. SHAPE-ID: Shaping Interdisciplinary Practices in Europe, Deliverable 2.3.

- Baptista, B. V., Lyall, C., Ohlmeyer, J., Spaapen, J., Wallace, D., & Pohl, C. (2020). *Final Report on Understanding of Interdisciplinary and Transdisciplinary Research – Policy Brief*. SHAPE-ID: Shaping Interdisciplinary Practices in Europe, Deliverable 2.4.

- British Academy. (2016). *Crossing Paths: Interdisciplinary Institutions, Careers, Education and Applications*. The British Academy, July 2016. Retrieved from http://www.britac.ac.uk/sites/default/files/Crossing Paths - Full Report.pdf

- Bromham, L., Dinnage, R., & Hua, X. (2016). Interdisciplinary research has consistently lower funding success. *Nature*, *534*(7609), 684–687. https://doi.org/10.1038/nature18315

- Brown, B. (2020). Interdisciplinary Research. *European Review*, *26*(2), 21–29. https://doi.org/10.1017/S1062798718000248

- Chen, S., & Larivière, V. (2015). Are Top-Cited Papers More Interdisciplinary ? Are Top-Cited Papers More Interdisciplinary ?, 9, 1034–1046. https://doi.org/10.1016/j.joi.2015.09.003

- Davé, A., Hopkins, M., Hutton, J., Krčál, A., Kolarz, P., Martin, B., … Stirling, A. (2016). *Landscape review of interdisciplinary research in the UK*. Report to HEFCE and RCUK by Technopolis and the Science Policy Research Unit (SPRU), University of Sussex.

- Davé, A., Melin, G., Swenning, A.-K., Berglund, E., Javorka, Z., & Arnold, E. (2018). *Case Study Review of Interdisciplinary Research in Norway*. Technopolis Group, February 2018.

- Elsevier. (2015). *A Review of the UK's Interdisciplinary Research using a Citation-based Approach*. Report to the UK HE funding bodies and MRC by Elsevier.

- Gibbons M, Limoges C, Nowotny H, Schwartzman S, Scott P, Trow M (1994). *The new production of knowledge: The dynamics of science and research in contemporary societies*. London: Sage

- Gibson, C., Stutchbury, T., Ikutegbe, V., & Michielin, N. (2019). Challenge-led interdisciplinary research in practice: Program design, early career research, and a dialogic approach to building unlikely collaborations. *Research Evaluation*, *28*(1), 51–62.

- Gleed, A., & Marchant, D. (2016). Interdisciplinarity: Survey Report for the Global Research Council 2016 annual meeting. Global Research Council (Vol. 44). Global Research Council.

- J. Rogers Hollingsworth. (2007). High Cognitive Complexity and the Making of Major Scientific Discoveries. In A. Sales & M. Fournier (Eds.), *Knowledge, Communication, and Creativity* (pp. 129–155). Sage Publications.

- Heo, Y., Kang, J., & Kim, K. (2019). National Scientific Funding for Interdisciplinary Research: A Comparison Study of Infectious Diseases in the US and EU. *Sustainability*, *11*.

- Huang, Y., Zhang, Y., Youtie, J., Porter, A. L., & Wang, X. (2016). How does national scientific funding support emerging interdisciplinary research: A comparison study of big data research in the US and China. *PLoS ONE*, *11*(5), 1–20.

- Institute of Medicine. (2005). *Facilitating Interdisciplinary Research*. Washington, DC: The National Academies Press. https://doi.org/10.17226/11153

- Knotts, R. (2013). *Overview of Federal Funding Agency Priorities and Interdisciplinary Themes*. Presentation, Office of Government and Community Relations, May 30, 2013.

- König, T., & Gorman, M. E. (2017). The Challenge of Funding Interdisciplinary Research: A Look inside Public Research Funding Agencies. In R. Frodeman (Ed.), *The Oxford handbook of interdisciplinarity* (2nd ed.). Oxford University Press.

- Krogh, G. von, Mazzucato, M., Ormala, E., Serger, S. S., Sundgren, J.-E., Walport, M., … Wyckof, A. (2019). *Policy Brief - Interdisciplinary research: constructing a level playing field*. Recommendations from the Research Council of Norway's International Advisory Board Issue 1 / January 2019 Interdisciplinary.

- Lyall, C., & King, E. (2013). *International good practice in the peer review of inter disciplinary*. Report of a scoping study conducted for the RCUK Research Group.

- Lyall, C., Bruce, A., Marsden, W., & Meagher, L. (2013). The role of funding agencies in creating interdisciplinary. *Science and Public Policy*, *40*(1), 62–71. https://doi.org/10.1093/scipol/scs121

- National Research Council. (2015). Enhancing the Effectiveness of Team Science. Washington, DC: The National Academies Press. https://doi.org/10.17226/19007

- Nurse, P. (2015). *Ensuring a successful UK research endeavour - A Review of the UK Research Councils*. BIS/15/625.

- Strang, V., & McLeish, T. (2015). *Evaluating Interdisciplinary Research: a practical guide*. Institute of Advanced Study, Durham University.

D.6.2   Literature review method

The literature review was conducted using a dual approach:

- Starting from the Landscape Review of Interdisciplinary research completed in 2016, we reviewed known relevant literature combined with a search through forward and backward citations

- Complementing known literature, we have conducted a systematic search, using Google Scholar, for publications about funding programmes and MIDRI. This allows us to cover blind spots and reduce bias in our review

The main challenge of the systematic search was that the key search terms are commonly used words and a simple search therefore returns an unmanageably large number of results. We therefore opted to search only in publication titles and to use the Boolean operator AND to target the search. Using this approach, our search generated 54 results of which 21 met our relevance criteria and have been considered in the study.

The table below summarises the processes and criteria used.

Table 14 Literature search criteria

	Inclusion	Exclusion
Search terms	- allintitle: Funding (AND) Interdisciplinary - allintitle: Funding (AND) multidisciplinary - allintitle: Funding (AND) inter-disciplinary - allintitle: Funding (AND) multi-disciplinary	

	Inclusion	**Exclusion**
Criteria	• Concerns issues relating to MIDRI funding mechanisms and processes • Concerns issues related to assessment, evaluation, and impact of MIDRI research	• Concerns results from a specific MIDRI project • Concerns issues related to a specific field or discipline • Concerns epistemological issues around MIDRI • Duplicates / incomplete references etc.
Date of publication	Since 2010	before 2010
Count	21	33
Example	• Konig et al. (2016) "The challenge of funding interdisciplinary research: A look inside public research funding agencies"	• Vermeire et al. (2020): "Impact of a shift in treatment funding on a multidisciplinary sleep clinic: a cohort study"

Source: Technopolis

D.6.3 *Selection of programmes*

The selection of programmes to be analysed follows a purposive approach. The aim has been to find programmes with a similar profile as the SPF, using the following main criteria:

- Programmes which support MIDRI either directly or indirectly

- Programmes with a similar intent to the SPF, i.e. to support R&I in alignment with government priorities and strategic opportunities

- Additionally the selection has prioritised current or recent programmes as well as programmes for which evaluations or other activities to measure effectiveness of the programme or approach are available.

It was not possible, within the scope of this task, to undertake a comprehensive mapping of all potentially relevant international programmes.[33] In a purposive approach, we have instead reviewed the portfolio of major international funding bodies to identify programmes which fit the criteria described above. As part of this search, we have consulted the project teams external advisors, Professor Veronica J. Strang (Executive Director of the Institute of Advanced

---

[33] Several MIDRI relevant programmes or initiatives have been evaluated but did not fall within criteria described above. Among many examples:

- A 2012 evaluation of the UK cross-council Rural Economy and Land Use Programme (Relu) (predating the creation of UKRI), found several 'instrumental' as well as 'conceptual impact, including better decision-making by private and government actors involved.

- An evaluation of the US National Institutes of Health (NIH) Interdisciplinary Research Consortium Initiative carried out in 2009-10 with a particular focus on behaviours, facilitators and inhibitors of interdisciplinarity within the funded projects (https://commonfund.nih.gov/interdisciplinary/evaluation)

- A recent evaluation of the Austrian Science Fund's (FWF) 'Special Research Programmes' (SFB) recommended, among other things, that the funder should incorporate measures to strengthen the performance of MIDRI research, e.g., by integrating review criteria for MIDRI in the review process, weighting scores, and MIDR-oriented panel-design. (Dinges et al. 2020)

- Some reviews focus on the support for MIDRI at the institutional level (as distinct from the programme or fund level), see e.g.,: Strang (ed) "Transforming the way we think", AIS Durham, 2016.

Study, Durham University) and Professor Catherine Lyall (University of Edinburgh) for advice on relevant programme to consider.

In our initial search, we reviewed funding organisations in 11 advanced R&I countries[34] (in addition to the UK) and identified 15 programmes, which we judged to provide a good fit against both of the two main criteria. Among the selected programmes, many were rather smaller in scale (several only £5-10 million per year) and often focused more on either one or the other of main criteria (e.g. fund MIDRI to enable scientific breakthroughs but not to support strategic priorities).

D.7 Appendix 2 - Description of programmes

D.7.1 Sinergia (Switzerland)

D.7.1.1 Strategic rationale

The Swiss National Science Foundation (SNSF) funds the Sinergia programme to support collaborative, interdisciplinary projects where breakthrough research is expected. The programme aims to promote collaborative and interdisciplinary research where breakthroughs can only be achieved through the combination of expertise from several applicants and disciplines.

D.7.1.2 Priority-setting

Sinergia is a response-mode programme with no pre-defined thematic priorities. Proposals to the most recent call covered over 40 different disciplines: 37 per cent in biology and medicine, 37 percent in mathematics, natural sciences and engineering, and 26 per cent in the humanities and social sciences.[35] By way of illustration, selected projects include:[36]

- Participatory Knowledge Practices in Analogue and Digital Image Archives (Information technology, Arts and Ethnology)
- Advanced Learning Methods On Dedicated nano-Devices (ALMOND) (Material science, Microelectronics, Condensed matter physics, and information technology)
- Functional chemoinformatic modelling of the host cell metabolome to fight apicomplexan parasites (Cellular Biology, Chemical engineering, Experimental Cancer Research etc.)

D.7.1.3 Mechanisms and processes for supporting MIDRI

The scheme funds project teams of 2-4 applicants for a period of 1-4 years with a grant of up to CHF 3.4m, or £2.8m. Since 2008, the programme has funded 432 projects with an average grant size of approximately CHF 1.7m, or £1.4m.[37]

The programme is dedicated to interdisciplinary and collaborative research (see above) and this is reflected in eligibility and assessment criteria. Applicants must submit a joint research plan and describe the collaboration between the participants in the Sinergia project. Applications are subjected to international peer review by at least two external experts and subsequently ranked according to the programme's assessment criteria by two members of the Sinergia

---

[34] Australia, Austria, Canada, Denmark, Finland, France, Germany, the Netherlands, Switzerland, and the USA.

[35] http://www.snf.ch/en/researchinFocus/newsroom/Pages/news-201218-innovative-and-interdisciplinary-14-sinergia-projects.aspx

[36] http://p3.snf.ch/?QueryID=8e4748ce-3c6e-4aaf-be88-5713827022ec

[37] SNSF grant database, P3: http://p3.snf.ch

evaluation commission.[38] In addition to scientific quality, reviewers are asked to assess "whether the interdisciplinary collaboration is of high quality and adequately organised in view of the joint research objectives".[39] Figure 5 below shows the relevant part of the list of questions reviewers are asked to use to assess Sinergia applications.

Figure 5   Question on interdisciplinarity for assessment of Sinergia applications

Source: SNSF: "List of questions for the assessment of Sinergia applications", Sinergia Programme, August 2017.

---

[38]

http://www.snf.ch/en/funding/programmes/sinergia/Pages/default.aspx#Preparation%20and%20submission%20of%20the%20application%20%28mySNF%2C%20research%20plan%2C%20etc.%29

[39] Regulations on Sinergia grants

The programme is aimed at established researchers who already hold a permanent position at a Swiss university, and as such does not provide direct support for early career researchers.

Monitoring of the Sinergia grants follows standard procedures of the SNSF. This includes regular reporting on financial and scientific progress as follows:[40]

- a financial report every 12 months;
- output data regularly after 18 months;
- a scientific report after 24 months
- a final report upon conclusion of the project.

Applicants are required to state the expected impact of their project, primarily on other disciplines and on science as a whole.[41] For applications in "use-inspired basic research", a project's broader impact is considered at the selection stage.[42] There are no specific provisions to track these impacts beyond the final project report.

A team of researchers conducted a 'policy evaluation' of Sinergia in 2016,[43] covering the period 2008-2012. Based on publication data, the evaluation compared successful to unsuccessful applicants as well as similar non-applicants along three dimensions: (i) scientific productivity, (ii) learning processes, and (iii) co-authorship dynamics. The analysis found that successful applicants were more likely to co-author articles with team members, but that even unsuccessful applicants experienced improved productivity (publications) and learning processes. The findings suggest that the process of preparing a collaborative proposal (combined with availability of alternative funding sources for unsuccessful proposals) has significant effects for researchers involved.

Methodologically, the reviewers deployed a series of statistical tests (t-tests) comparing successful and unsuccessful applicants (part I) and applicants and control group of non-applicants (Part II). To isolate the effect of the scheme, the authors have used formal regression specifications that include detailed controls for the application and applicants' characteristics. The methodology and key results are summarised in the table below.[44]

Table 15   Summary of methods used in the review of the Sinergia programme

	Productivity	Learning processes	Co-authorship dynamics
Description	Productivity growth after the funding decision (average publications per year after decision compared to average publications per year before decision)	New knowledge acquired is traced using the proportion of new journals cited after the funding decision (including / excluding articles co-authored with co-applicants)	Probability that a pair of awarded SINERGIA co-applicants establishes a co-authorship after the funding decision
Part I: Successful vs. unsuccessful applicants	0.51	0.83 / 0.43	0.00

---

[40] Regulations on Sinergia grants

[41] "Guidelines for the research plan – Sinergia programme", August 2017

[42] "Regulations on Sinergia grants", p. 6

[43] Foray, D. et al. (2016), "The SINERGIA Program: A policy evaluation", EPFL Policy Brief 2016/01, April 2016.

[44] Ibid.

	Productivity	Learning processes	Co-authorship dynamics
(t-test P-value)			
Part II: Applicants vs. non-applicants (t-test P-value)	0.00	0.00	n/a

Source: Adapted from Foray, D. et al. (2016). Note: Statistically significant findings marked in green.

D.7.2 *New Frontiers in Research Fund (Canada)*

D.7.2.1 Strategic rationale

The New Frontiers in Research Fund (NFRF) is a 'flagship tri-agency initiative' cutting across the boundaries of Canada's three discipline-based research councils and is investing $275 million CAD over 5 years (£170m, or £34m per year) from 2018/19 in international, interdisciplinary, fast-breaking and high-risk research. The programme was launched following a national consultation by the Canada Research Coordinating Committee (CRCC), which proposed an initiative that would:[45]

- help transform the research enterprise by reducing barriers to cooperation;
- increase the flexibility of researchers to adapt to new circumstances; and
- help researchers explore radically different approaches for developing new knowledge, insights, technologies and ideas.

In the context of this programme, the understanding of MIDRI is related to the term, "convergence research" defined as follows:

> *"research aimed at a specific and compelling problem requiring the deep integration of disciplines, knowledge, theories, methods, data and communities. Merging ideas, approaches and technologies from widely diverse fields of knowledge at a high level of integration is a crucial strategy for solving complex problems and addressing complex intellectual questions."* [46]

The NFRF has three funding streams summarised in the table below.

Table 16 NFRF funding streams

Stream	Description	Competition budget (to date)	Grant size
Exploration	Opportunities to build strength in high-risk, high-reward and interdisciplinary research	$75m CAD (2018,2019,2020)	Max $125k / year Up to two years
Transformation	Large-scale support for Canada to build strength and leadership in interdisciplinary and transformative research	$144m CAD (2020)	$2-4m / year Up to six years
International	Opportunities to participate in research with international partners	$10m CAD	Max $125k / year Up to four years

---

[45] https://www.sshrc-crsh.gc.ca/CRCC-CCRC/priorities-priorites-eng.aspx#fund-fonds

[46] "Conversation on the future of research and research infrastructure in Canada: role of the CFI", Discussion paper, Canada Foundation for Innovation

The **Transformation stream** is most relevant in the current context because of the scale and focus on mobilising MIDRI research to address major challenges. The stream grants supports projects that:

- tackle a well-defined problem or challenge;
- propose a novel world-leading approach that is different from the current state-of-the-art approaches to the issue;
- are interdisciplinary, bringing different perspectives to the defined problem; and
- have the potential to be transformative, defined as the potential to create a significant and real change or impact—a noticeable leap or tangible breakthrough rather than an incremental advance.

D.7.2.2   Priority-setting

The programme does not define a fixed set of priorities in advance. Project proposals may include any discipline or thematic area within the remit of the participating research councils, as long as it has the "potential to have a significant impact in addressing a well-defined challenge".[48]

D.7.2.3   Mechanisms and processes for supporting MIDRI

In order to promote ground-breaking and interdisciplinary research, the 'merit review processes' used for the competition differs from the research councils' normal process. Proposals are assessed using three different mechanisms, each composed with consideration for MIDRI:[49]

- External reviewers: selected for each proposal with relevant subject matter expertise
- A multidisciplinary/multisectoral review panel composed of national and international members with broad expertise
- A Jury, charged with making the final funding recommendations, composed of members with representation from different sectors (e.g. academic, government, private sector), areas of expertise, regions, career stages etc.

The NFRP Transformation stream employs a three-stage application process summarised in the table below. The three stages partly serve to lessen the burden on applicants by only requiring full applications from shortlisted applicants. The early Notice of Intent to apply also serves to allow the programme administrators time to select appropriate external reviewers for each proposal.[50]

---

[47] https://www.sshrc-crsh.gc.ca/funding-financement/nfrf-fnfr/index-eng.aspx

[48] https://www.sshrc-crsh.gc.ca/funding-financement/nfrf-fnfr/transformation/2020/competition-concours-eng.aspx (see 'Subject Matter (Fit to Program)')

[49] https://www.sshrc-crsh.gc.ca/funding-financement/nfrf-fnfr/transformation/2020/competition-concours-eng.aspx

[50] The SSHRC uses a two-stage process for certain other larger programmes, but these do not include the initial Notice of Intent (NoI) stage.

Table 17 Summary of NFRP Transformation application process

Stage	Deadline	Process	Criteria
Notice of Intent to apply (NOI)	Feb 2020	• Internal review to verify eligibility • Administrative process to help the NFRF program team identify external reviewers and review panel composition	• n/a
Letter of Intent to apply (LOI)	July 2020	• Internal review to verify eligibility • Review by multidisciplinary /multisectoral review panel	• interdisciplinarity (pass/fail) • Equity, Diversity and Inclusion (EDI) (pass/fail) • high risk (20%) • high reward (60%) • feasibility (20%)
Full proposals	April 2021	• External review (five recruited for each application) • Review by multidisciplinary/multisectoral review panel: Ranking of proposals • Jury: Highest ranked proposals presented in person and Jury makes recommendations for funding.	• interdisciplinarity (confirm pass from LOI stage) • EDI (confirm pass from LOI stage) • high risk (25%) • high reward (25%) • feasibility (50%)

Technopolis, adapted from SSHRC website[51]

The selection criteria have different weight at different stages in the process. The review in the second (LOI) stage emphases the application's potential (high reward criterion), whereas in the third stage, the panel is asked to place greater emphasis on feasibility. Interdisciplinarity is a pass/fail criterion, defined along several dimensions as shown in Figure 6 below.

---

[51] https://www.sshrc-crsh.gc.ca/funding-financement/nfrf-fnfr/transformation/2020/competition-concours-eng.aspx

Figure 6   NFRF programme: Definition of interdisciplinarity criterion

	✔ Pass	✘ Fail
Perspective	Proposes a novel interdisciplinary approach. Incorporates different disciplinary approaches, bringing a novel perspective to the defined challenge.	The proposed approach is largely based on a conventional perspective. Proposes an interdisciplinary approach where there is a long tradition and/or established co-operation/collaboration/interaction between the disciplines.
Approach	Proposes the application or adaptation of tools/methods/techniques from one discipline to solve a problem in another discipline. (This may also apply for projects where there is a history of collaboration between the disciplines.)	The proposed tools/methods/techniques are already in use in or easily applied to the second disciplinary area, requiring little adaptation or development.
Integration	The various disciplinary approaches and perspectives are fully integrated; the project is not an amalgamation of disciplinary-specific approaches.	The interdisciplinary nature of the project is achieved through an amalgamation of projects/activities that are disciplinary.
Team	The interdisciplinary approach is reflected in the team.	The team does not reflect the expertise required to execute the interdisciplinary approach.
Proposal design	Designed from an interdisciplinary perspective.	The proposal appears to be an interdisciplinary component "added on" to a more conventional project or program of research.
Other		The application did not adequately establish the interdisciplinary nature of the project. The project falls under the mandate of only one federal research funding agency

Source: SSHRC (Updated 2021)[52]

D.7.2.4   Monitoring and evaluation

A mid-term review of all funded projects is mandatory to ensure they are on track to meet objectives within the six-year timeframe. If the mid-term review is unsuccessful, grants may be terminated early.

---

[52] https://www.sshrc-crsh.gc.ca/funding-financement/nfrf-fnfr/exploration/2020/merit_indicators-indicateurs_du_merite-eng.aspx (accessed 17 May 2021)

D.7.3   Science, Engineering and Education for Sustainability NSF-Wide Investment (SEES)

D.7.3.1   Strategic rationale

Science, Engineering and Education for Sustainability NSF-Wide Investment (SEES) is one of the NSF's 'Areas of National Importance'. The SEES was a portfolio activity which is labelled as 'NSF-wide' and 'Cross-cutting' with activities spanning the entire range of scientific domains supported by the NSF.

The SEES was initiated in 2010 in response to a 2009 report from the National Science Board (NSB), which recommended a coordinated effort in the field of climate change and environmental research, stressing the need for a systems approach (including natural and human systems) and partnerships across organisations and sectors. In addition, the IPCC's 2007 climate change report was an important driver, highlighting several key scientific challenges that could, if addressed, improve predictions, mitigation and adaptation strategies.[53]

The initiative aims to:

- Support interdisciplinary research and education that can facilitate the move towards global sustainability
- Build linkages among existing projects and partners and add new participants in the sustainability research enterprise
- Develop a workforce trained in the interdisciplinary scholarship needed to understand and address the complex issues of sustainability

The NSF SEES portfolio formally ended after 2017, although some SEES activities continued to be funded.

