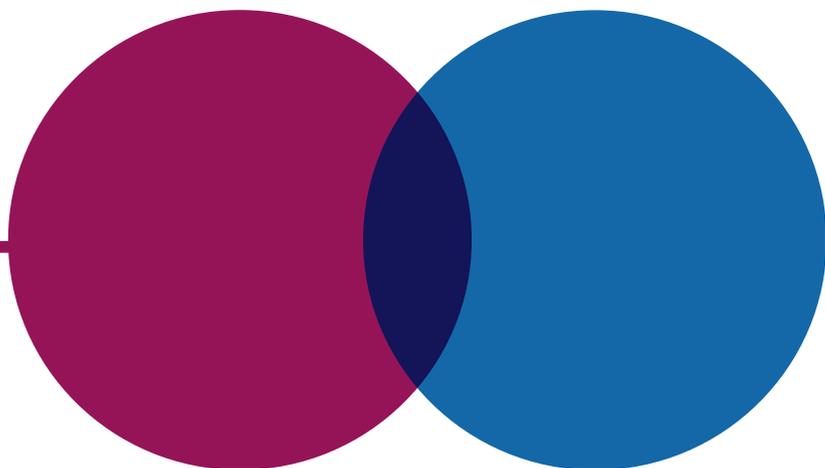




National Audit Office



REPORT

# The UK's resilience to severe space weather

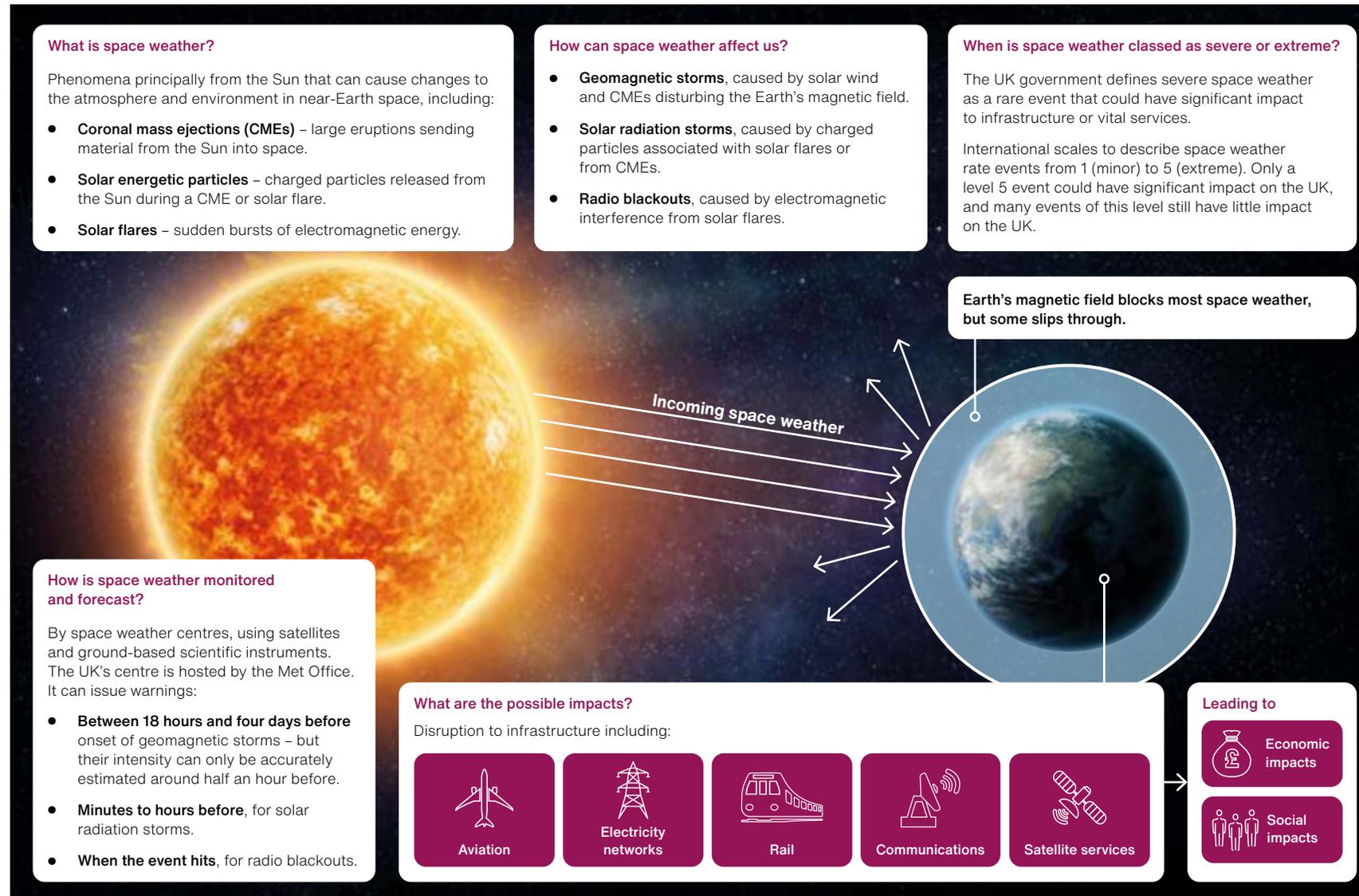
Department for Science, Innovation & Technology

