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Science and Technology Facilities Council

Specification for
UKRI-2183 SWIMMR S6: An Updated Space Weather Impact Assessment Study

Background

Over the last decade, a considerable amount of activity has been devoted to establishing the technical case behind the study of space weather processes, their prediction and the mitigation of potential impacts. Notable examples of relevance to the UK include the Royal Academy of Engineering's 2013 report "Extreme space weather: impacts on engineered systems and infrastructure" (Cannon et al, 2013) and the work of the Space Environment Impacts Expert Group (SEIEG), which forms part of the advisory mechanism for UK Civil Contingencies. In addition, the economic case for the importance of space weather prediction and mitigation has been demonstrated in a number of recently published papers, including those by Oughton et al (2017) (Space Weather, doi 10.1002/2016SW001491) and Eastwood et al (2018) (Space Weather, doi 10.1029/2018SW002003) - though these concentrated mainly on effects on the electric power grid. These have established a formidable scientific and technical case for space weather monitoring and research, which partly led to the SWIMMR programme. The economic and national strategic motivations for UK activity in space weather have also been captured in a number of previous studies, including work done by the insurance and risk analysis communities.

As scientific knowledge has evolved, new technologies have also emerged (e.g. 5G mobile communications, interconnected power grids, increased miniaturisation, more use of COTS components, proliferation of small satellites in LEO, new technologies for PNT applications, autonomous/connected vehicles for road, maritime and air). In addition, future technological systems (e.g. optical communications, quantum systems and graphene enabled system components) are being developed, which may have as yet undocumented space weather vulnerabilities.

A need now exists to build upon and extend the findings reported in Cannon et al (2013), taking account of these recent technological developments and identifying whether (and how) it might be necessary to broaden the scope of the currently-existing set of economic impact studies. In addition, account should be taken of recent scientific developments, such as new studies on the relative frequencies and impacts of more moderate space weather events, as compared to the extreme events considered in the 2013 report.

Objectives

The objective of the SWIMMR S6 project is to produce a report, building on and extending the 2013 Royal Academy of Engineering Report by Cannon et al, capturing the current scientific and technical rationale behind UK activities in space weather. The report should cover national strategic and economic factors, referenced to the various types of technical activity which the UK is currently undertaking, including those documented in the 2013 Royal Academy of Engineering Report. Reference should be made to established scenarios, such as "reasonable worst case" scenarios and other assumptions and language used in UK civil contingency planning for space weather resilience. In order to properly include the latest science and optimise the link between the report and the scientific advice provided to government, it is anticipated that the study leaders should work with academic partners, such as members of SEIEG, whose efforts should be reimbursed as required.

Given the context above, project S6 aims to:

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1. Produce an updated assessment of the technological and engineering impacts of space weather, focusing on the UK, which builds on and extends that identified in the 2013 Royal Academy of Engineering report (Cannon et al, 2013).

2. Extend the Cannon et al (2013) report by updating the scientific context and identifying new areas of potential space weather impact for which socio-economic impact studies should be performed, thus enabling more accurate future assessments of the cost of damage avoided through investment in space weather forecasting capability and monitoring infrastructure

3. Identify the strategic drivers for continued UK investment in space weather activities. These should include considerations related to national resilience, national security, industrial development, international partnerships and scientific advances.

   Consideration should be given to the strategic balance between stand-alone national activities and collaborative international developments. While the focus should be on space weather, motivations involving synergistic connections to other fields such as space safety, navigation, telecommunications and the transport and travel industries should also be taken into account. As well as the motivating factors for space weather work, the report could also consider the issue of potential future funding routes and possible ways to address the market failures which have historically restricted space weather prediction to public sector funding.

   In achieving these aims, the study will provide a clear overview of the context within which the SWIMMR programme is operating, which will be of considerable use for the final Monitoring and Evaluation of the programme. The output of the study will be a completed, peer reviewed report, for publication in the open literature, which would act as a reference document for the various SWIMMR stakeholders, including Research Councils, Public Sector Research Establishments and Government Ministries.

Deliverables

The required deliverables for this call should include:

- A published, peer reviewed report, updating the assessment of the engineering and technical impacts of space weather contained in the report by Cannon et al (2013) and setting out the economic and strategic national case for UK activities in space weather, including analyses of the cases for stand-alone national activities and collaborative international efforts
- A section containing an updated overview of space weather risks, taking into account recent research results on the frequency, severity and impact of events.
- A section addressing the current extent of socio-economic studies of space weather impacts, summarising any new areas, e.g. arising from recent technology developments, in which further such studies are required.
- A supporting bibliography, justifying the evidence base for any conclusions and recommendations relevant to the UK, including examples from other countries as appropriate.

Research Elements

This activity is not foreseen as requiring a great deal of new technique development. The inclusion of academic partners, whose efforts should be reimbursed as required, is recommended, in order that recent scientific results should be properly understood and assimilated.

Assumptions and dependencies on other SWIMMR projects

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Since the SWIMMR programme is, in itself, a way of increasing UK resilience to space weather, consideration should be given to the motivations for activities in the other SWIMMR project areas (broadly space and aerospace radiation, solar wind prediction, ionospheric and thermospheric modelling and prediction of induced currents). This could include critiquing and supplementing the economic case for SWIMMR as outlined in the original business case for the programme. A useful output of the S6 project would be an independent analysis of the economic and strategic case for each of the SWIMMR activities, including suggestions for follow-on work, either on a national level or in concert with international partners. In order to do this, participants in the S6 activity should maintain close links to the other SWIMMR projects, in order to make an assessment of the value of the developments which have been achieved.

There is significant value in maintaining a good linkage between the S6 activity, the SWIMMR Strategic Advisory Group and the UKRI Monitoring and Evaluation Team. One of the roles of Monitoring and Evaluation is to establish whether the SWIMMR study is achieving the benefits identified in its economic case, so an independent analysis of the rationale for activity in the various SWIMMR areas would be a valuable contribution for the M&E activity. Likewise, advice from the Strategic Advisory Group is of value for shaping the SWIMMR programme in detail, and certainly for the community positioning for potential successor activities, so that any suggestions from project S6 to the Strategic Advisory Group as to how SWIMMR might evolve to maximise its economic benefit would be of value.

In order to ensure good engagement with the UK community of space weather scientists, data users and policy makers, it is assumed that the successful applicants will want to organise a number of networking and community engagement events, to ensure that all relevant inputs can be captured. It is also assumed that the successful applicants will consult actively with members of SEIEG, to ensure that the space weather risks and contingencies being considered are aligned with those used in UK civil contingency planning.

Milestones

S6 is the smallest of the STFC studies and flexibility will be given to proposing groups to decide how best to structure the work. The following table of milestones illustrates the expectations of STFC and the Met Office, but the proposers may suggest earlier timings for milestones, respecting the length of the overall project, which should end by 29/02/2024.

Table 1: Milestones

DN1.1	Initial report on technical approach and proposed reporting structure, including specification of selected academic partners.	No later than 31/10/2022
DN1.2	Interim analysis of SWIMMR activities	No later than 31/05/2023
DN1.3	Final report including updated scientific rationale, technological impacts, recommendations for new socio-economic analyses, and strategic case for space weather activities in the UK, provided for peer review	No later than 31/01/2024

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DN1.4	Publication of the report	No later than 29/02/2024

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