D.7.3.2   Priority-setting

'Areas of National Importance' are activity portfolios focussing on areas of national interest, most often addressing complex challenges which require interdisciplinary approaches and collaboration between different agencies and departments.[54] The SEES programme was explicitly aligned with the federal government's priorities, e.g. the 2012 Innovation Strategy.[55] More generally, the NSF's process for setting priorities is embedded within the framework of the National Science and Technology Council (NSTC), which ensures a balance between alignment with the Federal government's strategic national priorities and scientific considerations.[56]

D.7.3.3   Mechanisms and processes for supporting MIDRI

The SEES portfolio is made up of existing ongoing programmes and new dedicated SEES programmes, each of which is implemented according to its own criteria and procedures. Several of these programmes encourage MIDRI through specific eligibility criteria requiring interdisciplinary collaboration. For example, proposals for the 'Coastal SEES' program "must

---

53 'FY 2011 NSF Budget Request to Congress', NSF-Wide investments – 29

54 https://www.nsf.gov/od/oia/additional_resources/interdisciplinary_research/support.jsp

55 See 'FY 2012 NSF Budget Request to Congress', Overview – 5.

56 NSF, 'Research Instrumentation: Enabling the Discovery Process', available at:
   https://www.nsf.gov/pubs/stis1995/nsf94102/

include meaningful and well-integrated contributions from multiple disciplines".[57] In addition, the NSF was able to take advantage of the initiative's portfolio structure and draw on a range of complementary support for SEES researchers such as funding for interdisciplinary and international workshops to support the preparation of MIDRI networks and partnerships.[58]

D.7.3.4   Monitoring and evaluation

The NSF commissioned an evaluation of the SEES portfolio in 2018, seeking to measure the success in terms of (1) the development of new knowledge and concepts that advance the overarching goal of a sustainable human future; (2) new and productive connections made among researchers in a range of disciplines; and (3) the development of a workforce capable of meeting sustainability challenges.[59] This evaluation has been completed but is not publicly available.[60]

D.7.4   Strategic Research Council (Finland)

D.7.4.1   Strategic rationale

The Strategic Research Council (SRC) was set up in 2014 as in independent body within the Academy of Finland to fund "long-term and programme-based research aimed at finding solutions to the major challenges facing Finnish society".[61] The strategic rationale for the creation of SRC, which was funded primarily through a reduction of direct funding for the Finnish research institutes, was a desire to reallocate funding towards higher value-added areas and make institutes more dynamic and responsive to external needs.[62]

Other aims of the scheme include: [63]

- Promotion of multidisciplinary research and enable new combinations of expertise
- Fund of long-term research to seek solutions to societal challenges in Finland
- Supporting regeneration and competitiveness of Finnish business and industry as well as the public sector
- Contributing to improved evidence-based policy and dissemination of research knowledge

The Council is primarily made up of representatives from academia, but also include members from government and business.

57 https://www.nsf.gov/pubs/2014/nsf14011/nsf14011.jsp#q7

58 See e.g. 'Dear Colleague Letter for the Science, Engineering and Education for Sustainability (SEES) NSF-Wide Investment Area', NSF 11-022, January 2011.

59 https://www.nsf.gov/od/oia/eac/evaluation-inventory.jsp

60 http://www.manhattanstrategy.com/newsread.aspx?nid=108

61 https://www.aka.fi/en/about-us/decision-making-bodies/strategic-research-council/

62 See e.g. Sylvia Schwaag Serger, 'Strengthening the Contribution of Higher Education Institutions and Research Institutes, OECD Review of Innovation Policy: Finland, presentation at Launch Event, Helsinki, 9 June 2017.

63 https://www.aka.fi/en/strategic-research/for-applicants-and-projects/for-applicants/characteristics-of-src-funding/

D.7.4.2 Priority-setting

The strategic research themes and priorities are set annually following a consultation process, following which the Finnish government makes the final decision based on a proposal from the SRC. Most recently, the government decided to support the following three strategic priorities for 2021:[64]

- Demographic changes – causes, consequences, and solutions
- Environmental and social links to biodiversity loss
- Pandemics as a challenge for society

There will be a programme for each theme in 2021 with a suggested total funding allocation €55.6 million for the purpose.

D.7.4.3 Mechanisms and processes for supporting MIDRI

SRC funding is primarily given as large grants to multidisciplinary consortia,[65] and are expected to include interaction with users aimed at creating societal impact. To be eligible, proposed projects must be organised as consortia of least two organisations, including at least three research teams or work packages (WP), and the planned research must cover at least three different research fields (following the Academy of Finland's classification). The applicants are asked to include in their application a research and interaction plan, which should include a description of societal relevance and impact.

Call for proposals are organised as a two-stage process:[66]

- a preliminary expression of interest, in which only the consortium leader is asked to apply
- a full application, incl. all work packages

The review of applications largely follows the same practices as other parts of the Academy of Finland's portfolio, including a panel review and in some cases interviews. The main selection criteria are societal relevance and impact as well as their scientific quality, considering the aims of the thematic programme.[67]

D.7.4.4 Monitoring and evaluation

The SRC's 'funding principles' specify that impact is reviewed at the programme level to evaluate the scheme's impact and to develop the Academy's strategic research funding. The impact review also has a particular focus on the ability of the funded multidisciplinary consortia to create new research. In that context, it is acknowledged that multidisciplinary research may not have the publication channels that single discipline consortia do.[68]

The first evaluation of the SRC, covering the first generation of SRC programme (active 2016-2019), was published in January 2021. Among the headline findings, the evaluation found that

---

[64] Government decides on themes for strategic research in 2021, Government Communication Department, 1 October 2020, retrieved from: https://vnk.fi/-/valtioneuvosto-paatti-teemat-strategiselle-tutkimukselle-vuonna-2021?languageId=en_US

[65] The SRC also grants national match funding for Finnish projects funded under EU Horizon 2020's societal challenges pillar.

[66] https://www.aka.fi/en/strategic-research/for-applicants-and-projects/for-applicants/faq/

[67] Funding Principles of the Strategic Research Council, May 2020, retrieved from: https://www.aka.fi/en/strategic-research/for-applicants-and-projects/for-applicants/funding-principles/

[68] Ibid., pp. 2-3

the definition of research themes had been successful and the scheme had introduced a more strategic approach to research in support of societal challenges. Specially, it was found that the requirements to integrate interaction with knowledge users (see above) "effectively intensify cooperation and contribute constructively to the delivery of research results to inform policymaking."[69] The evaluation concluded – based largely on case studies – that the funded projects had created many *possibilities* for impact but that longer time was needed to assess societal impact.[70]

Compared to other Academy of Finland programmes, the evaluation of the SRC places particular emphasis on measuring impact and on interaction with users. The Academy's staff have sought lessons from the UK experience from REF and the impact agenda.[71]

D.7.5   *Grand Solutions (Innovation Fund Denmark)*

D.7.5.1   Strategic rationale

Innovation Fund Denmark (IFD) was created through a merger of three funding bodies as part of a wider reorganisation of the support for strategic research in Denmark in 2013/14 to help bring about a simpler and more coherent funding system bridging basic research and industrial application.

Grand Solutions is the IFD's largest programme and aims to support collaborative projects based on excellent research focused on solutions of considerable societal value. Based on societal and business challenges, opportunities and innovation needs, IFD wants to enable cross-disciplinary investments in knowledge institutions and (private and public) companies.[72]

D.7.5.2   Priority-setting

The thematic priorities of the Grand Solutions scheme are ultimately determined politically but involves a broader process with several steps:

- A broad consultation every five years to produce a 'catalogue' of national priorities. The most recent of these catalogues, 'Research 2025', was published in 2017.[73]
- Annual budget allocations for strategic and challenge-led research through the government's Finance Act, with specified allocations for each thematic area.[74]
- IDF Grand Solutions call for proposals within the given priority areas

Current open 'Grand Solutions' calls include:[75]

- Life Science, Health, Welfare Technology and Clinical Research

---

[69] https://www.aka.fi/en/strategic-research/strategic-research/for-knowledge-users/whats-new/2021/evaluation-of-completed-strategic-research-programmes/

[70] Hjelt et al. (2021), Strategisen tutkimuksen ohjelmat 2016-2019: yhteiskunnallisen vaikuttavuuden arviointi, 5 February 2021

71 New models for evaluating societal impact in strategic research programmes in Finland, 10 December 2018, retrieved from: https://www.aka.fi/en/strategic-research/strategic-research/for-knowledge-users/blog/2018/new-models-for-evaluating-societal-impact-in-strategic-research-programmes-in-finland/

[72] https://innovationsfonden.dk/en/programmes/grand-solutions

[73] https://ufm.dk/en/research-and-innovation/research2025

[74] See e.g. the Finance Act of 2019, section 19:44 (p. 171): https://www.fm.dk/publikationer/2019/finansloven-for-2019

[75] https://innovationsfonden.dk/en/programmes/grand-solutions

- Technology and innovation that develops production and creates jobs and opportunities in Denmark.
- Green Research, Technology Development and Innovation

The potentially changing nature of annual political funding decisions is tensioned against the need for longer term planning within IFD and the funding organisation has developed thematic strategies in several areas for this purpose. Thematic calls also make reference ot the UN's Sustainable Development Goals.

D.7.5.3   Mechanisms and processes for supporting MIDRI

Applications to the Grand Solutions programme are assessed in several steps, including an initial internal assessment to decide which proposals are invited for full review, an external peer review for scientific/technical assessment of the applications, a project interview, and an overall assessment which may also consider the strategic importance and value of the project.

Four main criteria are used in the assessment:[76]

- Excellence - Quality of research and innovation
- Value creation
- Efficiency of project execution
- Implementation of results

These processes and criteria primarily aim to support MIDRI in the broader sense, with a focus on inter-sectoral collaboration. For example, proposals are asked to describe how they will ensure successful implementation of results, and active involvement of end users is seen favourably. The application process has also been streamlined to ensure a relatively fast turn-around, and the IFD aims to keep the processing period from application deadline to decision to less than 100 days.[77] This is meant to encourage participation from organisations outside of the research sector.

D.7.5.4   Monitoring and evaluation

Following the selection of applications for funding, Innovation Fund Denmark deploys an active approach to monitoring and follow-up. As part of the contractual process, participants are required to sign a collaboration agreement between themselves, e.g., to determine the use of background knowledge and use of results. The Fund requires projects to undertake regular reviews, typically once a year and reserves the right to collect data about project progress and results up to five years after the end of the project. Investments can be adjusted during the course of projects depending on results, so that projects that fail to make sufficient progress can be terminated whereas projects that show particular promise can be invited to apply for additional funding.[78]

In 2018, the Danish Government commissioned an international expert group to conduct a review of Innovation Fund Denmark.[79] The main purpose of the evaluation was to determine whether the Fund fulfilled its legal mandate and role within the innovation system, and thus not primarily about effectiveness and impact of funded activities. A consultation of programme

---

[76] "Guidelines for Grant Solutions", Innovation Fund Denmark, Updated 18 December 2020,

[77] Ibid., p. 4.

[78] Ibid, p. 12

[79] "Innovation Fund Denmark – Report of the International Evaluation Panel 2019" Ministry of Higher Education and Science, Denmark, March 2019.

participants and stakeholders found that the Grand Solutions scheme was seen to be relevant and useful,[80] but the reviewers also identified several issues with the scheme. Most notably:

- The Fund was generally found to have an insufficient focus on long-term strategic research, with the Grand Solutions scheme primarily funding 1-to-1 collaborations between public and private organisations within a relatively narrow field

- Projects funded under the scheme were found to be insufficiently interdisciplinary,[81] and with low participation from the social sciences and humanities

- The scheme attracted participation from large companies (complementing other schemes dedicated to small businesses), but participation from medium-sized companies was low

Overall, it was found that the Grand Solutions scheme did not quite live up to its name, and the review recommended a "new, bolder and better integrated programme" with longer term funding for a smaller number of priorities to be addressed jointly with other funding agencies.[82] It is not yet known whether these recommendations will be taken up.

D.7.6   *Knowledge and Innovation Covenant (KIC)*

D.7.6.1   Strategic rationale

The Dutch Research Council (NWO) launched its contribution to the 'Knowledge and Innovation Covenant' (KIC) in 2020 to address societal challenges more effectively in alignment with the Dutch government's new 'Mission-Driven Top Sector and innovation policy'. With the KIC, the NWO will invest more than €100m per year in the period 2020-2023 to support collaborative research involving knowledge institutions, the business community, government, and other public organisations.[83]

The initiative contains main funding lines, providing funding a mix of strategic and demand-driven priorities:

Table 18   Overview of KIC funding lines

Funding line	Description	Annual budget	Grant size
Mission-driven calls	Annual thematic calls to fund scientific and practice-oriented research aimed at societal impact.	€55m	€750k to €4m
Partnerships	A limited number of demand-driven partnerships are developed each year that focus on the knowledge or development issue of a private or public partner.	€15m	€1.5m to €5m (€3-10m incl. co-financing)
Strategic collaboration	Long-term programmes (10 years) to stimulate the national development of a scientific field in the Netherlands, focusing on a societal theme and/or key technology.	€30m (€20m for new programmes)	€30m to €100m (total budget over 10 years)

---

[80] Ibid, p. 33

[81] According to analyses carried out in support of the review,17% of the projects can be classified as interdisciplinary. This is based on an analysis university involvement and would likely be higher if other projects partners were included. (ibid, p. 60)

[82] Ibid, p. 39

[83] NWO Contribution to Knowledge and Innovation Covenant 2020-2023, Dutch Research Council (NWO), available at: https://www.nwo.nl/en/researchprogrammes/knowledge-and-innovation-covenant

Funding line	Description	Annual budget	Grant size
Practice-oriented instruments	Multiple instruments allowing practice-oriented researchers to build up innovation networks and collaborate with regional partners and SMEs.	€18m	Variable

Source: NWO website [84]

The 'mission-oriented' funding line has specific requirements relating to priority-setting and MIDRI as described below.

D.7.6.2   Priority-setting

The mission-driven calls focus on topics derived from government policy. The government's new innovation policy focuses on 25 'missions' covering four main societal challenge areas:

- Energy transition & sustainability
- Agriculture, water & food
- Health & Care
- Security

The Top Sectors have developed Knowledge and Innovation Agendas (KIAs) for each of these themes – as well as for 'key technologies' and 'societal earning capacity' – which define topics to be pursued in public private partnerships.[85] Each year, the NWO develops one or two mission-drive programmes based on each KIA.[86]

D.7.6.3   Mechanisms and processes for supporting MIDRI

NWO prioritises interdisciplinary research within KIC in order to ensure an optimum contribution to complex societal challenges.[87] In their use of interdisciplinarity, NWO emphasises three aspects:

- 'Integrated': projects include natural sciences as well as either humanities or social sciences (or both)
- 'From the outset': Collaboration should be interdisciplinary, starting from the formulation of research questions.
- 'Innovative': All researchers must be involved in innovative research (e.g., humanities researchers cannot be included with the sole aim to verify conformity to ethical standards).

For the mission-driven calls, specific requirements and support are put in place:

- Interdisciplinarity was *encouraged* from 2020. From 2021, interdisciplinary workshops will be organised to formulate research questions for the specific calls and interdisciplinarity will be *mandatory* in grant proposals (except under 'key technologies').

---

[84] https://www.nwo.nl/en/researchprogrammes/knowledge-and-innovation-covenant

[85] "Letter to Parliament on mission-driven Top Sector and Innovation Policy", 26 April 2019 https://www.rijksoverheid.nl/documenten/kamerstukken/2019/04/26/kamerbrief-over-missiegedreven-topsectoren-en-innovatiebeleid

[86] https://www.nwo.nl/en/researchprogrammes/knowledge-and-innovation-covenant/mission-driven-calls-kic-2020-2023

[87] This section is based on: https://www.nwo.nl/en/researchprogrammes/knowledge-and-innovation-covenant-kic/interdisciplinary-collaboration

- The NWO will organise matchmaking activities ahead of the deadline for each call, with participation from researchers and other organisations in the relevant sectors, in order to facilitate interdisciplinary proposals.[88]
- In the assessment of interdisciplinary proposals, the NWO emphasises the need to select and instruct members appropriately, although details are still to be worked out.

Proposals are assessed according to four key criteria, with an added emphasis on the problem diagnosis, solutions and impact:[89]

- Problem posed and problem analysis, contribution to solution (20%)
- Expected impact and route to impact (20%)
- Quality of the consortium (30%)
- Quality of the research (30%)

COVID-19 has led the NWO to introduce some flexibility in grant conditions, and this could possibly have had an impact on the implementation of Mission-driven calls and support for interdisciplinarity.

D.7.6.4   Monitoring and evaluation

No information about specific monitoring and evaluate on requirements for the KIC or mission-driven research has been found. The programme appears to follow standard NWO procedures.[90]

The government's missions define targets for different time horizons, e.g., 'Zero-emission mobility for people and goods in 2050', which may form the basis for future evaluations.

---

[88] See for example: Online matchmaking meeting KIC call 'Mission-driven innovation systems in a regional context' | NWO

[89] See for example: Data and Intelligence: A safe society with the help of data and intelligence | NWO

[90] https://www.nwo.nl/en/project-management

Appendix E   Case Studies

E.1   Adolescence, Mental Health and the Developing Mind

E.1.1   Introduction and context

The Adolescence, Mental Health and the Developing Mind programme (SPF wave 2), is a £35 million programme led by the Medical Research Council (MRC), and jointly delivered with the Arts and Humanities Research Council (AHRC) and the Economic and Social Research Council (ESRC). The programme started in 2019 and will end in 2025.

The programme aims to support better understanding of the developing adolescent mind and the genetic, physiological, social and cultural factors that shape it and influence lifelong mental health, educational attainment, identity, social relationships and behaviour. It will fund research that examines how mental health problems emerge, understanding the factors that might influence mental health as well as exploring preventative strategies and novel intervention approaches.

There are six linked objectives for the programme, which are to:

i) Understand the different factors that impact during adolescence and how they interact, including genes, environment and social interactions

ii) Learn what mitigates risk and enables resilience (risk and protective factors)

iii) Explore how to identify vulnerable young people early

iv) Explore new methods, resources and ways of working

v) Increase the evidence base on what works in delivering mental health support in schools

vi) Develop an improved understanding of online harms and how digital technology can be harnessed to promote positive mental wellbeing.

The programme involves collaboration with and across governmental departments and devolved administrations, including the Department for Education (DfE), the Department for Digital, Culture, Media and Sport (DCMS), and the Welsh and Scottish Governments. It also involves MQ Transforming Mental Health, a mental health research charity. This multidisciplinary collaboration reflects the variety of stakeholders contributing to a complex and rapidly evolving research area. It also reflects the fact that the challenge cuts across several Government departmental remits and priority research areas, for example:

- The DfE's research interests on mental health in schools (including early intervention and pupil wellbeing) and the impact on educational outcomes and wellbeing[91];

- The DCMS's interests in digital experiences, loneliness in young people, youth provision for mental health and wellbeing and the impact of cultural investment on wellbeing, mental health and emotional development; and,

- The Welsh and Scottish governments' commitments to improve the mental health of children and young people.

Furthermore, the programme emphasises the engagement, co-design and co-production of research with young people as well, especially around dissemination.

---

[91]https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/664855/Transf orming_children_and_young_people_s_mental_health_provision.pdf

E.1.2   Programme origins and idea development

Although adolescence is a crucial time when it comes to mental health (three quarters of mental health problems emerge before the age of 24), it is still a poorly understood period in the life course. The programme bid identified a need for research to improve the understanding of factors which put young people (aged 10 to 24) at risk of adverse mental health, to identify evidence-based approaches which can improve resilience before and during adolescence, and to better understand how and why some young people thrive despite exposure to adversity[92]. New knowledge across these fields (and others) is needed to advance early diagnosis and to deliver effective early intervention for those in need, enabling better management of mental health problems, and improving young people's life chances. Interviewees also noted the impact of the COVID-19 pandemic on young people's mental health has further highlighted the importance and relevance of the programme.

Although there are multiple centres of excellence that conduct research in this area, the programme bid identified a lack of multidisciplinary programmes able to explore relevant issues. These issues include, the complexity of interacting factors affecting people during adolescence, the high degree of inter-individual heterogeneity, the consequences of genetic, environmental and social interactions for life outcomes, and how these vary between individuals. Additionally, interviewees noted the need to create better links between research, policy and practice:

> *"We know it's an area where the research that's being done could be more interdisciplinary and it could be more connected to the routes for impact. So, a lot of research is being generated but that evidence is not sufficiently aligned with what those who would be involved in implementing the evidence require."*

The large scale and multi-disciplinary nature of the programme was considered outside of any single funding partner's remit and could not be met from core budgets. This therefore required external investment. While other UKRI funding schemes were not suitable, SPF provided a unique opportunity to coordinate an integrated, multi-sectoral approach at the scale needed.

When partners reflected on how this compared to usual, it was noted that the breadth of government departments engaged in the bid development was more varied than typical collaborations. Furthermore, while designing and developing the programme idea, the MRC engaged with a variety of different organisations to ensure coverage of research priorities. A workshop was held at the UK Mental Health Funders Forum meeting in October 2018, involving academic experts, government departments, mental health services, young people and other stakeholders. The research community was engaged throughout, including MRC Neurosciences and Mental Health Board, ESRC Mental Health Leadership Fellow, NIHR MindTech, UKRI Mental Health Network directors, and McPin Foundation. In addition, young people and mental health service users and the NIHR Young Person's Mental Health Advisory Group were also consulted.

The MRC engaged with Professor Eamon McCrory, Chair of Developmental Neuroscience and Psychopathology at University College London, and in March 2020 appointed him as the Director for the Adolescence, Mental Health and the Developing Mind programme. Professor McCrory was selected after a competitive search led by the MRC[93]. Young people with lived

---

[92] https://mrc.ukri.org/research/initiatives/adolescence-mental-health-and-the-developing-mind/

[93] https://mrc.ukri.org/research/initiatives/adolescence-mental-health-and-the-developing-mind/

experience of mental health problems met with the final candidates and contributed their views to the decision-making process[94].

E.1.3   Programme design and activities

The programme takes a multidisciplinary approach, encompassing medicine, biology, social science, arts and the humanities, to address the complex research challenges in this area. The integrated approach aims to support accelerated translation of research into policy and practice in areas such as education, health and social care and other public services.

The programme is being delivered through four interlinked areas of activity:

1. **Flagship research programmes (£30m)**: The workstream focuses on research to identify effective prevention and intervention approaches for young people's mental health. Current and recent calls for funding include:

   – Engagement Awards (closed): 11 Awards were made as part of the Engagement Awards funding call in February 2020 (totalling £1.06m). This includes funding projects conducting research into a variety of different topics related to adolescence mental health, including sleep, suicide, use of digital technologies and school-based interventions.

   – COVID-19 rapid knowledge mobilisation (closed): This was a change to the original plan as a reaction to the COVID-19 pandemic, though this aligns with the original ambitions for the programme. The programme invited proposals to support rapid mobilisation of research on adolescent wellbeing and mental health during the COVID-19 pandemic. Two awards (totalling £400k) commenced in September 2020. These are expected to result in the development of a portfolio of multimedia resources that will address the current challenges and concerns adolescents are experiencing in response to COVID-19, create practical advice and promote evidence-based strategies that meet the needs of young people during, and after, the pandemic, and that can be used to provide advice and recommendations to policy makers and professionals involved in supporting young people[95].

   – Research Programmes (closed): The £24m call invited outline proposals for innovative and ambitious interdisciplinary programmes of original empirical research in adolescence, mental health and the developing mind. This call aimed to support research which strengthens intersections between relevant disciplines that do not routinely engage with each other[96]. Successful projects were eligible to be awarded up to £4m and last up to 4-years.

2. **Methodological development (£12m)**: This workstream will generate and embed novel research methods and create data infrastructure that enables research at depth and scale. Activities so far include:

   – Methodology Scoping Workshop (November 2020): An online workshop to explore the challenges and opportunities for new research methods, tools, approaches, measures and resources to inform the development of the methodology funding call.

   – Methodology Call (Late 2021): A call focused on developing and embedding new research methods, tools, measures and resources to advance the overall field of adolescent mental health research.

3. **Community building (£3m)**: This workstream will establish a UK-wide network of researchers and stakeholders, oriented to the challenge in question, creating and strengthening multidisciplinary research collaborations, and facilitating interactions with policy makers,

---

[94] https://mrc.ukri.org/research/initiatives/adolescence-mental-health-and-the-developing-mind/

[95] https://webarchive.nationalarchives.gov.uk/20200524015153/https://mrc.ukri.org/funding/browse/amhdm-covid-19-mrc-ahrc-esrc-adolescence-mental-health-and-the-developing-mind-covid-19-rapid-knowledge-mobilisation/

[96] https://mrc.ukri.org/funding/browse/amhdm/adolescence-mental-health-and-the-developing-mind/amhdm-call-for-research-programmes/

health, social care and education sectors. Critically, the voice of young people will be central to these developments.