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**Figure 1**  
Introduction to space weather

Phenomena principally from the Sun can cause disruption to infrastructure on Earth



Source: National Audit Office analysis of publicly available information

# Summary

**1** The Cabinet Office sets out the most serious acute risks facing the UK in the government's classified National Security Risk Assessment (NSRA) and public-facing National Risk Register. Severe space weather has been on the National Risk Register since 2011 as one of the most serious natural and environmental hazards. In 2025, the government considered the likelihood of a severe space weather event occurring within the next five years to be 5–25%.

**2** Space weather originates from solar activity (**Figure 1**) and mostly causes no tangible disruption. Severe space weather can, however, disrupt a range of technologies. The largest event on record (September 1859), known as the 'Carrington event', affected telegraph communications.<sup>1</sup> It is expected that a similar event today would have significant and wide-ranging impacts due to advancements in, and increasing dependence on, technologies. For example, an event could cause the widespread disruption of air travel for multiple weeks, localised power outages in the UK, and disruption to satellite services such as satellite navigation and timing services used by many sectors. The Cabinet Office assigns ownership of NSRA risks to lead government departments, covering the following: risk identification and assessment; prevention, resilience, preparation and emergency response; and recovery. The Department for Science, Innovation & Technology (DSIT) coordinates the government's work on severe space weather, having formally taken on this role in December 2025. It is the parent department for the Met Office and the policy owner for the UK civil space sector. The Met Office is responsible for risk identification and risk assessment.

**3** In September 2021, the government published its *UK Severe Space Weather Preparedness Strategy* (the Strategy) setting an ambition to build the UK's resilience to the risk of severe space weather, while also collaborating with international partners and making science and technology integral to addressing this risk. DSIT told us it is planning to develop a new severe space weather preparedness strategy and is currently in the evidence-gathering phase.

<sup>1</sup> A solar flare on 1 September 1859 triggered a geomagnetic storm that is broadly accepted to be the largest on record.

**4** This report examines the government's work to increase the UK's resilience to the risk of severe space weather. It forms part of a broader programme of reviews examining preparedness for a range of risks on the NSRA and is intended to provide insights useful for the management of other risks. It covers:

- the extent to which the government understands the risks and potential cascading effects of severe space weather, and the adequacy of governance arrangements in place to oversee preparedness (Part One);
- the adequacy of the UK's forecasting capability (Part Two); and
- the adequacy and completeness of the government's response plans (Part Three).