4. **Stakeholder engagement and knowledge mobilisation**: This workstream will accelerate implementation of research evidence into policy and practice by linking researchers, stakeholders and relevant knowledge mobilisation organisations.

Led by the MRC, the programme will be managed through cross-council (MRC, AHRC, ESRC) governance building on their experience delivering previous funding calls together (e.g. UKRI mental health networks, GCRF and Newton Fund calls) and adopting similar working arrangements. This includes:

- A Cross-Council Executive Group and operations sub-group to oversee delivery, which is accountable to MRC Strategy Board, ESRC Directors and Strategic Advisory Network and AHRC Advisory Board.

- A Research and Stakeholder Advisory Board (RSAB) to provide leadership and direction for the programme, for example, advising on the development of calls, community building and knowledge mobilisation activities, and delivering reports to the Executive Group and beyond. It is comprised of research leaders from the Councils, government department partners, service users and young people, policy leaders and practitioners in education, social care, CAMHS and/or youth justice.

- Secretariat and administrative support for the Cross-Council Executive Group and the Research and Stakeholder Advisory Board provided by the MRC.

- Funding panels including academic experts, lay experts and industry.

- A Young Person's Advisory Group (YPAG) to ensure that the direct experience of young people living with mental health issues is at the centre of the programme. This includes young people who review proposals, sit on funding panels, participate in interviews and contribute to scoping workshops.

E.1.4   Programme outputs and uptake

There is limited evidence on the outputs of the R&I given the early stages of delivery. However, as of April 2021, the programme has funded the following:

- **11 Engagement Awards**: Although the call took place pre-COVID, the delivery of these engagement and networking activities had to take place virtually over the last year (projects lasted one year). These were largely focused on building partnerships and developing some pilot research. The analysis of outputs is underway so interviewees were unable to comment on the results of these, but there was some acknowledgement that these will likely have been impacted due to COVID. Positively, some partnerships have subsequently submitted high quality research programmes.

- **2 COVID knowledge mobilisation projects**: This was a rapid call developed in response to COVID to generate rapid outputs. The aims were to identify the priorities for young people given the impact of COVID and assemble the current/pre-existing evidence base to develop a 'toolbox' of resources, approaches and methodologies to support young people and health professionals. They are currently delivering activities and starting to disseminate resources.

- **7 substantive research programmes**: The call received 77 applications, of which 22 invited were invited to stage 2 and nine were invited to interview. The seven successful projects were finally selected in April 2021. As such, the projects are in early stages or have not yet started, meaning it is too early to assess the outputs of the R&I. Stakeholders noted however, that the call include engagement (co-design) with young people and the selected

projects involve non-academic partners (e.g. charities and third sector partners) as co-investigators (based on an ESRC approach),

The programme has sought an extension due to delays caused by COVID-19.

E.1.5   *Programme outcomes and impact*

E.1.5.1   R&I to address priorities

The programme has only recently finalised its selection of seven substantive research projects, meaning R&I outputs have not yet been generated, taken up or disseminated. However, interviewees were positive about the quantity and quality of the applications and that the successful projects reflected the programme objectives, with the additional need to account for the impact of COVID:

> *"Obviously we're just about to fund those so we're not in a position to talk about the detail, but I think the achievement is successfully creating a portfolio of high quality interdisciplinary programmes that address key gaps in our understanding around intervention and prevention around adolescent mental health and wellbeing."*

E.1.5.2   Intersectoral collaboration

Stakeholders agreed that the programme has so far been managed well and that there has been a good level of collaboration and input across partners, with strengthened links between the MRC, AHRC and Department for Education. Key collaborative inputs include:

- Input was sought from across partners to feed into the development of funding calls and representatives have sat on funding panels to represent individual priorities.

- Government perspectives are represented on the advisory board – this governance was broader than usual given that the programme is still relatively early stage/foundational research.

- The programme director as a figurehead has been able to disseminate the opportunities (potentially more effectively), advertise the programme, link up with key (new) stakeholders, and lead the knowledge mobilization strand.

However, stakeholders also noted some challenges:

- There was some concern that government priorities and policies were not sufficiently understood early on in the programme's development and that government participation could be increased to better ensure interests are met by UKRI funding investments.

- The arts and humanities component has not always been well-integrated in programme bids, i.e. appearing to be an add-on. However, stakeholders generally agreed that there was good representation of arts and humanities in the final selection of successful bids.

- The amount of time required for set-up, including supporting partners to work in new ways, was under-estimated and this made the spend profile challenging. This was further hindered by the pandemic, which limited their engagement with health professionals, young people (especially younger adolescents) and schools.

- Lack of in-person networking events to bring people together, which stakeholders felt could be a more effective way of promoting interdisciplinarity.

E.1.6   *Conclusions*

There was consensus among stakeholders that SPF provided an opportunity through this programme to coordinate an integrated, multi-sectoral approach at the scale needed. Interviewees noted that some key examples of the additionality under the SPF:

- Funding projects focused on knowledge mobilisation rather than new research as part of the COVID call. This was possible because the objectives for the programme are relatively broad and there was underspend from the Engagement Awards meaning the spend profile could be used in a reactive way.

- Creating a more "equal and holistic" approach to funding cross-disciplinary research:

  "We developed partnerships before to fund cross-disciplinary research so that was already there but think this fund has allowed this activity to be much more equal and holistic. It's not a complete step change in that we didn't do it before, we did, but this provides a lot more equality across the partners and across the contributions and it means that you design a programme that fits the objectives and what you want to achieve rather than the relative contributions which I think is a really good thing."

- Focus on the breadth of the evidence base rather than just the depth by encouraging multidisciplinary collaboration to address complex issues:

  "It includes so many different things that to look at those questions you need to bring people together across disciplines and that isn't easy to do, to look across all of those different factors because the type of research that you do is very different. Some of that research is very quantitative, some of it is very qualitative. It looks at different models, it takes different theories and concepts. To bring those together is quite complicated and it requires time and so perhaps previously the schemes that were available may not have provided the breadth and the duration that would be needed to do something like this."

- Additional funding/budget means increased ambition and scale of what is possible.

However, some stakeholders reflected that, although there was added value of SPF as noted above and that it has been a key enabler, some of the interdisciplinary science being done (or planned) through the programme could be delivered through previous/existing mechanisms. However, this was unlikely to involve the same amount of cross-council working.

E.1.7   Interviewees

Interviews were conducted with programme partners and stakeholders during April / May 2021.

- Programme Lead, MRC
- Programme Lead, MRC
- Research Council Partner, AHRC
- Government Department Partner, DfE
- Government Department Partner, Welsh Government
- Programme Director, UCL
- Programme Champion, MRC

E.2 Bacterial Plant Diseases

E.2.1 Introduction and context

Bacterial plant diseases, for example Xylella, are a key threat to our food supply. Advancing knowledge and developing effective strategies to manage these significant threats will therefore help to safeguard UK industries and environments. The Bacterial Plant Diseases SPF programme is being delivered by BBSRC, with support from NERC, alongside government department partners from DEFRA and the Scottish Government.[97] Matched funding of £1.1m was provided by DEFRA and the Scottish Government, with SPF funding of £17.8m.

The focus of the programme is interactions of bacterial pathogens with host plants, invertebrate vectors and wider ecosystems, which (according to the original programme bid) "present many research challenges of practical and policy relevance". SPF funding was sought to enable an integrated programme of:

- **Underpinning science,** needed to elucidate many aspects of pathogen biology and epidemiology (e.g. latency/viability in plants and vectors; mechanisms of transmission; determinants of host range; variation in host resistance; understanding of spread)

- **Applied research,** to inform strategies for management of the threats they pose (e.g. identification of potential vectors; assessment of impacts and management implications for different sectors; understanding trade practices)

- **Technological development** of innovations to enhance preventive measures (e.g. novel diagnostics for symptomless infections; "sentinel plants"; improved nursery design and operation; new monitoring strategies)'[98].

The bid document states that the portfolio would be actively managed to promote knowledge exchange between the separate projects and with stakeholders. Furthermore, to exploit opportunities for synergy and ensure relevance to user need, a programme coordination team would be employed to facilitate this knowledge exchange and dissemination.

E.2.2 Programme origins and idea development

Bacterial diseases threaten food production and tree health and yet very little is known about how they interact with plants, how to manage the threat they pose and how to identify bacteria on plants that appear symptomless. In the UK, such diseases endanger essential food crops such as potatoes, carrots and soft fruits, as well as trees and wild plants. Devastating bacterial pathogens have not, as yet, reached the UK but could cause significant economic and environmental damage if they do. An example of this is the pathogen Xylella fastidiosa that can be transmitted by sap-feeding insects and has caused devastation to olive groves in Puglia[99]. This threat — along with a related concern about loss of a critical skill base across UK science in the field of bacterial plant pathology — has driven the development of the Bacterial Plant Diseases programme.

Bacterial plant diseases, as a concern, was raised at a BBSRC strategic panel. The author of the eventual SPF programme bid from BBSRC was also following the spread of Xylella across Europe and noted it as a particular concern. They contacted colleagues at DEFRA and the Scottish Government and established their interest and subsequent involvement in the bid.

---

[97] See: https://www.ukri.org/our-work/our-main-funds/strategic-priorities-fund/

[98] The bid document

[99] See: https://www.ukri.org/our-work/iyph2020/bacterial-diseases-threatening-food-production-and-tree-health/

Both of the government partners were aware of the threat from bacterial plant diseases and noted the particular policy relevance. NERC was also contacted to confirm their involvement (BBSRC and NERC have a historical working relationship on areas of joint interest). The bid was then led by BBSRC with significant input in terms of policy requirements from DEFRA and the Scottish Government, plus some input from NERC regarding objectives relating to tree health.

The significance of the threat posed from bacterial plant diseases was strengthened by evidence from the cross-Departmental UK Science Partnership for Animal and Plant Health, which brings together UKRI with Defra, the devolved governments, the Forestry Commission and others. Concerns about implications for tree health were also set out in Defra's Tree Health Resilience Strategy (published on 25 May 2018) and were shared by Forestry Commission England, the Northern Ireland Forestry Service, Forestry Commission Scotland and Natural Resources Wales. There was also close alignment between this programme idea and the UK's internationally respected Plant Health Risk Register (PHRR), with the programme aiming to reduce risks associated with some of PHRR's highest ranked threats. Additionally, the bid was informed by the UK Science Partnership for Animal and Plant Health's consideration of the threat from *Xylella*. It also built on the successful multi-agency, multidisciplinary Tree Health and Plant Biosecurity Initiative, led by BBSRC and funded jointly with Defra, ESRC, the Forestry Commission, NERC and the Scottish Government.

All four partners had previously worked together on at least two successful projects and the relationships and methods of working together were quite well established by the time of the SPF bid. Similar working strategies as in previous projects were employed from the bid stage to the implementation of the programme.

The depth and breadth of the threat posed by bacterial plant pathogens and the lack of knowledge about them was felt by all of the partners to be too large for any individual funder to make significant progress in knowledge. The SPF provided the opportunity for all of the partners to be actively involved in a programme that was on a much larger scale, with the potential for greater complexity of science and scope than any of the partners would have been able to fund from their individual budgets.

The fund also allowed a common pot of money across the research councils and with some financial input from Government departments, which meant that there was less competition for the funds and allowed a shared focus of the programme and opportunity to have input to some areas of the programme or greater input to all aspects and interest, which meant the focus of the programme was led by the priority rather than territory.

The Government partners in particular noted that the programme would significantly impact on the development of policy to manage bacterial plant diseases. The size and scope of the programme was felt to provide a much stronger evidence base for developing policy.

The fund objectives provided a clear emphasis for the programme to embed a MIDRI perspective, to ensure that UKRI investment linked up effectively with government research priorities and that strategic priorities were addressed. The involvement of Government partners was not a new feature resulting from the SPF, but the Fund encouraged greater ongoing involvement and a more forensic understanding of the government research and innovation priorities. It was reported that as a result of changes to funding over the past 10 years, the opportunity for research into UK plant issues has been relatively limited until SPF.

None of the current partners consulted was directly involved at the bid stage (e.g. the programme lead for BBSRC only became involved once the funding was secured). However, they were aware of some elements of the process that had proved challenging. In particular, those consulted highlighted the short timescale to organise and write the bid and the tightly

defined spend requirements, which restricted what was achievable. It was commented that, had there been longer, the whole programme might have looked very different and would likely have involved capacity building and an open call for Phase 1, with the Xylella pathogen as one of a number of issues explored rather than the main focus. The bidding documentation was also felt to be geared more to towards a major programme, rather than a collection of research grants under the umbrella of a programme.

E.2.3   Programme design and activities

The programme is designed to address the identified priority across two linked phases:

- **Phase 1 of the programme** was designed as a 'fast track commissioning exercise' where the John Innes Centre (JIC) led the bid for, and were subsequently awarded funding of £5m for a 'body of integrated multidisciplinary work on *Xylella fastidiosa* by the BRIGIT consortium of institutions'(although focussed on Xylella, it was expected that this activity would also lead to insights and innovations with potential for wider application to other diseases)'[100] This first phase was modelled on BBSRC's and Defra's similar rapid response to ash dieback disease in 2012/13 through the JIC-led *Nornex* consortium.

    Although the JIC was directly approached to put a proposal in, BBSRC carried out their usual rigorous peer reviewed process, with six academics invited to review the proposal. The BRIGIT consortium is considered to be a truly multidisciplinary activity with 12 organisations engaging in activities across entomology, plant pathology, ecology, epidemiology, genomics, molecular biology and social sciences.

- **Phase 2 of the programme** was designed to build on Phase 1 and involved an open call with a fund total of £13 million and with individual projects costed not higher than £2.5 million. The call asked for 'multidisciplinary studies of the biology and epidemiology of a range of bacterial pathogens, and their interactions with host plants, invertebrate vectors and the wider environment. It covered all types of bacterial pathogens that affect or threaten cultivated or other plants (including trees) of commercial, environmental, social or cultural significance and value in the UK.'[101]

Given the limited time scales available for Phase 2, the programme partners decided that instead of insisting that all projects funded in Phase 2 have a multidisciplinary element, the phase 2 programme call as a whole would contain all of the relevant disciplines and would provide multi-disciplinarity across the separate projects.

The nine projects that were commissioned across the two phases are listed in the box below.

- BRIGIT (Phase 1): Surveillance and response capacity for Xylella fastidiosa.
- CALIBER: Benign infections or damaging epidemics: the influence of biology, the environment and agricultural practice on vector-borne phytobacteria
- PSEUDOMONAS-PRUNUS: Predicting the emergence of host adapted plant pathogens: Pseudomonas-Prunus system
- DISEASE SUPPRESSIVE MICROBES: Harnessing and integrating disease suppressive microbes and synthetic soils for sustainable, low input horticulture
- RALSTONIA PHAGE CONTROL: Using phages as a precision tool to control pathogen abundance and virulence in the plant rhizosphere microbiome

---

[100] Bidding template for strategic Priorities Fund (SPF) Wave 1

[101] See: https://webarchive.nationalarchives.gov.uk/20200930163429/https://bbsrc.ukri.org/funding/filter/2019-understanding-and-countering-bacterial-plant-diseases/

- BAC-STOP: BAC-STOP: Advancement of control and knowledge to save threatened oak and protect them for future generations
- XANTHOMONAS THREATS: Xanthomonas plant diseases: mitigating existing, emerging and future threats to UK agriculture
- FUTURE OAK: Future Oak: Characterising and engineering the oak microbiome to future-proof an arboreal icon
- BLACKLEG (DES-BL): Building a decision support tool for potato blackleg disease

The Programme also put out an open call for a **Programme Coordination Team** and selected a group directed by Forest Research. The main role of this team is to coordinate the integration of knowledge and knowledge synthesis between the grant holders and ensure that knowledge dissemination would be available and relevant for identified key users and stakeholders.

Multi and inter-disciplinarity was considered throughout the programme bidding process and embedded in the subsequent implementation. In the early stages, the partners gave great consideration to which disciplines were required to address the issue and recognised that as well as plant pathology, environmental science, engineering and social sciences would need to be involved. The role of the Project Coordination Team is to facilitate the synthesis of this.

The roles of the different partners are set out below along two main groups:

- <u>Programme Management Group</u>. BBSRC lead the programme, while partners from DEFRA, the Scottish Government and NERC sit on the Programme Management Group (PMG). The role of this group is to oversee the strategic aspects of the programme, but it also serves to provide information (including research findings and policy relevant evidence) that can be fed back to their respective organisations. Both government partners noted that a valuable additional dimension of being part of the Programme and on the PMG is the opportunity to discuss ideas and identify gaps for further work, as well as to explore what other work each of the partners are involved with. This has resulted in new funded work between some of the partners and it was commented that it helps everyone to see the bigger picture.

- <u>Advisory group:</u> An advisory group was also recently convened to provide scientific guidance and act as a sounding board for the programme. The Advisory group had only met once at the time of writing but it has already provided useful questions for the programme to consider relating to stakeholder engagement. In the early stages of the programme, there were proposed to be two advisory groups, one that advised the programme as a whole and one that advised the Programme Coordination group. However, it was quickly recognised that two advisory groups could provide conflicting advice and it was decided that only one should be convened to advise both.

E.2.4   Programme outputs and uptake

The global pandemic has had a significant and particular impact on the work of the grant holders of this programme and the coordination team (see box below). Delays in e.g. fieldwork have meant that there have been limited outputs from projects to date.

- COVID has had (and is still having) an impact across the programme in terms of people's time and capacity (caring responsibilities, home schooling and direct involvement in COVID work)
- There have been challenges with the recruitment of staff for projects. Over the past 10 -20 years there has been a focus on fungal disease for plants and trees in the UK resulting in a bacterial disease skills deficit. Staff are being employed from overseas to fill this gap but COVID has had a significant impact on recruitment activities, as well as subsequent employment (e.g. due to travel bans)

- Grant holders conducting fieldwork faced significant delays as a result of the lockdowns. The fieldwork is seasonal which meant that if one season of fieldwork is missed researchers have to wait another year before they can try again
- Lab work was delayed because some staff were on furlough. Lockdown also meant that staff were unable to work in the labs and when lockdown eventually eased there were strict social distancing rules, which meant that according to one participant the number of staff able to work at any one time was reduced to 25-30% capacity
- The projects faced (and still face) further delays in ordering and receiving lab equipment, chemicals and plant materials. An example was given of chemicals and equipment like syringes being redirected for Covid-related activities. Protective lab wear is delayed and an order originally placed in January 2021 will not be delivered until November 2021
- Some of the participants reported that a number of the activities at programme level have not occurred or had to occur very differently because of the pandemic. Face to face meetings have been prohibited and, although online meetings have been convened, the essence of the interaction is different and less conducive to networking. This has impacted on the PMG, Advisory group, and the Programme Coordination Group
- The Programme Coordination team were also unable to work in the way they might have. For example, there was a stakeholder engagement event planned which was unable to go ahead and there is no equivalent to face to face and networking. Online meetings have been held but it makes it very difficult to engage new stakeholders
- The programme held an online grant holder meeting to encourage a sharing of ideas and an early careers researcher meeting but the scope and breadth of the experience was not as successful as if it was held face to face

The role of the Programme Coordination team is to ensure that each of the nine projects are integrated with regard their stakeholder interactions and in the management and accessibility of their outputs. There are seven people involved in the team, and they come from different disciplines. For example:

- One of the members is from a social science background and another has a background in law. Together they are involved in stakeholder engagement and impact generation. They work across the projects to identify if there are any stakeholder synergies, as well as to ensure that the stakeholders will not be over contacted. Their role also includes providing advice on how to write impact plans and generate impact.
- There are then two bacteriologists whose role is to work on the scientific integration. They work with the different projects to understand where research methods, data or resources can be shared. Their role also involves determining how the projects are progressing.
- Two of the team works on event coordination and communication. They have set up a Programme website and twitter feed, where updates and information on the programme, events and outputs are shared. They are also involved in the organisation of workshops.

Programme Coordination team activities include:
- Regular meetings and discussions with the project teams.
- An online workshop on data management for the junior researchers.
- An online stakeholder workshop to look at stakeholder needs and how to translate research into practise.
- The development of a two-minute animation on the website, explaining the programme.
- An online Stakeholder meeting (planned) with speakers from different sectors of industry reporting on the problems they face as a result of bacterial diseases. This event was also intended to find ways to continue an effective dialogue with stakeholders to ensure that

the research addressed the issues directly faced by industry because the diseases could have an enormous economic impact.

- A 'Xylella week' (in Phase 1 via Brigit) where they reached out to a range of different stakeholders to publicise the outcomes of the research.

- A mid-term Hub event (planned). This was due to be held around now, but it has been delayed due to delays in fieldwork brought about by COVID. This event will be a dissemination and synthesis activity across the projects and will now be held in 2022.

- A genomics and comparative genomics working group, which has been set up at the request of academics working on the projects because genomics features across many of the projects and it was felt that the methodological and other issues involved would be better solved with a group of people working together.

The individual projects also have funds for knowledge synthesis and dissemination activities.

E.2.5   Programme outcomes and impact

E.2.5.1   R&I to address priorities

Given the delays to projects and programme outputs, there is little to report at this stage on the outcomes and impacts of the research work in terms of addressing the original priorities. However, stakeholders were invited to provide comment on progress and direction of travel.

All of the partners were very positive about their involvement in the programme and felt that they have gained and would continue to gain a great deal. There was general agreement across the partners that the structure and design of the programme with respect to the PMG, the Advisory Group and the Programme Coordination Team, as well as benefits gained from the interaction between the partners, was a key facilitator to the success. Furthermore, the Government partners reported that this Programme had provided greater opportunity to input policy needs and would use (or are using) this model of working together in the future because the 'joined up' approach works. An example of a project that has replicated this approach is the 'Future of UK Treescapes'[102] project, which is a NERC funded project with DEFRA as a partner.

All of the partners noted that the introduction of the Project Coordination Team added an extra dimension to the programme and the potential output. The linking across the projects to avoid duplication of effort and increase multi and interdisciplinarity, as well as to increase awareness and understanding of each other's work and ideas was felt by the partners to be potentially very beneficial. There was a sense that the whole was bigger than the sum of the individual parts. All of the partners commented that the Project Coordination team were already very proactive and producing some very useful guidance and information for the projects, partners and stakeholders.

The Government partners noted that the structure of the programme with the PMG helps to make filtering information, particularly policy relevant information, back through their organisation much easier. One of the Government Partners noted that the chance to input their evidence needs at the beginning of the project and follow it through to the conclusion was also a great benefit. There was the sense that the size and scope of the programme and the interaction with new or different research providers also added value, as it introduced them to new ideas and new ways of thinking and working that could be capitalised on in future work.

---

[102] https://nerc.ukri.org/research/funded/programmes/future-of-uk-treescapes/

Research Council participants noted that the additional input from the government partners into the bid decisions in terms of whether it was of high, medium or low policy relevance to their organisation was new and worked well and will be used again in future projects (and is currently in the NERC led Treescapes project).

Inputs from the stakeholders consulted suggest that the relationships between the partners (Councils and Government) have already strengthened as a result of the programme and there is a greater understanding of each other's requirements (even though the ways of working are similar to previous occasions where they have worked together).

An additional role for the Government partners was also introduced into this programme. As part of the bid assessment process, Government Partners reviewed the bids and assigned each of them a score in terms of strategic relevance. All of the partners reported that this input was very helpful and has been used in subsequent collaborations. The programme partners agreed that only bids with High or Medium policy relevance scores would be funded.

All of the partners also agreed that there has been a greater sharing of research and innovation understanding and policy relevance in this programme, which has directly impacted the Programme's delivery. This has also led to a greater understanding of the research efforts and the relevance of the evidence. This has largely been through the Programme Management Group meetings.

E.2.6   Conclusions

The Strategic Priority Fund has enabled a multidisciplinary focus on bacterial plant disease which is an identified gap in knowledge. Bacterial Plant diseases, including Xylella are a significant threat to food supply, and the programme is focussed on advancing knowledge and developing effective strategies to manage the threats, which will then help to safeguard UK industries and environments.

The structure of Programme has successfully enabled the sharing and understanding of priorities between Government Departments and Councils. This has strengthened and consolidated existing relationships, which will likely reap further benefits in the future. The establishment of a Project Coordination Team, dedicated to coordinating multi and interdisciplinary working across the projects as well as stakeholder engagement, will also help with knowledge synthesis and dissemination as the programme progresses.

The Programme has experienced significant complications and delays, however, as a result of Covid-19, and so there is limited insight at this stage into the progress of the programme in addressing the originally identified priorities and challenges.

E.2.7   Interviewees

Interviews were conducted with programme partners and stakeholders during April / May 2021.

- Programme Lead, BBSRC
- Research Council Partner, NERC
- Government Department Partners, DEFRA
- Devolved Government Partner, Scottish Government
- Project Coordination Team Director, Forest Research
- Project Coordination team and P.I., University

E.3   National Timing Centre

E.3.1   Introduction and context

The National Timing Centre (NTC), which sits within the National Physical Laboratory (NPL) was funded under the second wave of SPF. Its overall budget is £30.3m and the centre commenced operations in July 2019 (a few months later than intended).[103] NTC is a five-year programme.

NTC's key government stakeholder departments are the MoD (through the Defence Science and Technology Laboratory (DSTL) and StratCom), BEIS and the Department of Transport (DfT). However, there are a number of other partners also currently involved:

• Department Digital, Culture, Media and Sport, DCMS (Chief Scientific Advisor)	• Financial Conduct Authority
• Government Communications Headquarters, GCHQ	• The London Stock Exchange
	• Ofcom
• Scottish Government (CSA)	• Royal Institute of Navigation
• Department for International Trade (CSA)	• UK Space Agency
• The BBC	• NATS
• Arqiva (UK telecoms company)	• Rebellion Defence
• JISC	• Universities of Birmingham, Oxford and York
• RAL Space (part of the Science and Technology Facilities Council, STFC)	• The 5G Innovation Centre (5GIC)
• BT	

NTC aims to develop a secure infrastructure of time distribution at dispersed locations across the country. As such, it will enable the UK to become one of the first countries to develop a resilient time and frequency distribution network that does not rely on satellites for a reliable time source - whilst also supporting UK companies to innovate and develop skills in this field.

Note: the major national security aspect to NTC means that many key aspects of the centre's aims and activities are security classified and are not covered in this public domain case study.

The programme has three objectives:

- **Objective 1:** Deliver a resilient UK national time infrastructure through the building and linking of a new atomic clock network distributed geographically in secure locations

- **Objective 2:** Provide innovation opportunities for UK companies through funding projects in partnership with Innovate UK based on a successful NPL and Innovate UK partnership model

- **Objective 3:** Respond to the specialist skills shortage in time and synchronisation solutions through specialist, apprentice and post graduate training opportunities

A world-first, the NTC will provide additional resilience to public services and the economy against the potential impact of satellite systems failure. The centre will aim to provide accurate time to 999 responders and the energy grid without relying on satellite technologies (alongside providing accurate time to the Ministry of Defence and Front Line Commands) – which can potentially fail with major consequences for accurate timing in a modern industrial economy. The United States is now acting to emulate this type of whole-of-government approach.

---

[103] Work began in April 2019, although the contact for the programme was not signed until December 2019. Therefore up until December 2019 NPL were working at risk, which presented a barrier to working to the intended timeline.

NTC involves a team of researchers, based at sites across the UK, who are working together to make UK public services and the economy less reliant on satellites through a network of atomic clocks (i.e. clocks that use atoms and surrounding electrons to keep track of time). These clocks will be housed at four secure locations around the UK.

E.3.2   *Programme origins and idea development*

Modern industrial economies rely on very precise Position, Navigation and Timing (PNT) technologies. Aircraft, ships and (increasingly) road vehicles require very accurate position and navigation data access. Financial transactions require extremely accurate 'date stamps' for validation and fraud monitoring and auditing – not least because automated flash trading (in particular) relies on exploiting extremely fast buy or sell opportunities. Similarly, the national grid and electricity markets now rely on *phasor measurement units*, electronic devices that measure voltage and current thousands of times per second in order to optimise generation and transmission systems. Any degradation in the accuracy of phasor measurement due to a breakdown in timing synchronisation can lead to cascading problems that, if left unstopped, can create electricity blackouts as the system of closely coupled electricity supply and demand flux management breaks down. Similar issues exist in telecommunications systems. In short, a large part of a modern industrial economy (and national security) relies on PNT capability. This creates 'upside' opportunities for developing new markets, technologies and supply chains, but also 'downside' risks if PNT systems fail – or are attacked by adversaries. One estimate puts the reliance on PNT at around 11% of GDP[104] and likely to increase in the future.

Consequently, PNT capability has become part of our critical national infrastructure. This exposes the economy to threats linked to the denial of PNT services, whilst also creating new opportunities for business-driven innovation within the PNT system. Within PNT as a whole, *timing* (T) capability is viewed as having been neglected relative to position (P) and navigation (N) capabilities. This creates a challenge because each element of PNT is inter-dependent and cannot function effectively if there are pervasive faults – especially in precise timing.

In response to these concerns, the 2018 National Security Capability Review concluded that we are in a period of increased complexity and risk. The challenges identified in the previous 2015 National Security Strategy had grown faster than anticipated, and therefore the need for greater resilience had become a major policy concern in Whitehall. The risks faced were judged to be profound - with many important sectors demonstrating a critical dependence on PNT services for many of their operations. The National Risk Register reflected these concerns and the Cabinet Office started to take an active interest in PNT issues. The Blackett Review on satellite dependency reinforced these concerns, as did economic estimates of the potential impact on the City of London's activities should access to precise timing be unavailable (estimated at £1bn per day in losses)[105].

In response to these challenge and opportunities, NTC provides additional resilience for the country's reliance on accurate timing. High-precision timing is currently provided by satellite technologies, and underpins many everyday technologies, including: emergency response systems, 4G/5G mobile networks, communication and broadcast systems, transport, the stock exchange, and the electricity grid.

---

[104] Winning Moves (2017) *The National Measurement System: Customer Needs and Impact Survey*. Cited in NPL (2020) *The Economic Impact of the National Timing Centre on Collaborating Companies*. NPL Report IEA 2, Feb.

[105] London Economics (2017) *Economic impact to the UK of a disruption to GNSS*. April.

All these systems depend on precision timing from Global Navigation Satellite Systems (GNSS). Satellite-based timing from GPS and similar systems is the most common source. Consequently, if there were to be a large-scale GPS failure, for instance caused by a major solar flare or deliberate disruption by hostile actors (state and potentially non-state), the economic impact to the UK would be substantial. Also, the loss of accurate timing data would have severe and life-threatening effects, such as on getting ambulances to patients.

Therefore, additional land-based technologies to complement and backup satellite-based systems improves the UK's resilience to potentially damaging disruptions/shocks, and provides important back-up capability. As Science Minister Amanda Solloway has noted:

> *"Our economy relies on satellites for accurate timing. Without satellites sending us timing signals, everything from the clocks and maps on our phones, to our emergency services and energy grid would be at risk. I'm delighted that this world-first centre will see our brightest minds… working together to reduce the risks from satellite failure."*

The NTC is the latest expression of NPL's world-leading contribution to ultra-precise timekeeping. The laboratory developed the first accurate caesium-based atomic clock in 1955 (the very first atomic clock was developed in the USA in 1948), which led to the first internationally agreed definition of the 'second' as a unit of time.

As noted above, the original idea for the NTC stemmed from concerns over national security risks posed by a reliance on (easily) disruptable satellite-based time signals, and as a result, NTC has a nationally important classified component than cannot be covered in this case study. This national security impetus appears to have been crucial to making NTC happen, and thus forming a basis for broader business innovation objectives to be addressed. SPF provided a suitable funding mechanism for this strategically important national initiative and the MIDRI dimension to SPF aligned well with the pervasive (and growing) role of PNT in the UK economy – a role that potentially involves a range of technologies and disciplinary inputs.

One important consideration in NTC is that the UK currently does not have a domestic industrial base and supply chain in cutting-edge timing technologies. Advanced equipment must be imported, so this further exacerbates national security concerns and has simulated an interest in catalysing the growth of the domestic advanced timing equipment business ecosystem.

E.3.3   Programme design and activities

The programme design directly reflected the national security concerns noted above. In this sense, the NTC interventional rationale was directly driven by a growing concern that the UK economy is vulnerable to significant disruption by antagonists, including serious organised crime – as well as solar flares that would disrupt satellite time source assets. Given its well-established role as the UK's metrology (generic measurement) laboratory, NPL is the natural choice for delivering a response to these timing access-based national security concerns.

As regards specific activities of the centre:

- NTC are developing and characterising a new generation of optical atomic clocks which are based on laser-cooled trapped ions and atoms. Although improvements to the stability and accuracy of these clocks are ongoing, they already surpass the performance of existing caesium primary standards.

- NTC also participates in European collaborations to verify the international consistency of the new clocks. This work is expected to lead to a redefinition of the SI unit of time, the second. Optical atomic clocks have the potential to improve satellite navigation systems and measurements of the Earth's gravity potential, as well as test fundamental physical theories.

- NTC is developing compact and user-friendly frequency standards for applications in navigation, high-speed communications, security and defence.

- In addition, the centre is applying the techniques that underpin atomic clocks to develop new quantum sensors such as atomic magnetometers and inertial sensors. NTC research in this area interfaces with the work and remit of the NPL Quantum Metrology Institute.

- One of the key objectives of the NTC programme is focused on responding to the specialist skills shortage in time, frequency and/or synchronisation (TFS). As a starting point, NTC have carried out a skills assessment, which aimed to better understand the composition of the current TFS workforce, the availability of TFS skills across topics and proficiency levels, and the requirements for future skills and training. As part of this skills assessment, a survey was shared with NTC programme stakeholders and individuals who had previously expressed an interest in NPL's work or the NTC programme. The findings and recommendations of the assessment are now being analysed in more detail and are being incorporated into the NTC Training & Education Blueprint.

- More generally, NPL operates the national time scale UTC(NPL) and the UK primary frequency standards, and uses these to contribute to global timekeeping synchronisation. The laboratory also disseminates accurate time and frequency to users across the UK, via services such as the MSF radio time signal, our internet time service, and NPLTime®. NTC supports these established national contributions.

- Additionally, the NPL (through the NTC) have been developing training materials and delivering learning events. These include both online webinars and more formal learning materials to be worked through at a slower pace. These are targeted at the workforce in the UK which are dependent on time and navigation (see above for industries, but also includes engineers etc.).

- Finally, the NTC has also involved developing an innovation grant funding competition (working with InnovateUK) to fund technologies which can utilise the enhancements in the resilience, frequency and synchronisation of time. The competition was launched on 19 April 2021. The activities have so far involved developing the specification for the competition and advertising the grant funding to interested parties. The competition itself is aimed at funding a range of feasibility assessment projects.

As regards governance, the Steering Committee members are currently as follows.

JANet/JISC	Scottish Govt.
DSTL & MoD	BT
FCA	GCHQ
BEIS Chief Scientific Advisor (CSA)	UK Strat Com
NCSC	STFC
Oxford University	Rebellion Defence
DIT Chief Scientific Advisor (CSA)	DCMS Chief Scientific Advisor (CSA)
IBM	Ofcom
London Stock Exchange	Royal Institute of Navigation
UKSA	NATS

E.3.4   Programme outputs and uptake

At this point there is limited evidence on programme outputs and uptake. This is because:

- The NTC has not completed the development work on the atomic clock, and the progress it has made so far cannot be shared (due to national security restrictions).

- The innovation competition has not yet closed, therefore there have been no awards of funding or innovation activity undertaken by companies in the UK as a result of the

programme. However, the competition scope has been agreed and is available through the InnovateUK website.

- A small number of the learning materials have been developed, and some of the online learning sessions have been delivered. However, these have been relatively small in number (there is no Management Information which indicates how many activities have been delivered or how many individuals have attended).

The interviewees involved in the programme did suggest that there had been some knowledge generation outputs from the activities involved in the development of the new clocks, however this was still at a relatively early stage (just over a year into a five-year programme).

E.3.5   Programme outcomes and impact

E.3.5.1   R&I to address priorities

At this point evidence is not available on programme outcomes and impacts to address priorities. Again, this is because the InnovateUK competition has only recently been launched and is still open, therefore no additional innovation activity (outside that to develop the clocks) has taken place, and national security considerations mean that there is no evidence of outcomes achieved with the development of the clocks.[106]

E.3.5.2   Intersectoral collaboration

The organisations and individuals involved in the NTC programme are from multiple organisations. However, these organisations were known to each other, with many working together on the existing PNT working group. At this stage there is no evidence of new relationships and working arrangements outside the 'Business As Usual' context.

However, most of the individuals working together were also of the same discipline (the same type of job roles focusing on the same areas – timing and navigation – but for different organisations). As such, there is limited evidence of multi-disciplinary working.

Despite this, the interviewees still felt that in the absence of the SPF support, this type of research would not have proceeded at the time or pace that it has. This means that without this SPF support the UK's risk exposure to PNT services disruption, and the economic and national security consequences, would be greater than it currently is.

E.3.6   Conclusions

At this early stage in NTC development there is a clear case to support the proposition that SPF provided a suitable funding mechanism for addressing a nationally important strategic concern. Given the broad-ranging nature of NPT capability in general, and the specific challenge of creating an ultra-precise timing infrastructure not reliant on GNSS, SPF provided a means of acting (relatively) quickly to address potential threats (the 'downside' aspect)– whilst also helping to put in place a programme to support new innovation-based activities by UK firms in timing-related technologies (the 'upside' aspect).

Above all else, this NTC case study highlights the importance of UKRI's ability to address national security threats that require a generic science and innovation response that goes beyond the direct MoD/DSTL remit. The existence of SPF provided a suitable funding mechanism in this

---

[106] DSTL are undertaking a complementary research and development project, involving some of the same technology as being developed through the NTC. This has a value of £5 million – but it is not considered the same project as the NTC. So this could be considered additional R&I outcomes, but DSTL always planned to do this work.

context, and it is therefore likely to be in the national interest for UKRI to maintain this functionality over the long-term – perhaps via a ring-fenced national security science and innovation programme. In order to maximise national research and innovation responsiveness to future threats, and response lead times in particular, it may be preferable to have access to a funding mechanism with an explicit national security science and innovation remit rather than rely on more general and less security-focussed funding mechanisms.

E.3.7   Interviewees

Interviews were conducted with programme partners and stakeholders during April / May 2021.

- Programme leads, NPL
- Partner Council, IUK
- Partner Government Department, MoD
- Programme Director, NPL

E.4 Space Weather, Innovation, Measurement, Modelling and Risk programme (SWIMMR)

E.4.1 Introduction and context

The Space Weather, Innovation, Measurement, Modelling and Risk (SWIMMR) programme was funded under the second wave of SPF. The £20m programme was launched in April 2019 and will run for four years. It is led by the Science and Technology Facilities Council (STFC) in partnership with the Natural Environment Research Council (NERC) and the UK Met Office. Other partners are Surrey Space Centre (SSC) at the University of Surrey and Surrey Satellite Technology Limited. SWIMMR also involves collaboration with and across government departments, including the Department for Business, Energy and Industrial Strategy (BEIS), the Department for Transport (DfT) and the Ministry of Defence (MoD).

The programme aims to provide a strategic UK approach to Space Weather, enabling the Met Office to better predict space weather events and reduce their threat to economic and social activities. It will do so by meeting two objectives:

- Improving capacity to predict severe weather events
- Supporting the translation of the UK's pioneering research into practical solutions that will protect against adverse disruptions caused by cosmic chaos

The programme will facilitate the development and deployment of new products, processes and services through a series of activities managed by either STFC or NERC. The UK Met Office is providing in-kind support at the proposal stage and throughout project delivery to ensure the successful translation of research into its operational models and forecasts.

To date, the programme has delivered one funding call that focused on research into space hardware and satellites to address problems caused by space radiation, which presents significant risks to critically important UK infrastructure (e.g. communication systems used in aircrafts and power grids). It is also funding research to address space weather effects at lower altitudes, such as radiation effects on aviation, and on the Earth's surface, such as Geomagnetically Induced Currents (GICs) in power grids. The second call was expected to run in September 2020 but was delayed by the COVID-19 pandemic.

The Government was motivated to invest in this area of research because of the UK's increasing reliance on space-based systems for communications and time-keeping and its ambition to become a global leader in the development and commercialisation of space assets.

E.4.2 Programme origins and idea development

Space Weather describes solar eruptions that have the capacity to disrupt vital technologies (e.g. satellite communications, radio communications power networks) and infrastructure (e.g. corrosion of oil and gas pipelines). Space weather events — both large, sudden events and day-to-day variations — can have substantial impacts on aviation, satellites, radio systems and electricity networks, threating critical national infrastructures affecting business, defence, transport and health. At present, there are considerable gaps in the UK's ability to forecast and conduct effective space weather risk assessments, leaving the UK economically and socially vulnerable.

There are four key reasons why public sector investment is required for research into space weather:

- Existing international collaborations on space weather do not currently fund research and cannot be used to replace national funding for UK focussed forecasts.

- After its exit from the European Union, the UK no longer has access to EU data, including radiation data from Galileo in the Public Regulation Service (RPS) data stream.

- The Met Office is increasingly dependent on data and models from the US Space Weather programme that are not optimised to UK needs or geographic location.

- Present Met Office forecasting services are not accurate enough or do not meet user needs, leading to false alarms and costly mitigation.

When realised in the correct way, the benefits will manifest in both the governmental and commercial sectors. The establishment of a world-leading capability for space weather forecasting and mitigation will not only safeguard our considerable national investment in space-based infrastructure (now part of the Critical National Infrastructure, CNI), but also confirm the UK's reputation as an international leader, with potential to collaborate with key partners internationally.

Consultations with relevant stakeholders provided insights into the processes involved in developing the programme proposal and how the different parties involved in SWIMMR have worked together.

- **Research Council input**: the programme proposal was originally set out in a brief document prepared by STFC in response to an internal request for "priority project" ideas. The internal request was not specifically geared to the SPF opportunity, but rather to gather a variety of ideas and match these against specific opportunities. The initial proposal contained ideas that had been discussed with the Met Office space weather team, with whom STFC already had a close relationship. NERC became involved in the SWIMMR proposal as the initial idea was being developed. It was included in the collaboration because of its existing working relationship with STFC and because the space weather topic spans the remit of NERC and STFC. In this context, NERC's involvement was considered to be indispensable and proved to be a very important source of policy and scientific advice. Two other research councils (ESRC and EPSRC) were approached to see if they were interested to support this proposal, but the contacts was made too late and at the wrong level, so they did not participate in the SWIMMR call. It also emerged that both bodies were already fully committed to other SPF applications.

- **Met Office, the main beneficiary**: The Met Office was heavily involved in the drafting of the original SWIMMR proposal in light of its existing relationship with STFC, but also because it was identified as the main beneficiary of the SWIMMR outputs. Since 2014, the Met Office operates the Space Weather Operations Centre (MOSWOC), which lacked some substantial space weather forecasting capabilities, hence the eleven research projects funded under the SPF-SWIMMR are aimed at enhancing the MOSWOC forecasting capabilities.

- **Government department support**: governmental support was sought once the SWIMMR business case was advanced. BEIS' support was secured through existing linkages to the BEIS space weather team[107]. Existing contacts with the space weather group at DSTL facilitated links to the MoD, while contacts with DfT came mainly through Met Office and BEIS.

Consultees reported that working collaboratively across different councils (STFC and NERC due to shared competencies) or government departments was not a new practice, and all were used to this. However, it was noted that the SPF call promoted coordinated communication

---

[107] That provided a good overview of BEIS space weather policy priorities

among different participants: *"Usually there would have been bilateral conversations with partners, this time there were coordinated and multilateral conversations among all"*. In addition, SWIMMR funding (to projects) was awarded with enhanced processes: grant proposals have been assessed by dedicated review panels whose expertise is purely in space weather rather than the type of review panel used for standard grants - in which not every panel member would necessarily have specialist expertise in the area of the grant concerned.

E.4.3   Programme design and activities

Space weather is a topic that spans many different scientific fields under the remit of both STFC and NERC. This characteristic necessitates that space weather research projects are multi and inter disciplinary.

The programme will be delivered through a series of open calls for research projects managed by either STFC or NERC as appropriate. To ensure inputs are evenly distributed between the two councils, SFTC and NERC have split the budget equally and six research projects will be delivered though STFC grants while the remaining five will be delivered via NERC. Projects will be completed over four years (2019-2023).

The six projects delivered through STFC, for a total of £9.35 million, are as follows. Projects S1 to S3 will be mainly executed by STFC's own staff and with the support of the Met Office and universities[108]:

Project	Budget
S1: In-situ radiation measurements for space and aviation	£5.7m
S2: Support for technology testing and modelling	£0.6m
S3: Support for the transition from research to operations	£0.9m
S4: Forecasting from the Sun to L1[109]	£0.45m
S5: Support for a ground radiation monitoring network	£1.4m
S6: Production of an updated space weather impact study	£0.3m

NERC's first call for projects was launched at the end of 2019 for a total value of £8.7 million. A second call was pre-announced at the beginning of September 2020, however, due to the pandemic the call for proposals was postponed. The five topic areas where proposals are being sought are:

Project	Budget
N1 Satellite risk forecasts	£2m
N2 Aviation risk forecasts	£2m
N3 Global Navigation Satellite System (GNSS) and HF aviation forecasts	£2m
N4 Ground effects forecasts	£1.7m
N5 Satellite drag forecasts	£1m

As the governance of SWIMMR encompasses a number of different bodies it is structured such that councils and government departments are working collaboratively to ensure that SWIMMR

---

[108] Universities are especially invited to bid for project S1, and the funding for this will be provided as a grant.

[109] L1 is defined as the Lagrange point, these are defined as points near two orbiting bodies. Normally, the two objects exert an unbalanced gravitational force at a point, altering the orbit of whatever is at that point.

projects are successfully delivered and link up effectively with government research priorities. In particular, the Programme Board is responsible for the programme's strategic direction and the delivery of its objectives. To this end it comprises representatives of: STFC, NERC, BEIS, DSTL, DfT and the UK Met Office. The activities of the Programme Board are supported by the Strategic Advisory Board, through the provision of technical and scientific advice. Its members are: Imperial College, Civil Aviation Authority, UK Met Office, Boston College, Airbus UK, Rolls Royce, National Grid and Defence Science and Technology Labs.

In terms of specific ways of working together, during the set up and the delivery of the scheme, one council representative reported that at this stage it is too early to conclude that SWIMMR has led to new ways of collaborating between different institutions. However, another interviewee recognised that the SPF programme had introduced a number of processes. For example:

- A programme risk register was introduced, aimed at assessing the overall programme risks[110] by looking at each project funded. The research projects are closely interlinked, so if one component is not a success then it would compromise the achievement of the overall programme's ambition. Hence the SWIMMR risk register has been conceived to monitor the overall programme risk, by assessing the level of risk associated with the single research projects. This register is one of the key documents looked for by government departments and in part informs policy development.

- A virtual peer review and panel assessment was introduced at the onset of Covid-19 to evaluate research proposal and it proved effective, as evidenced by the number of research proposals approved for funding.

- There is a recognised need for a rigorous monitoring and evaluation framework and programme partners are working to determine a robust way to measure the outcomes of the SWIMMR projects.