**5** The cross-cutting nature of the risk and its impacts requires coordinated action to be taken across government and beyond. This report sets out how central government coordinates, supports and assures local activity. It does not directly cover local response arrangements, nor is it a comprehensive assessment of whether the UK is prepared for a severe space weather event. This report also does not cover arrangements in the devolved nations or activities in the remit of the Ministry of Defence.

## **Key findings**

### Understanding the risk, and oversight arrangements

**6** **The government is improving its understanding of the UK's vulnerability to severe space weather but does not yet understand the full range of possible impacts and cascading effects well.** The Met Office is responsible for assessing the risk of severe space weather on behalf of the government. It does so by drawing on the expertise of the Space Environment Impacts Expert Group and using a reasonable worst-case scenario (based on an event of approximately the same magnitude as the Carrington event), in line with Cabinet Office guidance. The government has a good understanding of some of the initial and knock-on impacts of this scenario. For example, it understands that an event could cause localised power outages in the UK, and the effects a loss of electricity could have on many services. However, limitations in scientific understanding and departmental planning mean the possible impacts and cascading effects on some sectors, such as the potential scale of impacts from space weather-induced errors in digital systems and how short disruptions to global navigation satellite systems would affect transport, are not well understood. The potential economic impact on the UK – estimated in 2022 at around £9 billion – is also uncertain. The government's understanding of the UK's vulnerability to severe space weather is improving as the science develops (paragraphs 1.3 to 1.8 and Figures 2 and 3).

**7 The government has not yet set out how resilient it would like the UK to be to severe space weather nor what level of resilience its spending will provide.**

The government's 2021 strategy included 12 high-level commitments aimed at improving resilience. It did not include target levels of preparedness or resilience, the outcomes it is seeking, or any cost estimates or additional specific public funding. It also did not consider the amount of risk the government is willing to accept (known as its risk appetite). We identified areas of existing spending including around £6.7 million in 2025-26 on the Met Office Space Weather Operations Centre, and around £300 million to date committed to the European Space Agency's (ESA's) Vigil space weather mission, although this is unlikely to be comprehensive. The government does not know its total spending on managing the risk of severe space weather. Many investments which increase resilience to severe space weather also increase resilience to other risks, so isolating funding for one particular risk is difficult. Private sector organisations also invest in resilience, and the government's regulation can encourage this. In the 2025 Spending Review, the Cabinet Office analysed resilience-related spending proposals across government and advised HM Treasury on which should be prioritised. Five packages of spending bids included resilience to severe space weather as a large part of their justification. The government has not, however, mapped out the totality of its requirement or reviewed whether the spending package meets its overall requirements (paragraphs 1.9 to 1.15).

**8 Roles in managing the risk of severe space weather are not clearly defined, and accountabilities and assurance arrangements could be stronger.**

The Cabinet Office has assigned roles to four public bodies: the Met Office is responsible for risk identification and risk assessment; and DSIT, the Department for Energy Security & Net Zero (DESNZ) and the Department for Transport are responsible for prevention, resilience, preparation and emergency response depending on the policy areas. Although not formally assigned the role of overall lead government department, DESNZ coordinated the government's work on severe space weather across all areas until April 2025, when DSIT took over with a transition period running over the summer, and the transfer formalised in December 2025. The Cabinet Office's guidance for lead government departments does not explain what processes should be followed, nor does it set minimum standards. It told us it intends to publish new written expectations on the role by summer 2026. As the coordinators, DESNZ and DSIT have overseen cross-government work through a steering group. However, DESNZ told us it had difficulty getting senior officials to regularly attend and, in some instances, found it challenging to galvanise action from other government departments. We also found some confusion over what individual departments were responsible for. The government does not have an up-to-date assessment of progress against the aims of the 2021 strategy (paragraphs 1.16 to 1.23 and Figures 4 and 5).