Representatives from government departments did not feel that the SPF funding had encouraged different or more collaborative ways of working with other institutions. Their general view was that public officers are used to working collaboratively with multiple organisations so the experience of working on SWIMMR did not bring changes from business as usual.

E.4.4   Programme outputs and uptake

No outputs have yet materialised yet from the SWIMMR projects.

Both the STFC and NERC calls for proposals were launched at the end of 2019, aiming to start work at the end of January 2020. Hence they have been commissioned quite recently. Although the flow of applications was deemed appropriate ("We did not get a huge number of responses, but we got the right responses"), the projects were subject to some delays and for this reason they have not yet produced the expected results, although they are reported to be on track to do so at the end of 2021.

The onset of the Covid-19 pandemic has also significantly delayed the laboratory activities associated to the SWIMMR project deployment. Consultees reported issues in hiring the right candidates to progress the projects as well as accessing laboratory facilities. To address this, the research councils asked for a formal project extension for an additional year. It was noted

---

[110] For example budget reprofiling, risks of losing key people/partners in a similar way, risks of programme not achieving its overall objectives

that without Covid-19 related disruptions, the projects would have been able to deliver the first results on time (i.e. by the end of 2020).

Finally, as of the 25th of February 2021, three of the STFC call for proposals[111] have been put on hold due to Covid-19, currently only one of these calls is s open for applications, while the others remain uncertain.

E.4.5 *Programme outcomes and impact*

E.4.5.1 R&I to address priorities

Similarly, the programme's outcomes and impacts are yet to be observed due to the early stage of projects. However, the stakeholder consultation confirmed that the research conducted under SWIMMR is expected to address important challenges related to the Met Office's forecasting capabilities. Research council representatives agreed that addressing such challenges was a key priority to prevent severe space weather events having significant repercussions on UK industries and infrastructure (e.g. energy, satellites, communications and aviation, as well as marine, road and rail transports)[112].

E.4.5.2 Intersectoral collaboration

Some insights emerged during the consultations in respect to the collaborative relationships established among the SWIMMR partners. In general, participants rated their experience of the programme positively.

Research council representatives and UK Met Office were satisfied with the way the programme was designed. They felt that they were able to shape the programme according to scientific needs, thus providing the country with relevant forecasting capabilities:

> *"It really did come more from the bottom-up than the top-down. It came from me and my colleagues as scientists, […] talking between ourselves and with the Met Office, saying, 'What would we really like to do?' And I think that was a strength, because, actually, it enabled us to be quite direct in what we were asking for […]".*

The UK Met Office, being the main beneficiary of the programme, underlines the important role of the different SWIMMR projects in translating scientific research into activities with practical implications for safeguarding UK essential infrastructures:

> *"What SPF does is bridging the gap between fundamental research being done and put it into operation, this is a fundamental gap."*

Government representatives, like other partners, recognised the importance of this strand of research and were pleased with how the programme was progressing. They welcomed the creation of the programme's risk register and stressed that it was a useful tool to assess risks in a straightforward manner (i.e. avoiding the scientific details not accessible to non-technical

---

[111] Specifically, S4 Forecasting from the Sun to L1, S5 Support for development of a ground radiation monitoring network and S6 Production of an updated space weather impact study. This information has been taken from the UKRI website: https://www.ukri.org/opportunity/space-weather-instrumentation-measurement-modelling-and-risk-swimmr/

[112] This list is available on the UK Met Office website: https://www.metoffice.gov.uk/weather/learn-about/space-weather/impacts

audiences) and to track the status of the programme and make sure it keeps on addressing relevant government priorities[113].

Partners also highlighted several barriers and challenges faced:

- Covid-19 added significant delays to the research activities during the first year, in part due to added uncertainty around funding (i.e. councils waited for confirmation that budgets could be carried over to subsequent years) and also due to recruitment challenges.

- The highly technical content of the research projects funded made it difficult to translate this research into clear information that could be used by government to make sure the programme was responding to strategic priorities. In this respect, a risk register described above, was created to remove this barrier (but it is unclear how this would be achieved)

- A potential future challenge is the lack of follow on funding after 2023. The view is that four years are not enough to complete the scientific work: "There should be a mechanism to keep funding these type of projects, [these projects] bring the research forward but the work is not completed in terms of the science."

E.4.6 Conclusions

SWIMMR aims to address important national challenges related to space weather events and their link with the functioning of UK energy, transports and infrastructure.

Consultees agreed that the fund has enabled the creation of a programme whose governance induced a greater collaboration across different institutions: "colleagues such as those who represent the government come onto our weekly programme catch up meetings, on the monthly programme board meetings, advisory and the equivalent, […] it has meant that there is much closer interaction between the research councils, and the policy people than probably would otherwise have been the case, which is just helpful."

Additionally the relatively large grant size allowed the Councils to finance more ambitious projects than would have been feasible under traditional research programmes: "[SPF] has given us a broader canvas to paint on and therefore it has allowed us to include some things that definitely do address priorities, but that we might not necessarily have included if the opportunity was smaller". Although, the first outputs will only be available at the end of 2021, SWIMMR appears to be on track to deliver on its immediate objectives (understanding that, as mentioned above, further advances in scientific knowledge in this area will require additional funding).

E.4.7 Interviewees

Interviews were conducted with programme partners and stakeholders during April / May 2021.

- Programme Lead, STFC
- Programme Lead, STFC
- Research Council Partner, NERC
- PSRE Partner, Met Office
- Government Partner, BEIS
- Government Partner, BEIS

---

[113] In this instance, government representative, stressed that the priority is to equip the country with the right capabilities to prevent severe space weather events and avoid repercussions on crucial infrastructure.

E.5   Ensuring the Security of Digital Technologies at the Periphery (SDTaP)

E.5.1   Introduction and context

There has been a recent exponential increase in the number of digital technological products in people's homes and workplaces that require access to the internet. This has provided a sharper focus on the need for additional cyber security against threats. The aims and objectives of Ensuring the Security of Digital Technologies at the Periphery (SDTaP) is to create a national centre of excellence for the Internet of Things (IoT) and 'digital periphery' security community to address this need, and to create a step change in the approach to cyber resilient systems. The programme will include input from academia, industry and government.

SDTaP received £30.6m of funding during Wave 1 of the Strategic Priorities Fund (SPF) to establish the centre of excellence. The programme is led by the EPSRC with significant support from Innovate UK, and both of these organisations hold funds. The Government departments involved in this programme are the Department for Digital, Culture, Media and Sport (DCMS), GCHQ/NCSC, and the Home Office, each providing letters of support in the bid.

The IoT world, with its linkages and dependencies between systems, increases vulnerability to broader, more sophisticated cyber threats. This programme addresses the challenge of providing confidence that such systems will behave as expected and required under different circumstances. This can be through an improved verification and validation process, and through a monitoring and control process. An example of a challenge here, and one addressed in the programme, is the preservation of data privacy in connected systems. With personal data for example, where monitoring is deployed to identify and control security (looking for anomalous signals for example), there needs to be a robust process for preserving the privacy of the data - a significant challenge. This requires interdisciplinary R&D spanning technical and behavioural sciences, law and ethics, with Artificial Intelligence (AI) a key programme theme.

SDTaP's key objective is focused on resilience and security (and confidence in such) of dynamic and adaptive connected IoT systems. In such systems, data are transferred across system boundaries and are vulnerable to corruption or infiltration, generating ethical and assurance issues with both economic and social (privacy) impacts.

Explicit objectives are listed in the box below.

- Combine physical, human and cyber security for safety, security and resilience.
- Create new methods for resilience and recovery of complex 'digital at the periphery' systems.
- Improve trust in the Internet of Things (IoT) systems for citizens and how individuals and communities respond.
- Address the assurance needs of dynamic and adaptive IoT systems.
- Leverage the use of AI and data-driven decision making, whilst ensuring the privacy of users and addressing the vulnerability, ethical and assurance aspects of such approaches.
- Preserve privacy while maintaining monitoring.
- Facilitate the sharing of trustworthy data and the management and sharing of information extracted from data for both protection and economic benefit.
- Deal with scale extremes: large interdependent complex systems and small scale systems where traditional approaches fail to apply.
- Develop a more targeted approach in key sectors, such as Healthcare and CNI (e.g. Energy and Transport) systems.

E.5.2   Programme origins and idea development

The process for developing the idea for the programme was to build on the pre-existing 'Privacy, Ethics, Trust, Reliability, Acceptability and Security' centre (PETRAS), in existence prior to the SPF funding bid. This provided for an initial engagement of key parties that was good from the beginning, given that about half of the partner organisations consulted in this research worked together on the first iteration of PETRAS. The PETRAS project called 'IoT UK' was funded by the Treasury in 2016 with additional funding input from DCMS and was led by EPSRC. At that time, funding was also received by the predecessor of IUK (Technology Strategy board) for demonstrators and there was an additional NHS strand of work. As the Treasury funding was coming to an end, the SPF was announced and the partners involved all reported being encouraged to apply for the SPF. This was because PETRAS was considered to align well to the SPF objectives - with a focus on Multi and Interdisciplinary Research, Innovation and strategic priority and with the potential to be enhanced to broaden and deepen the capacity of the work undertaken.

To highlight the importance of the current programme, it is emphasised that connected systems underpin improved services, drive innovation, create wealth and help to tackle some of the most pressing social and environmental challenges[114]. It is clear that IoT will be integrated into much of the physical world over the next 20 years, and cyber security is a UK Tier One National Priority. The programme idea is rooted in an appreciation that the UK is amongst the top three countries in cyber security, in particular the socio-technical human dimensions, and in Machine Learning/Artificial Intelligence (AI), placing the UK, and the programme team at the forefront in the development of solutions to this growing challenge.

EPSRC led the bid preparation with significant input from DCMS, Innovate UK, PETRAS, the Home Office, and GCHQ/NCSC, providing a cohesive and focused weight of support and common goal. Additional organisations that had input into the bid and have continued involvement on the Governing Board include, AHRC, ESRC, NERC, MRC, the Office for Security and Counter Terrorism, National Security, Department for International Trade and GCHQ/NCSC. Such integrated early support has provided for particularly effective early engagement when compared to business as usual.

The specific requirement identified by the programme authors is for a central point of contact for knowledge dissemination and engagement, in the form of a centre of excellence. Such a centre would ensure that *'IoT systems are safe and secure, particularly as more critical applications emerge meaning there is increased vulnerability to broader, more sophisticated cyber-threats.'[115]* A key element in the need for the centre of excellence is the expectation that it will help to combine and integrate the different threads within this multi-faceted area, both in terms of subject areas –safety, security, regulations, ethics – and also in terms of the technical disciplines – digital, AI, machine learning, human behaviour etc.

One participant reported that once the SPF was announced there was a request for programme ideas to fund which met the SPF objectives: strategic priorities that aligned with government interests and were interdisciplinary research. SPF was seen as a positive opportunity to secure further funding for PETRAS. Participants reported that because they could build on PETRAS and the demonstrators, and the structure was already in place, they

---

[114] The bid document

[115] Working document regarding the programmes

were able to articulate a strong case for funding and could identify programmes that could be set up quickly and that could start spending quickly, as supported by SPF.

The opportunity to bid for SPF was welcomed by the partners. It offered the chance to capitalise on the lessons learned from the previous iteration of PETRAS and strengthen the centre. The addition of Innovate UK with the demonstrator competitions and the commercialisation of research aspects of the programme was felt to further strengthen the programme. SPF also provided the opportunity to bid for a greater funding amount than usual deemed necessary to tackle this complex, multifactorial challenge. Four of the partners from government departments and research councils, were involved in the bid development for the SPF programme. Some of their roles and/or organisations have changed over time, but the programme memory remains good.

Despite the positive elements of the setup of the programme, in particular the leveraging of the pre-existing relationships through PETRAS, and the benefits from SPF funding providing a recognisable presence for IoT as a theme across the UK, rather than the fragmented research funding that was previously available, Government and Research Council participants reported several challenges to the funding process of the SPF, some of which are outlined here:

- The time scale from the call for bids to the deadline was challenging, putting pressure on the drive for quality in the competition, and on the aspiration for research councils to work together on ideas generation in a collaborative way. There were also delays in confirmation of funding, and variations to the funding structures that created additional changes.

- Participants commented on the Haldane principle, noting that this may be seen as at risk where funding and success criteria of the bid require an explicit link to governmental priorities. This is raised by participants as a topic for consideration and perhaps further thought.

- Some commented that the bid assessment criteria and funding process could have been more transparent, although the SPF process became clearer by wave 2.

E.5.3   Programme design and activities

The Internet of Things (IoT) is inherently a cross sector, multidisciplinary concern, so the SDTaP programme has been designed to bring a multi and interdisciplinary perspective. SDTaP note in the bid that they will build on the proven inter/multi-disciplinarity approach created by PETRAS. Each project within PETRAS has a social scientist and computer scientist and gathers input from industry. The demonstrators run by Innovate UK (IUK) add a further dimension to the programme. IUK's role is also to address the commercialisation of Research, to identify and address barriers and facilitators across academia.

PETRAS, reflecting the critical national security implications and interdisciplinary breadth required will expand its reach in the cyber security and AI communities; broaden engagement with behavioural sciences, through a programme combining concrete experimentation and demonstration (to improve public engagement and adoption by businesses) and use fundamental research to address gaps in knowledge.'[116]

At the time of the bid, PETRAS had convened collaboration across 11 universities and 110 industrial and government partners. At the time of writing in May 2021, this has increased to twenty-two research institutions. These include UCL, Imperial College London, University of Oxford, Lancaster University, University of Warwick, University of Southampton, Newcastle

---

[116] The bid document

University, University of Nottingham, University of Bristol, Cardiff University, University of Edinburgh and University of Surrey, Coventry University, Northumbria University, Tate and University of Glasgow.

There was a rigorous peer review process before PETRAS received funding within the programme and the peer review panel provided suggestions that were incorporated into the programme activities. One example of this is that the peer review panel suggested that post-doctoral researchers should be offered training in general business and workplace skills as well as research training which would 'upskill' the future workforce. It was noted that PETRAS after receiving SPF funding had expanded to manage calls which was different from business as usual and required them to identify and procure a submission management tool and identify an independent peer review board.

SDTaP programme has funded the following projects since receiving SPF funding:

- PETRAS 2
- Trust in Human-Machine Partnership
- AutoTrust: Designing a Human-Centred Trusted, Secure, Intelligent and Usable Internet of Vehicles
- VeTSpec: Verified Trustworthy Software Specification
- SYNERGIA - Secure bY desigN End to end platfoRm for larGe scale resource constrained IoT Applications
- Secure-AIM: Security for AI-enabled Mesh networks in IIoT Systems

To date, PETRAS have funded 16 projects across two funding calls, being delivered by 10 different Universities (see Box below). In addition, Innovate UK funded three demonstrators in the first round of funding.

PETRAS Funded Projects

- Building Evidence base for CoP Legislation (BECL), Dr. Saheli Datta Burton, University College London
- Bridging the gap between legal and technical anonymisation (BLATA), Dr Yves-Alexandre de Montjoye, Imperial College London
- Digital Twins in Cyber Effects Modelling of IoT/CPS Points of Low Resilience (DTCEM), Dr Gregory Epiphaniou, University of Warwick
- Edge of Tomorrow: Understanding the Impacts of IoT Cybersecurity and Datafication to Co-design a Sustainable Edge (ET), Dr Adrian Gradinar, Lancaster University
- New forms of Public Value at the Edge: Designing for HDI and Trust in Media IoT Futures (eValuatE), Professor Derek McAuley, University of Nottingham
- Experimental IoT: Explorations in Sound Art and Technology (EXIoT), Dr Alan Chamberlain, University of Nottingham
- Integrated Cyber-Secure Edge Computing (ICEC), Professor David De Roure, University of Oxford
- Improving the Security of Centralised Transport Infrastructure Efficiency System (ISCTIES), Professor Jeremy Watson CBE, University College London
- The PETRAS Data Sharing Foundation: Building a Trustworthy Data Sharing Ecology for IoT Data Assets (PETRAS-DSF), Professor Dame Wendy Hall, University of Southampton
- Participatory Policies for IoT (at the Edge) Ethics (P-PITEE), Dr Naomi Jacobs, Lancaster University
- Positional Referencing for IoT at the Edge (PRIoTE), Professor Tim Watson, University of Warwick
- Understanding disruptive powers of IoT in the energy sector (Power2), Professor Awais Rashid, University of Bristol
- Resilient Built Environments (ResBE), Dr Charith Perera, Cardiff University

---

- Software Defined Receiver IoT Speclinktrum Survey (SDRIOTSS), Dr Matthew Ritchie, University College London
- Secure Ontologies for IoT Systems (SOfIoTS), Professor Jeremy Watson CBE, University College London
- Trade-off Management between Safety and Cybersecurity (TOMSAC), Dr Giedre Sabaliauskaite, Coventry University

COVID has caused significant challenges for aspects of the project. Over the past eighteen months members of staff have been unwell, had caring responsibilities, were furloughed or their jobs became focussed primarily on COVID related activities. Furthermore, there were problems for laboratory based staff accessing the labs.

It was reported that some of the work the programme had planned needed to be amended or changed as a result of the impact of COVID. One of the participants noted an example of this - if a project wanted to deploy sensors in order to understand people's reactions in a night club, it would be impossible to achieve during lockdown. Another example which was unable to proceed was how the Internet of Things could be utilised in Care homes. The programme has shifted to focus on the aspects that it can achieve, which has not compromised the delivery, it just meant that certain elements were not possible, which is true across all of society.

E.5.3.1   The role of the different partners and governance

The Governing Board comprises EPSRC, Innovate UK, Department for Digital, Culture, Media and Sport (DCMS), Home Office as well as AHRC, ESRC, NERC, MRC, the Office for Security and Counter Terrorism, National Security, Department for International Trade and GCHQ/NCSC. The Governing Board meet in full for a programme review twice yearly and a reduced number of members meet monthly. This provides a place to continue their involvement and address strategic issues. There is also an Industry Advisory Group that provide ideas which are input into the Governing Board.

All of the participants commented on the usefulness of the Governing Board. The Governing Board facilitates communication across the partner organisations and produces a regular opportunity for discussion and contribution from partners and organisations with interest in the programme and the outputs it will produce.

The Governing Board was felt to be a positive and different arrangement to other funded research with the governing board having higher level strategic roles. It was also reported that the Governing Board were shaping the project collectively as it evolved, and that collective thinking provided valuable strategic perspective to the programme. This scale of the Programme in both size and funding reportedly led to the need for greater involvement of personnel than in other funded projects.

E.5.4   Programme outputs and uptake

The individual elements of the programme are developing, with some ongoing, and some yet to start, and so there are no R&I outputs yet to report. Outputs and impact will be noted in greater detail in the next stage of this evaluation.

However, there have been some sharing and dissemination activities, and there are plans in place for encouraging uptake in later stages of the programme. Additionally, a large-scale conference was cocreated with IET, as well as Research Fellow secondment to DCMS and DfT and Industry. The aim of PETRAS is to connect the projects and to avoid silos. At a recent meeting, the twenty-two universities that received funding from PETRAS presented their

research to each other. PETRAS plan to create a knowledge sharing and synthesis across their work. PETRAS has also arranged 'fireside' conversations where senior people have been able to talk informally about their careers, how and what they have achieved etc. to Post-doctoral Researchers (PDR).

E.5.5 *Programme outcomes and impact*

E.5.5.1 R&I to address priorities

As the programme is only halfway through, there will be more information available about outcomes and impact in later stages of the evaluation. It was reported that PETRAS has already achieved one of the main purposes of the programme which was to establish it as a 'go to' centre for enquiries. It was also anticipated that relevant findings would go back to government via the governing body. The participants involved in the Governing Board reported that it was extremely useful to have input from Government Department Chief Scientific Advisors (CSA) on the board to communicate their priorities, to learn outcomes of the research to feed back into policy and to have general discussions about IoT, cyber security, gaps and future potentials.

One participant reported that they hoped for white papers that take an area and report on trends, which provides useful summations of state of the art, general trends, specific instances and examples technologies tried or tested in a particular way. The other aspect of relevance is the demonstration of future possibilities and future capabilities. These all contribute to departmental understanding of the nature of the technology, what direction it is going and how to think about regulation of policy.

E.5.5.2 Intersectoral collaboration

Partners were in agreement that their experience was that the implementation of the programme has been successful and is largely proceeding as planned. The partners reported that the existence of PETRAS at the start was an enabling factor in this respect, avoiding some of the usual challenges when setting up a programme. However, it was also reported that there were challenges where certain activities would require amending or reshaping as knowledge is acquired.

The developing relationships between the members of the governing board and reciprocal information sharing was considered a valuable outcome that each partner felt would significantly benefit them and will continue in future work.

Some key facilitators of success have been highlighted in the evaluation to date. These centre around the key themes of mutual interest and collaboration; common goals; and the benefits that arise from a larger and broader pool of expertise.

It was reported that SPF provided an opportunity for the research councils to come together to write the business case and be joint delivery partners – supported by a sufficient, joint fund available at a suitable time. The relationship between the two Research Councils was reported to be mutually beneficial and would be repeated in future work. SPF also offered the programme partners to function as a cohesive whole by developing the relationships between PETRAS, the demonstrators and the other projects, thereby enabling closer working relationships. The governing board has functioned to hold this all together.

Three participants reported that the relationships with Government Departments was facilitated by one of the partners whose prior role as a Government Chief Scientific Advisor provided valuable knowledge about methods of approaching and communicating with the Government departments and is instrumental in the continued relationships. One of the

Government Partners reported that better access and continued exposure to advanced technologies and trends in those technologies was increasing the technical understanding of their policy team. They also felt that it was extremely useful to have access to a consortium of researchers dedicated to this research.

E.5.6 Conclusions

The SPF, through the SDTAP programme, has enabled the establishment of a centre of excellence set to provide the national capability required for the security of the IoT and digital technologies at the periphery. The programme, under PETRAS leadership, provides a multidisciplinary focus on the challenges of security, safety, privacy in IoT systems.

The structure of Programme and in particular the Governing Board has successfully enabled the sharing and understanding of priorities between Government Departments and Research Councils. This has strengthened and consolidated existing relationships and allowed new ones to develop, which will continue in the future.

The Programme is halfway through the funding period. Outcomes and impact will begin to become available in the coming period. There have already been significant knowledge sharing and synthesis activities across the projects.

E.5.7 Interviewees

- Programme Lead, EPSRC
- Previous Programme Lead, EPSRC
- Programme Director, EPSRC
- Government Programme Partner, DCMS
- Programme Partner, Innovate UK
- Programme Partner, Innovate UK
- Director of PETRAS, UCL
- Programme Partner, AHRC

E.6 The Policy and Evidence Centre for Modern Slavery and Human Rights

E.6.1 Introduction and context

Modern slavery traps 40m people worldwide, costs the UK economy between £3.3-£4.3bn a year and was described by the [then] Prime Minister, Theresa May as "the great human rights issue of our time". The UK is widely recognised as world leading with its comprehensive legal and policy response, including its 2015 Modern Slavery Act and accompanying strategy. Despite this, there are still between 10,000-13,000 people enslaved in the UK with British citizens being the largest source of victims.[117]

The concept for the Policy and Evidence Centre for Modern Slavery and Human Rights (PEC) Programme was developed by the AHRC in consultation with the Home Office and experts working in modern slavery and interrelated fields. The consortium totals six organisations with a track record in world-class work on modern slavery, comprising:

- the Bingham Centre for the Rule of Law;
- the Rights Lab at the University of Nottingham;
- the Wilberforce Institute at the University of Hull;
- the Centre for the Study of International Slavery at the University of Liverpool;
- the Bonavero Institute on Human Rights at the University of Oxford; and
- The Alan Turing Institute.

The lead council for the £10m Programme is the AHRC, with the ESRC as the partner, supporting council. The lead consortium member is the Bingham Centre for the Rule of Law, part of the British Institute of International and Comparative Law.

The key objective of the programme may be summarised as the aim to develop and transform understanding of modern slavery, and to establish a connected and shared, joined-up approach to address it. Critical to this, is policy-relevant research that responds to strategic challenges in a collaborative and connected way, advances understanding, and stimulates innovative and effective solutions.

The objectives of the programme are specifically to:

- Transform our understanding of modern slavery;
- Model and bring about a more collaborative approach to responding to modern slavery;
- Establish a "network of networks", to enable better dialogue, knowledge sharing and collaboration in the fight against modern slavery;
- Make legal and policy responses to modern slavery more effective; and
- Take a distinctively human rights-based approach to tackling modern slavery[118]

The Home Office is the key government department partner, and one that leads on work to tackle modern slavery. The funding of this programme (£10m over 5 years) is seen to be of strategic importance, as highlighted by the letter of support from John Aston[119], the Home Office Chief Scientific Advisor, to confirm that the programme responded to the government

[117] The bid document

[118] https://ahrc.ukri.org/documents/calls/ms-pec-covid-19-rapid-response-call-specification/

[119] The bid document

https://modernslaverypec.org/about-us

areas of research interest - noting that ending modern slavery was one of the government's top priorities. The [then] Prime Minister Teresa May also identified Government priority in this area when she launched the Call to Action to End Forced Labour, Modern Slavery and Human Trafficking at the 2017 UN General Assembly.

E.6.2   Programme origins and idea development

The AHRC had prior experience in developing a Creative Industries Policy and Evidence Centre led by Nesta[120]. It was recognised that gaps exist between academic research, policymaking and law-making, and frontline work with people directly affected by modern slavery. A potential solution identified was to bring together academics, policymakers, businesses, civil society and people affected by modern slavery, and connect research and policymaking – an approach considered possible under the SPF process.

In the initial stages of the development of the programme idea, AHRC held inclusive workshops with a range of key parties (including academics, data scientists, media, businesses, the Home Office, the Foreign and Commonwealth Office and DFIS) to identify the need for a policy and evidence centre (PEC) and then to help establish the structure of the Centre. It was agreed that an independent authoritative voice able to move the research agenda at 'scale' was required. The PEC would enable a focus on this identified priority by facilitating a collaborative approach, drawing together different disciplines and organisations and integrating research and evidence that was hitherto seen as disconnected and disparate. The idea would be to develop a more coherent narrative, and the focus of the bid aligned directly with the three SPF objectives. The bid authors also noted that the bid was closely informed by the publication of the Home Office and other government departments' Modern Slavery Research Priorities.

Compared to business as usual, the SPF process provided the opportunity to bring together a comprehensive multidisciplinary consortium, with direct input from the Home Office, on a much greater scale than individual budgets would ordinarily allow. The partners recognised that the complexity of addressing Modern Slavery required this level of collaboration (and commensurate funding) for the programme to be successful. The specific PEC partners were chosen because they are experts in their individual fields and were prior recipients of significant levels of peer reviewed funding, and had the associated, required experience and knowledge.

Given the limited funding timeframe of 5 years, it was reported that the decision was taken by AHRC to name the lead organisation and partners of the PEC in the bid. An alternative would have been to put out an open call after receipt of funding. The chosen approach was considered to help streamline the process of establishing an effective, operational PEC.

E.6.3   Programme design and activities

Modern slavery is inherently multidisciplinary. The PEC, as an authoritative voice with a multidisciplinary structure, has largely completed establishing a collaborative research strategy through consultation with a wide range of disciplines and stakeholders. The AHRC will issue and run calls under the direction of the PEC, and work with the UKRI's expert review mechanisms to ensure a breadth of inter- and multidisciplinary assessment. To supplement the over-arching 'joined-up' approach and strategy, there will also be a reserve fund established to fund agile short-term responses to rapidly emerging issues – see

---

[120] https://www.nesta.org.uk/project/creative-industries-policy-and-evidence-centre/

Call 1. This fund, coupled with specific emphasis within the calls, will enable and encourage new or innovative ways of working.

To date, the PEC has run <u>three calls for research proposals</u>, each set out below.

- Call 1: The impact of Covid-19 pandemic on modern slavery closed 25/09/2020[121].

  There were 11 awards of £150,000 (max, 100% FEC, AHRC to fund 80% FEC) and the duration is 6 months. The purpose of this call is to support original and innovative research, which can act swiftly to improve understanding of the impact that the COVID-19 pandemic is having on those who are vulnerable to slavery, those who are enslaved, and those who are survivors of modern slavery, as well as the organisations which support them, and services that seek to prevent, detect, and prosecute the perpetrators.[122][123][124]

- Call 2: Victim and survivor recovery and support - closed 27/10/2020[125].

  Funding available £300,000 total (max, 100% FEC, AHRC to fund 80% FEC). The duration of the funding was 12 months (max). The purpose of this call is to fill gaps in the evidence base in areas such as:

  – the decision-making processes for identifying people affected by slavery and the impact it has on survivors,

  – the recovery and reintegration needs of both adults and children identified as victims, and

  – approaches to prevent re-trafficking.

- Call 3: Rapid research call: assessing the potential of interventions to prevent modern slavery in the UK – closing date 18th June 2021[126]

  Funding available for one project (maximum budget of £70,000 at 100% FEC). Led by a UK higher education institution or approved research organisation eligible to receive UKRI funding - in collaboration with at least one UK based third sector organisation.

To support the direction and strategy of the PEC, a comprehensive system of governance is defined. The director of the PEC will be accountable for the delivery of the Centres output – directing mission, vision and strategy and will be accountable to the Steering Committee for the delivery of its objectives. A co-director with a special expertise in Modern Slavery has been recruited into the lead organisation, the Bingham Centre, to work with the partners and external stakeholders to steer and cocreate the research agenda and the strategy for delivery.

The following points further describe this governance, which is an important element in the delivery of the strategy to meet the objectives. It is the governance that helps to integrate the different strands and approaches within the programme.

---

[121] Programme information document compiled internally

[122] See: https://www.ukri.org/opportunity/modern-slavery-and-human-rights-policy-and-evidence-centre-the-impact-of-covid-19-on-modern-slavery/

[123] See: https://ahrc.ukri.org/documents/calls/ms-pec-covid-19-rapid-response-call-specification/

[124] See: https://modernslaverypec.org/latest/pec-firs-calls

[125] Programme information document compiled internally

[126] https://modernslaverypec.org/latest/call-research-prevention-modern-slavery-uk

- Each of the six partner organisations will have a member on the <u>Senior Management Board</u>. The board will agree commissioned research calls and recommend funding for specific initiatives.

- The PEC's <u>Steering Committee</u> (SC) oversees strategy, monitors delivery, agrees funding, and gives assurance to UKRI that the management of the PEC is appropriate and effective. The SC includes members who can represent views of external stakeholders at a senior level.

- The PEC's <u>Advisory Board</u> acts as a 'critical friend' with reference to the research agenda. It gives advice regarding external stakeholder engagement, research strategy and delivery, identification of gaps or further opportunities, and ensures the Modern Slavery community is represented and engaged in consultation as appropriate.

- <u>Expert assessment panels</u> will have representation from the Advisory Board/SC to ensure that research is not only of excellent quality but also adheres to the aims and objectives of the PEC's research strategy.

The PEC is established, close to fully staffed, and governance is in place. These systems and structures reflect the priorities and needs of the programme as defined at inception and are anticipated to be sufficiently flexible should these needs and priorities shift in time. The next iterations of this case study will look further into whether and how the programme flexes to reflect changing needs.

E.6.4   Programme outputs and uptake

Although, the programme is at an early stage and the majority of the research outputs are still in progress with publications expected later in the year, mechanisms are being implemented to manage outputs and dissemination. The research strategy consultations highlighted that the PEC was considered to be a place to bring together findings from different research projects and disseminate them to relevant end users. The Director of Policy and the Director of Communications work closely to identify end users and develop relationships with them. End users include policy makers, law makers, businesses, academics, NGOs, survivors, and survivor groups as well as the general public.

Outputs will include online research summaries with policy recommendations from each research project, policy briefs drafted by the PEC based on findings from across the research projects and sent to named contacts in government with an interest in that policy output.

The Director of Communications' role is public facing and ensures that outputs are accessible to all end users. This involves working with research projects to develop dissemination events, to engage media, write opinion pieces, and they are in the process of developing a podcast.

E.6.5   Programme outcomes and impact

The programme is at an early stage. The PEC is in place, systems and structure have been established, and the first two calls issued late 2020 (a third call has just been issued) but the R&I outputs are yet to be produced, taken up or disseminated. Programme outcomes will be addressed in more detail as appropriate in future iterations of this case study. The focus here is on initial feedback and issues of note at this early stage.

A key finding from interviews with stakeholders concerns the challenges that arose in the early stages as a result of the way the PEC was initially configured and set up. Given the urgency and the imperatives to cut short the setup period (which could have been two years), the PEC partners and configuration was established at bid stage. It would have been usual for this to be established through a competitive open call for proposals.

The pre-determination of the configuration at bid stage created a number of challenges for the PEC:

- It was reported that there was an onus on the consortium to justify the predetermined assembly. Questions were asked internally and externally about the reasons for the choice of configuration and mix of partners. This was particularly important because the purpose of the consortium was to facilitate and promote collaboration. Establishing trust and confidence in the decision was imperative.

- Contrary to the perceived benefits of rapid establishment of the PEC, there was general feeling among the partners that the approach, and the resulting challenges led to it taking longer than expected for the PEC to become fully functioning:

    - Challenges faced were partly to do with delays in the employment of core PEC team staff because of COVID.

    - Delays may have occurred because the Centre had to be established without any existing structures in place (absence of process and mechanisms for the complicated issues of developing a centre, defining partner terms of reference, funding process, governance etc.)

- The challenges faced, and the timeline of establishing the structure of the PEC, and the calls for research, have meant that the early calls have been made in advance of the consolidation of the strategy. So, there is some misalignment which is being addressed.

Despite the difficulties faced, there were positive outcomes reported:

- Perhaps as a result of the challenges that followed the pre-defined configuration, it was reported that responding to the issues has resulted in transparency and fairness being considered in all of the PEC's activities.

- Some success is shown in the process given that participants agreed that the issues were slowly being resolved and the PEC was now almost fully functioning. At the time of writing the PEC is close to being fully staffed.

- Stakeholders reported that lessons had been learned. Some stated that, for the future, an open call might have addressed some of these issues earlier.

With regards the relationships, communication mechanisms and ways of working between programme partners, there are some reported concerns:

- It was reported that there was conflict between partner organisations, likely because of the means of establishing the pre-determined structure of the PEC, sufficient to consider the introduction of a conflict resolution organisation. The conflict was recognised by all partners, and tension at meetings would have been evident.

- No defined data sharing protocol or collaboration agreements have yet been established and agreed. The absence of such may make the process of integration and collaboration sub-optimal in these early stages.

Despite these early relationship and communication challenges, there are positive signs:

- Natural personnel changes rendered the intervention of a conflict resolution organisation largely unnecessary. And, paradoxically, it was noted that the occurrence of these conflicts was useful to the extent that the issues were discussed.

- Participants reported, positively, that some of the relationships between the partners have flourished.

- The PEC is now largely operating effectively, and most of the issues in the earlier stages have been resolved.
- The method of sharing priorities and information between the government partners and the PEC was reported to be working extremely well. It has taken some time to establish and will inevitably develop further. A key addition to this is the employment of the Director of Policy.
- There are promising initial signs of collaboration between partners outside the PEC, as a result of the shared objectives of partners within the programme.

E.6.6   Conclusions

There was a clear, common agreement that the approach facilitated by SPF for the joining together of world class expertise in the subject of modern slavery, under the structure of the PEC, brings great benefits, and will facilitate the rapid advancement towards objectives that would have likely been unachievable at this scale in the absence of the SPF approach. The integration of research with a policy focus, has the potential to meet the overall objectives, where the aim is to develop and transform understanding of modern slavery, and to establish a connected and shared, joined-up approach to addressing the important issues within.

The programme by encouraging and enabling a secondary, flexible and agile response, has provided for the early establishment and call for the COVID related research in modern slavery.

However, there are elements reported which have generated significant challenges in the early stages. These are largely in regards to the pre-configuration of the PEC which, while potentially bringing benefits and early efficiencies, has generated the contrary in some aspects. Early PEC definition without clear responsibility definition, collaboration agreements, data sharing protocols, and without pre-agreed partner positions, has caused some challenges. These now appear to be largely overcome, with the PEC established.

E.6.7   Interviewees

- Programme Leads - AHRC
- Programme Government Partner - Home Office
- Director and Coordinator of PETRAS - Bingham Centre
- Programme Partner - Alan Turing Institute
- Programme Partner - University of Hull
- Director of Research - University of Liverpool
- Programme Partner - The Rights Lab - University of Nottingham
- Programme Partner (knowledge of bid) - ESRC
- Programme Partner - ESRC
- Programme Participants - PETRAS

E.7   Clean Air

E.7.1   Introduction and context

The Strategic Priorities Fund (SPF) is an £830m investment in multi and interdisciplinary research (MIDRI) across 34 themes that align to UK Government areas of research interest. The Clean Air: Analysis and Solutions programme within the SPF is led by the Natural Environment Research Council (NERC) and the Met Office with an overall budget of £42.5m across both waves (£19.6m in Wave 1[127] and £22.9m in Wave 2). The programme was launched in late 2018 and will run until 2025. Delivery of the programme is supported by the Economic and Social Research Council (ESRC), Engineering and Physical Sciences Research Council (EPSRC), Innovate UK, Medical Research Council (MRC), National Physical Laboratory (NPL) and the Science & Technology Facilities Council (STFC). Government departments overseeing and involved with the project are the Department for Environment, Food and Rural Affairs (Defra), Department for Health and Social Care (DHSC), Department for Transport (DfT), Scottish Government and Welsh Government.

This case study of the Clean Air: Analysis and Solutions programme provides analysis to respond to the evaluation questions, primarily Q3 (particularly with regards to Objective 2 – ensuring investment links up with cross-departmental R&I priorities and opportunities), but also Q1 (SPF delivery), Q2 (supporting an increase in MIDRI), Q4 (addressing R&D gaps) and Q5 (delivering economic, knowledge and societal impact).

The Clean Air programme aims to bring together the UK's research base to develop solutions to current air quality issues and future air quality challenges. It seeks to bring together leading researchers from across atmospheric, medical, and social sciences to better predict exposure to air pollution and its effects on vulnerable groups such as children and the elderly. It will identify practical and usable solutions to air pollution to help policy makers and businesses protect the public's health and work towards a cleaner economy.

The specific objectives of the programme are to:

- Drive forward new multidisciplinary research and innovation
- Leverage existing UK investments and enable a challenge-focused multidisciplinary community to work together
- Inform implementation of the UK government's Clean Air Strategy
- Develop new solutions to reduce emissions of atmospheric pollution and protect public health, whilst avoiding perverse consequences
- Present information to stakeholders and the public in an accessible way

It will also boost an existing community of world-class research within the UK that includes extensive national capability and a diverse research base across established research centres and leading universities. Wave 1 and 2 activities should lead to MIDRI benefits as they bring together existing disciplinary centres of excellence through a challenge focus, spanning environmental science, engineering disciplines, health and the social sciences. This would build a multidisciplinary community with experience of engaging with stakeholders across different sectors and widen the pool of researchers who have experience of and are able to deliver and peer review interdisciplinary proposals in the future.

---

[127] Wave 1 of funding was launched at the end of 2018 and closed in February 2019, while two wave 2 call were lauched in 2020 (Jaunury and October) and the remaining two in March 2021.

In identifying and supporting solutions to air pollution, the programme responds to the government's strategic priority of improving air quality set out in Defra's Clean Air Strategy of 2019. The strategy has outlined how the government intends to tackle all sources of air pollution, making our air healthier to breathe, protecting nature and boosting the economy. The programme also responds to the government's Clean Growth Strategy 2017, Industrial Strategy and the 25 Year Environment Plan.

E.7.2   *Programme origins and idea development*

The SPF Clean Air programme originated because of the existing relationship between NERC and MRC. Evidence collected though consultations described the process through which the consortium formed and highlighted the main challenges at the programme origination stage:

Existing professional relationship: NERC and MRC played an important role in the creation of the Clean Air consortium. Both councils engaged in a collaborative research programme on atmospheric pollution and human health for the past ten years and more recently aimed to broaden the collaboration to include experts from other scientific fields. When the SPF opportunity arose, NERC and MRC decided to participate and involve ESRC, EPSRC and STFC[128], with whom they had existing, although 'unexplored', professional links. The Met Office and NPL, were connected to the group through the UKRI board, who informed the councils that these institutions were working on a project about atmospheric pollution. Since the start of the Clean Air programme, the two leading organisations have been NERC and the Met Office.

Not business as usual: Consultees agreed that research consortia involving multiple councils were traditionally hard to form. This was mainly due to difficulties encountered in agreeing how to split the budget and, in general, finding suitable working arrangements among numerous partners: *"It's very difficult to get multiple research councils to agree to work together on something and then come up with a budget at the same time, you know triple, quadruple jeopardy to try and take something forward". The creation of such a large consortium for the SPF Clean Air programme, therefore, represented a significant change compared to previous research groups.*

Consultations with the relevant stakeholders provided insights into the main objectives of the Clean Air programme, identifying some important knowledge gaps that the programme aimed to fill:

Connect close disciplines: Council representatives reported the need to link similar disciplines such that greater insights could be derived from Clean Air research. It was felt that until recently, the pollution forecasts conducted by the Met Office were not put in relation to relevant heath research activities, hence a bigger effort was needed in order to link up all these disciplines and provide different, more comprehensive, results.

Research into unexplored topics: A few participants noted that some topics related to Clean Air were underexplored (i.e. the quality of indoor air), hence, they thought that SPF was a valid opportunity to carry further work in these areas.

Consultees felt that the research conducted under SPF is necessary despite the considerable progress made in reducing air pollution in the UK. However, atmospheric pollution is still significant and responsible for approximately 40,000 early deaths a year and an estimated cost of around £20 billion to health services and business annually. Future improvements will require

---

[128] STFC pulled out from wave 1 but re-joined the consortium in wave 2.

innovative solutions underpinned by new research to protect the health of society, whilst pursuing clean growth and increasing national productivity.

E.7.3   Programme design and activities

Consultations provided further insights into the extent to which the SPF Clean Air research projects benefitted from a multi- and inter-disciplinary approach. The key points raised are:

Incentive to collaboration: The SPF call encouraged the submission of bids from consortia formed by multiple organisations; this feature represented an incentive to collaboration especially at bidding stage. They way funds were allocated, not to a single institution but to multiple organisations, removed a barrier to interdisciplinarity. It was noted that, as the single institution did not just have to be accountable for its own inputs (but rather the consortium as a whole), the collaboration among parties all throughout the projects' life (i.e. from bidding stage and during the projects' implementation), was easier than for traditional proposal calls and most importantly, something that did not happen in the past.

Support to policy making: Another point was made around the links that the MIDRI approach has now created among all Clean Air partners and how these will support the future policy making on this topic. The current governance of the Clean Air programme (Programme Board and Steering Committee), ensures that representatives from seven research councils are responsible for research conducted on Clean Air, bringing a more comprehensive perspective on the issues investigated: "*One of the simple things we were saying at the start of Clean Air is, 'If we could just get a few people from the medical research world talking to […] people who do atmospheric composition, so we could just tie up how much air pollution is there going to be in the atmosphere and what effect does that have on people.' It's so important to have that link […], otherwise all you're doing is saying, 'Oh, the pollution levels are this,' and you're not tying those things together. How do you build a policy then to address equality issues, if you haven't got those links?"*

Since the start of the programme, there have been two waves of SPF supporting Clean Air research projects. The table below lists the request for proposals launched in waves 1 and 2.

Wave 1 and 2 calls for proposals

Wave	Title	Purpose
1	UK Clean Air Champion	Funding to develop the Clean Air programme and link it with other relevant activities. Responsible for working with the academic, innovation and Met Office community to drive integration of research across the programme.
1	Clean Air: Analysis and Solutions programme (3 lots)	The overall aim of these activities is to develop community modelling system(s) to simulate outdoor air quality in the UK and evaluate health outcomes of policy decisions at urban scales. Lot 1: Urban outdoor air quality modelling. Lot 2: Air quality exposure modelling. Lot 3: UK Emissions Modelling System
2	Networks to build interdisciplinary communities to address air quality challenges at the indoor/outdoor interface	The objective of the call is to fund a cohort of networks that will start to build a new influential UK interdisciplinary community in the area of the indoor/outdoor air quality, comprising academics, Public Sector Research Establishment (PSRE) researchers, and other relevant stakeholders including from across healthcare, policy, practice and industry.

| 2 | Preparing for Future Clean Air Challenges: Interdisciplinary research and innovation consortia | The purpose of the call is to fund interdisciplinary consortia in the area of the indoor/outdoor air quality interface which will deliver new knowledge that provides critical foresight on emerging air pollution challenges and associated health risks and impacts.

This enables an increased understanding and quantification of human behavioural change and practices in order to develop and assess interventions, that limit harmful exposure to mitigate negative health impacts individuals most at risk. |
| --- | --- | --- |
| 2 | Indoor Air Quality Emissions & Modelling System | The indoor air environment may contain in excess of 900 chemicals, particles, and biological materials, all with the potential to cause health impacts. This activity will identify a reduced set of key indoor air pollutants, or pollutant families (chemical and biological) as well as their main sources, which are required to characterise overall air quality. |

The Clean Air programme benefits from the scientific collaboration of six research councils, the support of three government departments and two devolved governments. The principal governing bodies are structured as follows:

Governance arrangements

The Programme Board is responsible for providing the strategic direction for the programme and the delivery of the programme's objectives, and it is the ultimate decision-making authority for the programme. It comprises the programme's delivery partners including NERC and the Met Office as co-Chairs, alongside EPSRC, ESRC, MRC, Innovate UK, Defra, and the National Physical Laboratory.

A Steering Committee provides strategic advice to the Programme Board in support of the programme's objectives. The Programme Secretariat comprises a secretary, based at NERC Head Office, providing administrative support to the Programme Board and Steering Committee.

Clean Air Champions

The programme is also led by four 'Clean Air Champions'. This was funded by a £500,000 call within Wave 1 spending activities. The Champions are to act as thought leaders, flag bearers and strategy owners for the Clean Air research programme. The Champions' role spans across different activities; the key ones are to:

- Ensure alignment across portfolios of projects and promote knowledge exchange
- Ensure research projects link to business, practitioners and to governmental policy requirements
- Raise the profile of the programme in all relevant communities
- Coordinate monitoring and evaluation activities
- Provide advice to the Programme Board on the scope of calls and to participate in the Steering Committee.

The Champions have developed a new 'Roadmap' for the programme in collaboration with the Steering Committee which should shape priorities and spending on UK clean air activities, including those funded by this SPF in Waves 1 and 2. The roadmap has identified key

overarching themes that should shape the future direction of the Clean Air programme. The themes are listed in Annex 1.

Responding to changing needs

Finally, Covid represented an opportunity for the programme to shift its priorities and reflect changing needs. The focus on indoor air pollution was strengthened at the onset of the pandemic; with more people spending time indoors, domestic air pollution became a greater issue than it might have been twelve months ago, where office air pollution might have been a bigger factor. Therefore, the programme has adapted partly to look at this question and feed into that post-Covid recovery.

E.7.4   Programme outputs and uptake

Most of the projects funded in waves 1 and 2 started in 2019 and should conclude in 2022-2023. At this stage, very few of them have produced significant results that can be shared. The programme is at a point where it soon will benefit from the first outputs, although the first results are expected for the end of 2021.