## The UK's forecasting capability

**9 The Met Office has played a vital role in establishing and enhancing the UK's forecasting capability.** In 2014, the Met Office opened its Space Weather Operations Centre (the Operations Centre), which it reports to be one of a handful of 24/7 space weather prediction centres globally. Forecasting continues to be a scientifically complex challenge, however, with a forecasting window of up to 96 hours depending on the type of space weather. The Operations Centre issues space weather alerts and specialist forecasts that can help sectors take preventative action, for example shutting down at-risk electricity transformers to prevent damage. We found the Operations Centre is well regarded internationally, with international forecasters drawing on its expertise, for example for training and technical advice (paragraphs 2.2 to 2.5 and 2.8 and 2.16, and Figure 6).

**10 The Met Office has built the UK's space weather monitoring and forecasting capability with limited resources, but the resilience of these services remains vulnerable.** Predicting space weather relies primarily on satellite data. The Operations Centre had a budget of around £6.7 million in 2025-26. As the UK does not have any of its own space weather satellites, the Met Office has an agreement with the United States' Space Weather Prediction Center to use data from satellites owned by the United States and to collaborate on forecasting. Some of the satellites the UK relies on have passed, or are nearing the end of, their predicted lifespan, and several are primarily scientific missions with scientific research taking priority over forecasting. To improve resilience, the Met Office uses data from multiple satellites in case one goes out of service, and it told us it is working with international partners to formalise its data-sharing arrangements; however, this will not fully ensure the resilience of the UK's capability (paragraphs 2.3, 2.9 and 2.10, and Figure 7).

**11 There is more to do to make forecasting information useful for government officials and industry.** Forecasting can only be effective if it is meaningful for those needing to take action. To describe conditions and their potential impacts, the UK uses the United States' National Oceanic and Atmospheric Administration's space weather scales, which are currently being revised to be more meaningful to users. We found the Met Office has worked collaboratively with some sectors, for example the electricity sector, to develop specialist forecasts. However, other sectors continue to find the technical information difficult to interpret. The Met Office is developing its communications, and during the May 2024 space weather event, it issued a new-format briefing with more specific details on the type and scale of likely impacts (paragraphs 2.15 to 2.17 and Figure 8).

**12 The government is investing in programmes to advance the UK's future space weather forecasting capability.** The UK is a member of ESA, which provides access to large-scale multi-national space programmes that are challenging to replicate nationally. This includes the government taking a leading role in supporting ESA's space weather mission, Vigil, which aims to improve the accuracy of forecasts of coronal mass ejection arrival times, giving more confident estimates of when impacts will be felt. To date, the UK has contributed just over half of the overall funding, with a total UK commitment to date in the region of £300 million. The Vigil satellite is currently expected to launch in 2031, with an operational life of five years. DSIT, with the Met Office, has begun to consider future programmes beyond this mission but has not yet initiated formal planning, creating uncertainty over how resilience will be maintained in future decades (paragraphs 2.11 to 2.14).

The government's response planning

**13 The maturity and completeness of response plans across the government varies, with departments taking a variety of approaches.** We would expect departments to assess the suitability for severe space weather of their generic response plans, fill in any gaps with risk-specific planning, and share their plan with the risk's lead government department. In 2023 and 2024, DESNZ requested information on sector response planning from relevant government departments and received limited replies. Plans in the electricity and aviation sectors were the most mature and specific.<sup>2</sup> Departments outlined a range of reasons for not producing plans, including the following: competing priorities; lack of resources; a lack of mechanisms to engage with a sector; and a lack of response and planning structures within some relevant organisations. Some sector teams we spoke to also described limitations in their understanding of the risk or the potential impacts. In February 2026, DSIT commissioned updated response plans from departments, but to date there has been no central assurance over the separate plans to ensure they are sufficient to enable an effective response (paragraphs 3.2 to 3.8).

**14 The government has begun testing the effectiveness of response plans, but to date tests have been limited in number and scope.** It is essential that the government gains assurance that response plans are fit-for-purpose for all relevant risks, many of which are managed by organisations outside the government's direct control. The government does this by reviewing and approving plans and testing them through discussion and simulation exercises. DESNZ ran three discussion exercises in 2024, and DSIT is in the process of applying the lessons learned and deciding its plans for future exercises. A full simulation exercise involving local responders has not yet been run. We found that other government departments have also carried out exercises and workshops, but there is no systematic learning from these. Past reviews of the NSRA process also argued that the government should avoid treating the reasonable worst-case scenario as a prediction and should consider a range of ways in which risks could manifest (paragraphs 3.2 and 3.14 to 3.19).