Only one project has already progressed to the point of testing a "clean air engine" used in construction site. This tool is currently being used in the High Speed 2 (HS2) construction site after only 18 months from the start of the project and it is aimed at replacing traditional engines used in construction. At the same time, researchers are gathering data to see how much emissions are reduced thanks to this innovation.

Although in most cases results are still not available to be shared among the programme's partners and the wider Clean Air community, significant effort is being dedicated to the widening of this community and to raising awareness about the air pollution and its impacts on the environment and human health. In particular, Clean Air Champions are bringing forwards two initiatives to share the latest developments of the Clean Air programme:

Linking the research with the practitioners: Clean Air Champions are raising awareness about the different research projects funded through SPF. The objective is to try and interface Clean Air researchers with themselves and with other bodies who can make use of the results of this research (for example, GP practices or pharmacies), such that knowledge about Clean Air is widened and does not stay just in the remit of the scientists that conducted the research.

Annual SPF meeting: In June 2021, the Clean Air Champions will organise the annual SPF Clean Air meeting. This will be an opportunity to showcase any result achieved and invite all the partners involved in the programme to discuss the development of the projects.

E.7.5   Programme outcomes and impact

E.7.5.1   R&I to address priorities

Similarly to the programme's outputs, outcomes and impacts are yet to be observed due to the early stage of the majority of Clear Air projects. However, information gathered during stakeholder consultations confirmed that the research conducted under this programme is addressing priorities mentioned in government's official Clean Growth Strategy 2017, Industrial Strategy and the 25 Year Environment Plan. It is therefore expected that the outputs of the programme will be utilised by policymakers.

E.7.5.2   Intersectoral collaboration

In terms of the **overall experience** of the programme, the general feedback was positive, and consultees appeared highly engaged with the Clean Air research projects. There was

consensus among the different stakeholders interviewed that the type of collaboration initiated because of SPF was positively shaping research and innovation in this field.

Other themes that emerged during the consultations were:

- **Tight timings**: Some consultees commented on the bidding process and reported on the lack of time to put together the bid as well as the lack of clarity of the SPF objectives ("I still didn't understand what the 3rd objective is"). In some instances, it was found that the decision making was not transparent ("who decided and how?") and finally, allocation of funding was not considered timely.

- **A wide network of experts:** However, the participation of so many experts from different backgrounds was welcomed by all interviewees as it encouraged Clean Air partners to connect in ways that would have not necessarily happened in the past: *"The network call was designed to bring together researchers who wouldn't normally work together. So, as I say, chemical and atmospheric scientists working with front-line GPs and healthcare professionals and things like that, so you probably wouldn't see that, outside the SPF."*

- **Communication mechanisms and ways of working together:** Consultees did not think that the way of communicating among partners was necessarily different from the past, as many Clean Air partners declared that they had already interacted on a one-to-one basis on very specific activities in the past. However, the key difference was that as a result of SPF, they have been communicating multilaterally for a greater objective: *"I think the SPF really provided this unique opportunity to bring together the full UK research activity in this area".*

- **Long term perspective needed:** It was also noted that the creation of the SPF working network did require a great deal of effort (especially at onset of the programme) and it was not easy to create certain professional links. This necessitates a long-term perspective and funding to ensure sustainability of the collaborations created. *" I think what we didn't anticipate is just how long it takes to form some of these communities. It's not as straightforward as, 'Let's run a workshop'. […] You've got people from the arts and the humanities research community working with meteorologists. And they are so far apart, that actually bringing them together is a slow process. And I think we need to make sure we don't underfund this set-up period, assuming that you can fund a programme for three years and then it goes into business as usual, because I don't think it will. I think it will just revert back again. I think these kind of intentional funds, aimed at bringing these communities together, almost need to be long enough to form those connections and get those new ways of working."*

- **Barriers:** Ensuring the right representation from government departments and key stakeholders on the advisory groups was felt challenging and a potential barrier to provide the right strategic direction for the programme. One consultee noted that it took some time to find the right governmental support to the scheme. In part, this was explained by the fact that governing/advisory groups need to engage with senior people that are often stretched on too many commitments. For Clean Air, the right balance was found in the end, but it required some time.

E.7.6   Conclusions

Based on the evidence collected through baseline stakeholder consultations and the general programme documentation, SPF Clean Air projects aim to tackle atmospheric pollution involving a wide range of expert scientists, such that the issue is analysed and addressed in the most comprehensive way.   Despite the fact that the projects are still ongoing and have not yet produced their first results, it was recognised that:

- SPF allowed funding of research into underexplored and complex aspects of air pollution, that would not have been investigated otherwise.
- SPF ensured UKRI spending links with cross departmental R&I priorities by making sure that Clean Air governance and advisory bodies include stakeholders from the government departments, such that researchers get the right steer from them.

Although the first outputs will only be available at the end of 2021, the SPF Clean Air programme appears to be delivered by a rich and diverse group of experts and should be on track to deliver on its objectives, responding to strategic priorities for the UK.

E.7.7 Annex 1

List of overarching Clean Air research themes forming the base of the SPF funded research projects:

- The primary target of air pollution effects are humans.
- More work is required to connect Health and Medical Sciences with Atmospheric Scientists.
- Health messaging and communication needs to be less negative in tone and give more emphasis to solutions, incorporating more Social and Behavioural Science, Psychology and Economics.
- Greater effort should be made to bring together data scientists from health (HDR-UK, NHS Digital, Usher Institute, industry e.g. Dyson, Philips, Microsoft, Google etc.) with the Met Office and large data sets on atmospheric science.
- A more coherent and strategic effort is required to improve the quality, visibility and extent of messaging and communication transfer to health scientists, practitioners and the public at large.
- More research is needed on the virtually unresearched space of indoor air pollution.
- More effort needs to be made in connecting the climate change policy and research community with those interested in air pollution.
- A specific target for this Clean Air SPF is greater ease of access of information, publicity and education about the adverse health effects of air pollution
- The first wave of the programme has several strands of activities:

E.7.8 Interviewees

- Programme lead, NERC
- Programme lead, Met Office
- Partner Council, IUK
- Partner Council, MRC
- Partner PSRE, NPL
- Partner Gov, Defra
- Programme Champion, University of Southampton

E.8 Transforming Productivity Research: productivity and health and healthy working practices

E.8.1 Introduction and context

Rates of productivity in the UK are significantly below those of peer nations and growth has flattened since 2009. As the productivity of a nation is directly linked to its overall economic performance and to citizens' living standards, stimulating productivity is a significant challenge faced by the UK over the coming years. As a response to this troubling issue, the Transforming Productivity Research: productivity and health and healthy working practices programme was funded during Wave 1 of the Strategic Priority Funding (SPF). The lead organisation of the programme is the ESRC, and the partner organisations are the EPSRC and the MRC. There are three government departments involved in this bid. These are the DWP, BEIS, and DHSC. The bid was written with input from the ESRC, EPSRC and the MRC. The overall budget is £8.9 million.

The bid for the programme outlines the objectives across the two waves of the Strategic Priority Fund. The proposal for funding for Wave 1 was intended to galvanise a multi- and interdisciplinary community, building towards a larger synergistic Wave 2 bid that would create a sustainable world-leading UK research and data infrastructure dedicated to bringing about a strategic and integrative shift in how we understand and address productivity.[129]

Letters in support of the bid were received from the three Government departments, outlining the relevant policy areas that the programme aims to address:

- A letter from the DWP highlights that the programme would address a clear national priority, and is well-aligned with a number of DWP Areas of Research Interest, including producing an integrated approach to improving health and work outcomes and joined-up, tailored and personalised health and work support structures and practices[130]

- A letter of support from DHSC cites the potential benefit of the programme to the joint work carried out by DWP and DHSC, noting the new government strategy around 'Improving lives: The Future of Work, Health and Disability' and the centrality to this of the role of managers in delivering healthy and inclusive workplaces where all can thrive and progress.

- The third letter of support from BEIS notes that 'Our BEIS Areas of Research Interest include understanding the drivers of productivity differences and dynamics, investigating cross-UK and international comparisons, and exploring solutions to tackling our 'long tail' of low productivity, all of which would be addressed via this programme of research'[131]

E.8.2 Programme origins and idea development

There has been considerable staff turnover in the department that leads this programme at the ESRC. This has resulted in a loss of organisational memory specifically relating to this programme and it has proved challenging to identify names and contact details of partner stakeholders who were involved at the bid stage and throughout the programme. This means that there is limited information about the bid stage, and limited information that could be collated from interviews with partners. Attempts at identifying relevant contacts to provide a clearer understanding of the bid process and implementation for this programme continue.

---

[129] The bid document

[130] The bid document

[131] The bid document

The specific gap in knowledge that the authors of the bid are responding to is that 'At present inter-relationships between significant contributors to productivity (labour, resource, TFP) remain relatively un- or under-explored.'[132]

Prior to the bid, the ESRC invited researchers to take part in a 2 day 'sandpit' workshop. The aim of this workshop was to bring together researchers from different disciplines to encourage the production of ideas for proposals for interdisciplinary research focussed on productivity and with the expectation that this approach would assist quick funding. One of the stakeholders reported that this process was extremely useful and quickly resulted in a proposal idea that spanned disciplines, and which was ultimately funded.

E.8.3   Programme design and activities

The bid notes that wave 1 of the programme of work will mobilise a diverse MIDRI community to address productivity, assessing the current state of knowledge and delivering innovative pilot projects under directed thematic areas (see Figure 7, below). This is intended to build towards the development and submission of a wave 2 bid, 'Productivity and a Productive Society'.

Figure 7   Overview of the Transforming Productivity Research programme
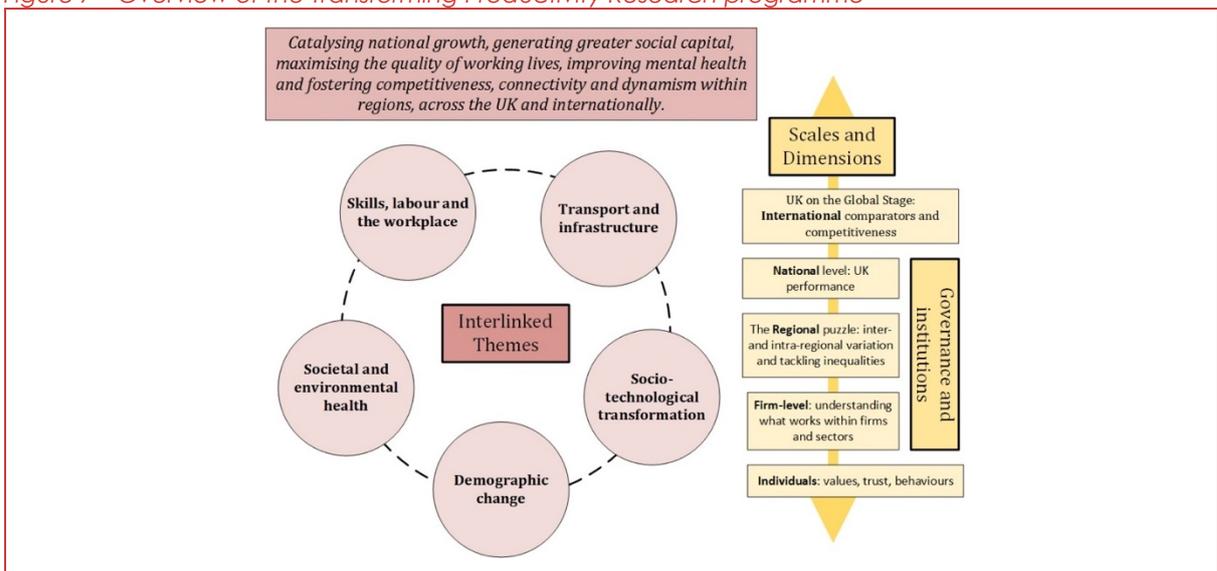
Source: Extracted from programme bid document

The purpose of this programme is to develop a multi- and interdisciplinary community to address the priorities and gaps in knowledge. The 'sandpit' events successfully introduced researchers from different disciplines and encouraged the generation of research ideas and proposal development. As well as funding proposals that developed from the 'Sandpit' workshops. The programme also further funded the Productivity Insights Network (PIN) which was already in existence prior to SPF and doubled the amount that the PIN was able to spend on multi and interdisciplinary proposals in their small grant funding competitions, the Productivity Catalyst Fund. This increase in the amount of funding and the projects able to be funded means that PIN are able to be reactive and shift to think about emerging priorities.

---

[132] The bid document

The authors of the bid identify three key deliverables from the Wave 1 funding, proposing that this work will build on substantial capabilities and programmes of work already on-going, but which lack an overarching collaborative truly interdisciplinary agenda.

- A mapping of current knowledge and interventions across the interlinked themes, to deliver an understanding of the current state of knowledge; syntheses of interventions and lessons learned across scales, localities and sectors; key research gaps.

- A productivity catalyst fund to explore innovative perspectives within and between the interlinked themes. This aims to 'spring-board' an interdisciplinary productivity agenda for Wave 2, building the MIDRI community and funding innovative outcome-driven projects delivering short-term insights and intervention analyses

- An integrated approach to stimulating productive and healthy workplaces, in order to deliver insights into the role of productive and healthy management and working practices as contributors to productivity, profitability and employee health, as well as to inform and assess ongoing policy and practice interventions.[133] This will fund five interlinked thematic workstreams and a coordination and evidence function.

The programme is supported in-kind by the Bank of England in the form of analyst time, launch and convening space, and the DWP and ONS in the form of analyst collaboration and data. Sir Alan Wilson of the Turing Institute expressed support for exploring how data could support the initiative, and the potential for future co- located 'campus' space. The DHSC has also indicated an ambition to fund complementary work via the NIHR[134].

The bid authors provide an outline for the governance of the programme to ensure the SPF objectives are met as well as the objectives of the programme (see box below). However, it is unclear the extent to which these measures are in place or relate to the Wave 2 funding because it was reported that there was no executive board or advisory group for the TPR unlike the Productivity Institute which has an executive board, advisory board, Key stakeholders are kept well informed.

- ESRC will manage the funds centrally on behalf of collaborating Councils to avoid a siloed approach to project funding. ESRC will work closely with EPSRC and MRC staff, and wider UKRI Councils, to ensure that their research communities are appropriately engaged in the opportunities emerging from this funding and to ensure true interdisciplinarity.
- Utilising a PRINCE2 framework, the programme will be managed through a dedicated Programme Board comprising a senior ESRC representative as SRO, and representatives from collaborating organisations as senior suppliers. The Board will be an executive decision-making body and will oversee delivery, finance and budgets, monitoring and evaluation.
- The Programme Board will be advised by high-level Strategic Advisory Group (which will also advise on the direction of any Wave 2 investment) comprising senior Departmental representatives, leading academics across disciplines and senior voices from other key stakeholder organisations.
- Task and Finish groups will be convened as required for particular purposes, themes and activities with advice from the Strategic Advisory Group via the Programme Board. Cross-representation from the Strategic Advisory Group will be built in to ensure coherence.
- Short-term time-limited assessment groups will be formed from experts (including academics and users) in the areas of the specific investment being commissioned.[135]

---

[133] The scope for this was developed via a dedicated workshop, co-convened with ONS and BEIS, attended by leading academics and a range of senior representatives from across government and organisations such as ACAS, CBI and the Institute of Directors

[134] The bid document

[135] The bid document

The programme consists of a number of discrete activities which has led to a portfolio of awards. However, In 2020, The PROPEL Hub was created through ESRC funding[136]. The PROPEL Hub comprises five university partners with University of Strathclyde leading. The five university partners and projects are from the original funding. The projects under the PROPEL Hub share knowledge and learning across the projects to expand and develop knowledge in the area and share each other's outputs and dissemination. Future planned work is shared and joins the findings and methodologies together to create new knowledge and realise the benefits of the full synergies across the projects.

The recipients of the Transforming Productivity Research programme funding are in the box below.

- The PROPEL Hub - Productivity Outcomes of workplace Practice, Engagement and Learning. Colin Lindsay - University of Strathclyde
  - Improving management practices, work engagement and workplace innovation for productivity and wellbeing. Patricia Findlay - Strathclyde University
  - Practices and Combinations of Practices for Health and Wellbeing at Work. Kevin Daniels - University of East Anglia
  - Managerial competences, engagement and productivity - developing positive relationships. Richard Saundry - University of Sheffield
  - Understanding and Explaining Management Practices to Promote Higher Productivity in UK Businesses. Rebecca Riley - Kings College London
  - Productivity from Below: Addressing the Productivity Challenges of Microbusinesses. Monder Ram - Aston University
- The Good Employment Learning Lab. Julia Rouse - Manchester Metropolitan University
- Local Institutions, Productivity, Sustainability and Inclusivity Trade-offs (LIPSIT). Nigel Gilbert - University of Surrey
- Mapping the production, diffusion and drivers of future technologies. Mirko Draca - University of Warwick
- From productivity to prosperity: Inclusive growth for the West Midlands. Nigel Driffield - Warwick Business School
- Powering Productivity: Mapping the Role of Energy Infrastructure in UK Labour Productivity using Expert Elicitation and a Thematic Literature Review. Tim Jackson - University of Surrey (project complete)
- Productivity Insights Network. Philip McCann - University of Sheffield

---

E.8.4   Programme outputs and uptake

It was reported that the individual projects are responsible for disseminating their results externally. PIN has completed two well received books, one called 'Productivity and the Pandemic' during COVID. The PIN's relationships with government have developed and deepened since the funding. The other research projects findings are expected within the following few months.

E.8.5   Programme outcomes and impact

E.8.5.1   R&I to address priorities

It was reported that findings and learnings from this programme was fed into the successful wave 2 grant for the Productivity Institute. An example of this is that it was recognised that the

---

reactive fund available to PIN provided the flexibility to respond quickly to emerging priorities and on the basis of this a greater amount of funding was put aside in the Wave 2 bid for 'reactive' funding. It was also reported that it was recognised that a more collaborative centralised approach to the wave 2 programme than was present in the wave 1 funding would be beneficial and would help integration of knowledge and dissemination efforts. It was also reported that the Productivity Institute wave 2 funded programme superseded interest in the TPR programme because it is a much larger, more ambitious and complex programme developed and expected to make a step change in the productivity puzzle. The PI programme was reported to be well supported by government departments, research councils and other stakeholders at a much higher organisational level than the TPR. Furthermore, the findings and outputs from the PIN will be feeding into the Productivity Institute to inform the research areas.

E.8.5.2 Intersectoral collaboration

At present, the issue of intersectoral collaboration in terms of the TPR programme is unclear because of the difficulties in identifying named partner contacts for this programme. It was reported that COVID has delayed research projects and most of the projects have applied for and been granted no cost extensions.

E.8.6 Conclusions

The Transforming Productivity Research programme was designed to produce knowledge and learning on the significant and complex issue of productivity that is to feed into the planning and establishment of the much larger wave 2 Productivity Institute. The outputs of the TPR has and will continue to feed into the PI as more findings from the projects become available.

The loss of organisational memory has proved difficult to draw together a cohesive report about the programme and as progress is made with identifying relevant named partner contacts, this should be addressed by the next iteration of this report.

E.8.7 Interviewees

- Programme lead / co-lead, ESRC
- Government partner, DWP
- Key participant, University of Strathclyde
- Key participant, University of Sheffield

Appendix F   Survey analysis

F.1   Survey of programme leads (programme templates)

1. The name of the programme:		
	Response	**Number**
1 Open-Ended Question	100.00%	33
	answered	33
	skipped	0

2. We would like to understand the extent to which programme partners were involved in the development of the programme idea / bid? Please use a scale from 1 to 5 in each case (where 1 is not involved at all, and 5 is heavily involved). Please type 0 where the programme does not involve this type of partner. If you want to indicate differences between organisations of the same type, please use the comment box after the question.

	0	1	2	3	4	5	Response
Your own organisation	0.0% (0)	0.0% (0)	0.0% (0)	9.1% (3)	0.0% (0)	90.9% (30)	33
UKRI Councils*	0.0% (0)	3.1% (1)	15.6% (5)	18.8% (6)	12.5% (4)	50.0% (16)	32
Government Departments / Agencies	6.7% (2)	3.3% (1)	16.7% (5)	20.0% (6)	23.3% (7)	30.0% (9)	30
Public Sector Research Establishments (PSREs)*	39.3% (11)	25.0% (7)	7.1% (2)	3.6% (1)	7.1% (2)	17.9% (5)	28
Universities / Academia	7.1% (2)	10.7% (3)	7.1% (2)	28.6% (8)	25.0% (7)	21.4% (6)	28
Industry	17.9% (5)	35.7% (10)	17.9% (5)	21.4% (6)	3.6% (1)	3.6% (1)	28
Other	30.0% (6)	15.0% (3)	10.0% (2)	5.0% (1)	5.0% (1)	35.0% (7)	20
* excluding your own						answered	33
						skipped	0
Comments: (19)							

3. Please name the main disciplines involved in this programme:		
	Response	**Number**
1 Open-Ended Question	100.00%	33
	answered	33
	skipped	0

4. Has the programme put in place new or enhanced processes to assess Multi- and Inter-Disciplinary Research and Innovation (MIDRI) proposals for competitive calls / competitions (e.g. in relation to panel composition or scoring criteria)?

			Response	Number
1	New processes have been put in place to assess MIDRI, not implemented before		18.18%	6
2	Enhanced processes have been put in place to assess MIDRI		54.55%	18
3	Existing processes have been used to assess MIDRI		54.55%	18
4	No processes have been put in place that are specifically designed for the assessment of MIDRI proposals		3.03%	1
5	We have not launched competitive calls / competitions		18.18%	6
			answered	33
			skipped	0

Comments: (24)

5. Could you please provide a brief description of any processes employed, and indicate if / how they are different from common practice within your organisation?

		Response	Number
1	Open-Ended Question	100.00%	30
		answered	30
		skipped	3

6. Have you taken any other action to encourage MIDRI proposals. If yes, please describe.

		Response	Number
1	Open-Ended Question	100.00%	27
		answered	27
		skipped	6

7. Is the programme funding (or planning to fund) any of the following activities to bring together insights or knowledge across projects / work packages / research activities?

			Response	Number
1	Coordination workshops (to raise awareness and understanding across the programme)		89.66%	26
2	Synthesis workshops / seminars (to combine insights or knowledge emerging from the programme)		86.21%	25
3	Dissemination activities of programme results		100.00%	29
4	Other (please describe below)		44.83%	13
			answered	29
			skipped	4

Comments: (27)

8. We would be interested in speaking to someone who is leading on these activities. Could you please provide details of a relevant individual below:

		Response	Number
1	Name	100.00%	26
2	Email	84.62%	22
3	Role within the programme	84.62%	22
		answered	26
		skipped	7

9. Is your programme…

			Response	Number
1	Running competitive calls or competitions to award funding?		93.33%	28
2	Awarding funding externally through other means?		33.33%	10
3	Undertaking R&I activities within the partner organisations?		40.00%	12
		answered	30	
		skipped	3	

Comments: (17)

10. If yes to Q7, to what extent are representatives from each of the following types of organisations involved in the call process?

	Involved in defining the call / competition(scope / criteria)	Involved in the bid / proposal review process	Involved in the funding decision	Involved in another capacity	Not Involved / Not yet	Response Total
Representatives from Councils	42.1% (24)	19.3% (11)	24.6% (14)	10.5% (6)	3.5% (2)	57
Representatives from Government Departments / Agencies	37.0% (20)	25.9% (14)	14.8% (8)	14.8% (8)	7.4% (4)	54
Representatives from PSREs	20.0% (7)	17.1% (6)	14.3% (5)	14.3% (5)	34.3% (12)	35
Representatives from Universities / Academia	26.5% (13)	42.9% (21)	14.3% (7)	8.2% (4)	8.2% (4)	49
Representatives from Industry	28.2% (11)	35.9% (14)	7.7% (3)	10.3% (4)	17.9% (7)	39
Other (please specify below)	26.1% (6)	30.4% (7)	21.7% (5)	13.0% (3)	8.7% (2)	23
					answered	30
					skipped	3

Comments: (21)

11. Please indicate the extent to which you agree or disagree with the statements below about the SPF and your programme. SPF has provided funding for a programme that …

	Strongly agree	Agree	Neither agree, nor disagree	Disagree	Strongly disagree	Don't know	NA	Total
… addresses more-complex challenges than would normally be the case	54.5% (18)	27.3% (9)	9.1% (3)	6.1% (2)	0.0% (0)	0.0% (0)	3.0% (1)	33
… it would have been difficult to fund via other means	57.6% (19)	36.4% (12)	3.0% (1)	3.0% (1)	0.0% (0)	0.0% (0)	0.0% (0)	33
… operates at a scale that would not otherwise have been possible	69.7% (23)	30.3% (10)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	33
… involves more / different types of partners than would normally be the case	39.4% (13)	39.4% (13)	15.2% (5)	0.0% (0)	3.0% (1)	0.0% (0)	3.0% (1)	33
							answered	33

12. We are trying to understand the added value of SPF (i.e. the extent to which the Fund has encouraged or enabled a change from "business as usual"). To the best of your knowledge, do you agree or disagree with the following statements: SPF allowed has this programme (and the programme partners) to…

	Strongly agree	Agree	Neither agree, / disagree	Disagree	Strongly disagree	Don't know	NA	Total
… explore & implement new or enhanced ways to support MIDRI	24.2% (8)	42.4% (14)	18.2% (6)	6.1% (2)	0.0% (0)	3.0% (1)	6.1% (2)	33
… improve the ability to attract high quality MIDRI proposals/applications	39.4% (13)	18.2% (6)	21.2% (7)	6.1% (2)	0.0% (0)	3.0% (1)	12.1% (4)	33
… to fund more MIDRI activities	42.4% (14)	36.4% (12)	9.1% (3)	0.0% (0)	0.0% (0)	3.0% (1)	9.1% (3)	33
… explore & implement new or enhanced ways of collaborating with Government Departments	30.3% (10)	27.3% (9)	27.3% (9)	6.1% (2)	0.0% (0)	3.0% (1)	6.1% (2)	33
… explore & implement new or enhanced ways of collaborating with PSREs	18.2% (6)	27.3% (9)	30.3% (10)	3.0% (1)	3.0% (1)	3.0% (1)	15.2% (5)	33
… explore & implement new or enhanced ways of collaborating with other relevant stakeholders	36.4% (12)	33.3% (11)	24.2% (8)	3.0% (1)	0.0% (0)	0.0% (0)	3.0% (1)	33
… improve understanding of Government R&I priorities/ needs	30.3% (10)	27.3% (9)	36.4% (12)	0.0% (0)	0.0% (0)	0.0% (0)	6.1% (2)	33
… fund strategic opportunities that would not have been funded otherwise	54.5% (18)	39.4% (13)	3.0% (1)	0.0% (0)	0.0% (0)	3.0% (1)	0.0% (0)	33
… improve agility in responding to emerging opportunities	21.9% (7)	40.6% (13)	12.5% (4)	18.8% (6)	0.0% (0)	0.0% (0)	6.3% (2)	32
							answered	33

F.2 Survey of CSAs

1. Consent			
Answer Choices		**Response Percent**	**Response Total**
1	I give consent for my response to this questionnaire to be processed and used according to the assurances on confidentiality and data provided in the box below.	100.00%	12

2. Please select the Government department that you represent from the menu below.			
Answer Choices		**Response Percent**	**Response Total**
6	Department for Environment Food & Rural Affairs	37.50%	3
8	Department for Transport	37.50%	3
14	Ministry of Defence	25.00%	2
		answered	8
		skipped	4
Other (not listed): (3) Food Standards Agency, Welsh Government, NPCC (Policing)			

3. Which of the following best describes your knowledge or involvement with the development of SPF programme bids and the subsequent implementation of SPF programmes? Please tick all that apply			
Answer Choices		**Response Percent**	**Response Total**
1	I have been involved in the development of at least one successful SPF programme bid	41.67%	5
2	I have been involved in the subsequent implementation of at least one SPF programme	50.00%	6
3	I have only been involved in the development of unsuccessful SPF programme bids (and have not been involved in the implementation of any SPF programmes)	8.33%	1
4	I have not been involved in the development of any SPF programme bids or the implementation of any SPF programmes	33.33%	4

Those involve in bids

Programme bids

	4. Below you will find a list of all SPF programmes (and lead organisations).Please indicate which of these programmes you have been directly involved in the design of (i.e. developing the programme idea and bid)		%	Total
	Answer Choices		**%**	**Total**
4	Bacterial Plant Diseases (UK Animal and Plant Health) (BBSRC)		20.00%	1
6	A food systems approach for healthy people and a healthy planet (BBSRC)		40.00%	2
24	Constructing a Digital Environment (NERC)		20.00%	1
33	Extreme Photonics Application Centre (EPAC) (STFC)		20.00%	1
			answered	5
			skipped	7

Involvement in programme bids

	5. Thinking about the SPF programmes where you were directly involved at the bid / design stage, which of the following describes your involvement? Please tick all that apply		%	Total
	Answer Choices		**%**	**Total**
1	Identification of area(s) of interest		80.00%	4
2	Provision of inputs for the design of the programme (including scope and activities)		100.00%	5
3	Identification of partners		20.00%	1
4	Provision of support letter		100.00%	5
5	Other (please specify):		20.00%	1
			answered	5
			skipped	7

	6. In your opinion, did the bid development process work well in terms of identifying and addressing cross-departmental government R&I priorities?		%	Total
	Answer Choices		**%**	**Total**
1	Yes, to a great extent		20.00%	1
2	Yes, to some extent		80.00%	4
3	Not at all		0.00%	0
			answered	5
			skipped	7

	7. Do you have any suggestions for improvement in relation to the development of programme ideas and bids (for future iterations of the Fund or similar schemes)?		%	Total
	Answer Choices		**%**	**Total**
1	Open-Ended Question		100.00%	1

Those involve in programmes

SPF Programmes

	9. Below you will find a list of all SPF programmes (and lead organisations).Please indicate the programmes where you have been directly involved in the implementation			
	Answer Choices		**%**	**Total**
4	Bacterial Plant Diseases (UK Animal and Plant Health) (BBSRC)		14.29%	1
6	A food systems approach for healthy people and a healthy planet (BBSRC)		28.57%	2
10	Protecting Citizens Online (EPSRC)		14.29%	1
24	Constructing a Digital Environment (NERC)		14.29%	1
30	UK Climate Resilience (NERC & Met Office)		14.29%	1
33	Extreme Photonics Application Centre (EPAC) (STFC)		14.29%	1
			answered	7
			skipped	5

Your involvement in SPF programme implementation

	10. Thinking about the SPF programmes where you have been involved in their implementation, which of the following describes your involvement? Please tick all that apply			
	Answer Choices		**%**	**Total**
1	Member of programme Advisory Board		28.57%	2
2	Providing advice on research agenda		71.43%	5
3	Providing advice on the implementation of activities		14.29%	1
4	Involvement in designing calls for proposals		57.14%	4
5	Involvement in assessing proposals		57.14%	4
6	Involvement in dissemination activities		28.57%	2
7	Other (please specify):		14.29%	1
			answered	7
			skipped	5

	11. In your opinion, is this degree of involvement fit for purpose to capture CSA insights and address R&I priorities?			
	Answer Choices		**%**	**Total**
1	Yes, to a great extent		42.86%	3
2	Yes, to some extent		57.14%	4
3	Not at all		0.00%	0
			answered	7
			skipped	5

12. Do you have any suggestions for improvement to these aspects (for future iterations of the Fund or similar schemes)?

	Answer Choices	%	Total
1	Open-Ended Question	100.00%	3

13. In your opinion, what are the key factors that support a fruitful collaboration between government departments and Research Councils (to address government department R&I priorities)?

	Answer Choices	%	Total
1	Open-Ended Question	100.00%	6

SPF added value

14. Please indicate the extent to which you agree or disagree with the statements below about the SPF, based on your experience and involvement across one or more SPF programmes.The SPF has provided funding for programmes that …

Answer Choices	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	Don't know	N/A	Total
… address more-complex challenges than would normally be the case	0.00% 0	85.71% 6	14.29% 1	0.00% 0	0.00% 0	0.00% 0	0.00% 0	7
… it would have been difficult to fund through other means	28.57% 2	42.86% 3	14.29% 1	14.29% 1	0.00% 0	0.00% 0	0.00% 0	7
… operate at a scale that would not otherwise have been possible	42.86% 3	42.86% 3	0.00% 0	14.29% 1	0.00% 0	0.00% 0	0.00% 0	7
… involve more / different types of partners than would normally be the case	14.29% 1	42.86% 3	28.57% 2	0.00% 0	14.29% 1	0.00% 0	0.00% 0	7
							answered	7
							skipped	5

15. We are trying to understand the added value of SPF (i.e. the extent to which the Fund has encouraged or enabled a change from "business as usual"). To the best of your knowledge, do you agree or disagree with the following statements:The SPF has encouraged or enabled programmes (and programme partners) to…

Answer Choices	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	Don't know	N/A	Total
… explore and implement new or enhanced ways to support MIDRI	0.00% 0	57.14% 4	28.57% 2	0.00% 0	0.00% 0	14.29% 1	0.00% 0	7
… improve the ability to attract high quality MIDRI proposals/applications	28.57% 2	28.57% 2	14.29% 1	14.29% 1	0.00% 0	14.29% 1	0.00% 0	7
… fund more MIDRI activities	14.29% 1	57.14% 4	0.00% 0	14.29% 1	0.00% 0	14.29% 1	0.00% 0	7
… explore and implement new or enhanced ways of collaborating with Government Departments	0.00% 0	71.43% 5	14.29% 1	14.29% 1	0.00% 0	0.00% 0	0.00% 0	7

15. We are trying to understand the added value of SPF (i.e. the extent to which the Fund has encouraged or enabled a change from "business as usual"). To the best of your knowledge, do you agree or disagree with the following statements:The SPF has encouraged or enabled programmes (and programme partners) to…								
… explore and implement new or enhanced ways of collaborating with Public Sector Research Establishments (PSREs)	28.57% 2	57.14% 4	14.29% 1	0.00% 0	0.00% 0	0.00% 0	0.00% 0	7
… explore and implement new or enhanced ways of collaborating with other relevant stakeholders	0.00% 0	71.43% 5	28.57% 2	0.00% 0	0.00% 0	0.00% 0	0.00% 0	7
… improve understanding of Government R&I priorities and needs	14.29% 1	71.43% 5	0.00% 0	14.29% 1	0.00% 0	0.00% 0	0.00% 0	7
… fund strategic opportunities that would not have been funded otherwise	42.86% 3	42.86% 3	0.00% 0	14.29% 1	0.00% 0	0.00% 0	0.00% 0	7
… improve agility in responding to emerging opportunities	28.57% 2	42.86% 3	14.29% 1	14.29% 1	0.00% 0	0.00% 0	0.00% 0	7
							answered	7
							skipped	5

16. What has been the single most important benefit of having the SPF funding?		
Answer Choices	**%**	**Total**
1 Open-Ended Question	100.00%	6

Research and Innovation outputs

17. Please indicate the extent to which you agree or disagree with statements about the R&I outputs expected to emerge from the different SPF programmes in which you have been involved.R&I outputs are expected to…								
Answer Choices	**Strongly agree**	**Agree**	**Neither agree nor disagree**	**Disagree**	**Strongly disagree**	**Don't know**	**N/A**	**Total**
… be of better quality (in comparison with those emerging from other sources of funding)	16.67% 1	33.33% 2	50.00% 3	0.00% 0	0.00% 0	0.00% 0	0.00% 0	6
… be of more relevance to the work of my Government department (in comparison with those emerging from other sources of funding)	28.57% 2	42.86% 3	14.29% 1	0.00% 0	14.29% 1	0.00% 0	0.00% 0	7
… have a higher uptake within my Government department (in comparison with those emerging from other sources of funding)	28.57% 2	28.57% 2	28.57% 2	14.29% 1	0.00% 0	0.00% 0	0.00% 0	7
							answered	7
							skipped	5

18. How confident are you that the SPF programmes that you are aware of will help to address the originally identified priorities / challenges?

	Answer Choices		%	Total
1	Very confident		28.57%	2
2	Somewhat confident		57.14%	4
3	Not confident at all		0.00%	0
4	Too soon to tell		14.29%	1
			answered	7
			skipped	5

Examples of notable achievements

19. We understand that the SPF programmes are still at an early stage, but we are interested in capturing any interesting early developments with respect to the research and activities that are being funded. Do you have any examples of notable achievements emerging from the programmes?

	Answer Choices		%	Total
1	Yes		66.67%	4
2	No		33.33%	2
			answered	6
			skipped	6

20. Are you aware of any findings emerging from SPF programmes being taken up within government so far?

	Answer Choices		%	Total
1	Yes		33.33%	2
2	No		16.67%	1
3	Too soon to tell		50.00%	3
			answered	6
			skipped	6

Further Recommendations

21. If a new Wave of SPF programme funding, or similar, were to be launched what would you recommend in terms of

	Answer Choices	%	Total
1	Maximising its ability to address government R&I priorities?	80.00%	4
2	Ensuring a fruitful collaboration between government departments and Research Councils to address those priorities?	100.00%	5
		answered	5
		skipped	7

Those involved in only unsuccessful bids

The programme idea

	22. The following question asks about the unsuccessful programme bid that you were involved with. What best describes what happened to the programme idea addressed by the bid you were involved with (specifically to the elements that concern your department R&I priorities). Please tick all that apply			
	Answer Choices		**%**	**Total**
1	The department is pursuing research in that area, but with fewer resources (budget)		0.00%	0
2	The department is pursuing research in that area, but with a narrower scope		0.00%	0
3	The department is pursuing research in that area, but not in with UKRI		0.00%	0
4	The department is not pursuing research in that area for the time being		100.00%	1
			answered	1
			skipped	11

Value added of SPF

23. Please indicate the extent to which you agree or disagree with the statements below about the SPF, based on your knowledge of the Fund.The SPF provides funding for programmes that …								
Answer Choices	**Strongly agree**	**Agree**	**Neither agree nor disagree**	**Disagree**	**Strongly disagree**	**Don't know**	**N/A**	**Total**
… address more-complex challenges than would normally be the case	0.00% 0	100.00% 1	0.00% 0	0.00% 0	0.00% 0	0.00% 0	0.00% 0	1
… would have been difficult to fund via other means	0.00% 0	100.00% 1	0.00% 0	0.00% 0	0.00% 0	0.00% 0	0.00% 0	1
… operate at a scale that would not otherwise have been possible	0.00% 0	100.00% 1	0.00% 0	0.00% 0	0.00% 0	0.00% 0	0.00% 0	1
… involve more / different types of partners than would normally be the case	0.00% 0	100.00% 1	0.00% 0	0.00% 0	0.00% 0	0.00% 0	0.00% 0	1
							answered	1
							skipped	11

	24. What would have been the main added value of implementing the programme bid you were involved with?		
	Answer Choices	**%**	**Total**
1	Open-Ended Question	100.00%	1

Recommendations

	25. If a new Wave of SPF funding, or similar, were to be launched what would you recommend in terms of		
	Answer Choices	**%**	**Total**
1	Maximising its ability to address government R&I priorities?	100.00%	1
2	Ensuring a fruitful collaboration between government departments and Research Councils to address those priorities?	100.00%	1

For those not involved in SPF bids/programmes

Reasons for no involvement

	26. Which of the following best explains the reasons why you have not been involved in an SPF programme bid or in the subsequent implementation of an SPF programme. Please tick all that apply			
	Answer Choices		**%**	**Total**
1	I am new to my position		66.67%	2
2	The government department I represent decided not to participate		33.33%	1
3	The timing of the applications meant we could not participate		0.00%	0
4	We did not manage to find the right partners to put together a strong bid in our areas of interest		0.00%	0
			answered	3
			skipped	9

Value added of SPF

27. Please indicate the extent to which you agree or disagree with the statements below about the SPF, based on your knowledge of the Fund. The SPF provides funding for programmes that …								
Answer Choices	**Strongly agree**	**Agree**	**Neither agree nor disagree**	**Disagree**	**Strongly disagree**	**Don't know**	**N/A**	**Total**
… address more-complex challenges than would normally be the case	0.00% 0	33.33% 1	66.67% 2	0.00% 0	0.00% 0	0.00% 0	0.00% 0	3
… it would have been difficult to fund through other means	0.00% 0	66.67% 2	33.33% 1	0.00% 0	0.00% 0	0.00% 0	0.00% 0	3
… operate at a scale that would not otherwise have been possible	33.33% 1	33.33% 1	33.33% 1	0.00% 0	0.00% 0	0.00% 0	0.00% 0	3
… involve more / different types of partners than would normally be the case	0.00% 0	33.33% 1	66.67% 2	0.00% 0	0.00% 0	0.00% 0	0.00% 0	3
							answered	3
							skipped	9

Recommendations

	28. If a new Wave of SPF programme funding, or similar, were to be launched what would you recommend in terms of		
	Answer Choices	**%**	**Total**
1	Maximising its ability to address government R&I priorities?	100.00%	4
2	Ensuring a fruitful collaboration between government departments and Research Councils to address those priorities?	100.00%	4
		answered	4
		skipped	8

F.3   Survey of Programme Advisory Board members

	1. Please indicate that you give consent.			
			Response Percent	**Response Total**
1	I give consent for my response to this questionnaire to be processed and used according to the assurances on confidentiality and data provided above.		100.00%	89

2. Characteristics

	2. Please enter the name of the programme mentioned in your invitation email.			
			Response Percent	**Response Total**
1	Open-Ended Question		100.00%	85

	3. Which of the following organisations do you represent, in your capacity of Advisory Board member for this SPF programme?			
			Response Percent	**Response Total**
1	UKRI		3.49%	3
2	UKRI Councils		3.49%	3
3	Government Departments / Agencies		4.65%	4
4	Public Sector Research Establishments (PSREs)		1.16%	1
5	Universities / Academia		45.35%	39
6	Industry		11.63%	10
7	None of the above (personal capacity)		10.47%	9
8	Other (please specify):		19.77%	17
			answered	86
			skipped	3

	4. As part of your professional life, are you directly involved in conducting research?			
			Response Percent	**Response Total**
1	Yes		76.74%	66
2	No		23.26%	20
			answered	86
			skipped	3
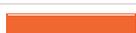
5. Are you?			Response Percent	Response Total
1	Male		50.59%	43
2	Female		47.06%	40
3	Other		0.00%	0
4	Prefer not to say		2.35%	2
			answered	85
			skipped	4

3. Advisory Board function(s)

6. What best describes your involvement in the programme, as part of the Advisory Board? (tick all that apply)			Response Percent	Response Total
1	Providing advice on the R&I agenda		79.07%	68
2	Providing advice on implementation of activities		75.58%	65
3	Involvement in designing calls for proposals		50.00%	43
4	Involvement in assessing proposals		37.21%	32
5	Involvement in knowledge synthesis activities		30.23%	26
6	Involvement in dissemination activities		38.37%	33
7	Other (please specify):		15.12%	13
			answered	86
			skipped	3

Other (please specify): (13)

4. SPF value added

7. Please indicate the extent to which you agree or disagree with the statements below about the SPF programme. SPF has provided funding for a programme that …	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	Don't know	N/A	Response Total
… addresses more-complex challenges than would normally be the case	38.4% (33)	50.0% (43)	7.0% (6)	2.3% (2)	1.2% (1)	0.0% (0)	1.2% (1)	86

7. Please indicate the extent to which you agree or disagree with the statements below about the SPF programme. SPF has provided funding for a programme that …

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	Don't know	N/A	Response Total
… it would have been difficult to fund through other means	40.7% (35)	41.9% (36)	9.3% (8)	4.7% (4)	0.0% (0)	3.5% (3)	0.0% (0)	86
… operates at a scale that would not otherwise have been possible	43.0% (37)	44.2% (38)	7.0% (6)	3.5% (3)	1.2% (1)	1.2% (1)	0.0% (0)	86
… involves more / different types of partners than would normally be the case	38.4% (33)	39.5% (34)	17.4% (15)	1.2% (1)	1.2% (1)	2.3% (2)	0.0% (0)	86
							answered	86
							skipped	3

Do you wish to make any additional comments on any of these areas? (27)

8. We are trying to understand the added value of SPF (i.e. the extent to which the Fund has encouraged or enabled a change from "business as usual"). To the best of your knowledge, do you agree or disagree with the following statements:SPF has allowed this programme (and the programme partners) to…

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	Don't know	N/A	Response Total
… explore and implement new or enhanced ways to support multi- and inter – disciplinary research (MIDRI)	36.0% (31)	48.8% (42)	9.3% (8)	1.2% (1)	1.2% (1)	3.5% (3)	0.0% (0)	86
… improve the ability to attract high quality MIDRI proposals/applications	25.9% (22)	45.9% (39)	11.8% (10)	4.7% (4)	1.2% (1)	8.2% (7)	2.4% (2)	85
… fund more MIDRI activities	21.4% (18)	47.6% (40)	14.3% (12)	3.6% (3)	0.0% (0)	8.3% (7)	4.8% (4)	84
… explore and implement new or enhanced ways of collaborating with Government Departments	21.2% (18)	28.2% (24)	32.9% (28)	7.1% (6)	0.0% (0)	8.2% (7)	2.4% (2)	85
… explore and implement new or enhanced ways of collaborating with PSREs	8.2% (7)	38.8% (33)	23.5% (20)	7.1% (6)	1.2% (1)	20.0% (17)	1.2% (1)	85
… explore and implement new or enhanced ways of collaborating with other relevant stakeholders	17.4% (15)	55.8% (48)	16.3% (14)	5.8% (5)	1.2% (1)	3.5% (3)	0.0% (0)	86
… improve understanding of Government R&I priorities and needs	16.7% (14)	35.7% (30)	33.3% (28)	8.3% (7)	1.2% (1)	4.8% (4)	0.0% (0)	84

8. We are trying to understand the added value of SPF (i.e. the extent to which the Fund has encouraged or enabled a change from "business as usual"). To the best of your knowledge, do you agree or disagree with the following statements:SPF has allowed this programme (and the programme partners) to…	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	Don't know	N/A	Response Total
… fund strategic opportunities that would not have been funded otherwise	41.2% (35)	45.9% (39)	5.9% (5)	4.7% (4)	0.0% (0)	2.4% (2)	0.0% (0)	85
… improve agility in responding to emerging opportunities	18.6% (16)	40.7% (35)	30.2% (26)	4.7% (4)	1.2% (1)	3.5% (3)	1.2% (1)	86
						answered		86
						skipped		3

Do you wish to make any additional comments on any of these areas? (11)

6. Final questions

9. In your view, what is the single most important benefit of having the SPF fund?		Response Percent	Response Total
1	Open-Ended Question	100.00%	79

10. Are there any other comments you would like to make about the Strategic Priorities Fund or the Advisory Board / Group for this programme?		Response Percent	Response Total
1	Open-Ended Question	100.00%	45

11. Thank you for taking the time to complete this questionnaire.The study team would like to conduct a short follow-up interview with some respondents to explore their answers in more depth. This will provide an opportunity to collect additional feedback that may inform future iterations of the SPF. Would you be happy to be contacted further for the evaluation?			Response Percent	Response Total
1	Yes*		56.47%	48
2	No		43.53%	37

*If yes, please provide the best email address to contact you with: (44)

technopolis |group

www.technopolis-group.com