<sup>2</sup> We have been told that Defence also has specific procedures, but these fell outside the scope of this review, and we have therefore not audited these plans.

**15 The government has yet to define actions for businesses and citizens in the event of a severe space weather emergency.** In the government's *2025 Resilience Action Plan*, it set an objective to enable the whole of society to take action to increase their resilience. In May 2024, the government launched its *Prepare* public information website to help citizens prepare for emergencies and be more informed about hazards. For severe space weather, however, it has yet to identify any actions it would want individuals or businesses to take before or during an event. We found the Met Office has undertaken work seeking to raise public awareness of space weather and its potential impacts. The government has an outline communications plan for severe space weather events, which it plans to revise and expand, but it has not yet developed pre-agreed messages for the public in the event of a severe space weather emergency, risking an ineffective whole-of-society approach (paragraphs 3.20 to 3.22).

### **Concluding remarks**

**16** The government has identified severe space weather as a risk with potentially significant impacts that the UK must adequately prepare for and respond to. Since it first included it in the UK's National Risk Register in 2011, the government has invested in developing and enhancing the UK's forecasting capability and encouraged awareness of the risk it presents. The Met Office is well respected internationally, has built the UK's forecasting capability and is taking steps to increase its resilience while taking account of the developing science and user needs. The government has drawn on expertise in the scientific community to inform its assessment of the risk and has begun collating and exercising departmental response plans.

**17** However, there are a number of issues that could undermine the UK's ability to prepare for and respond effectively to a severe space weather emergency which the government needs to resolve. Roles and responsibilities for managing the risk remain unclear, accountabilities could be stronger, and the government has yet to set out what outcome it is looking to achieve and the level of residual impacts it is willing to accept (risk appetite). There is more the government can do to engage local responders and businesses in planning to ensure the effectiveness of its whole-of-society response. The centre of government has an incomplete understanding of how sectors plan to respond to a severe space weather emergency, including whether they plan to use risk-specific or generic response plans, and the testing of response plans through simulation exercises has been limited, constraining understanding of vulnerabilities. Now that responsibility for coordinating the risk sits with DSIT, as the parent department for the Met Office and policy owner for the UK civil space sector, it brings the opportunity to reinvigorate the government's ambition and address the gaps in its approach.

## Recommendations

- a** The government is updating its severe space weather preparedness strategy. To invest efficiently and effectively in long-term resilience, it must define what outcomes it is seeking and the work required, and make informed decisions about prioritisation. It must also test plans against a range of plausible scenarios and embed knowledge from its past exercises and responses to space weather. In designing its new strategy, DSIT should consider and define:
- roles and responsibilities for severe space weather resilience across the public sector;
  - what level of resilience to severe space weather's impacts the government is seeking for the UK to achieve, including agreeing expectations for different sectors;
  - what public investment will be required to deliver its objectives; and
  - which knowledge gaps on severe space weather's impact the government will prioritise and fill.
- b** Cross-government initiatives can often be more difficult to implement due to the large number of bodies involved in delivery and their existing individual governance and accountability structures. By the end of 2026, DSIT should review governance arrangements for overseeing the risk of severe space weather to strengthen leadership, accountability and assurance arrangements as required. This should include consulting with the Cabinet Office for guidance on governance arrangements for managing this cross-cutting risk.
- c** DSIT should, with the Met Office, decide what long-term forecasting capability, and at what level of resilience, the UK requires. Ahead of the next spending review, it should develop a delivery plan to secure the required capability.
- d** To strengthen response plans, DSIT should develop a continuous plan of learning and exercising by September 2026. This should include:
- collating, disseminating and applying lessons from past exercises, including those relevant to but not specifically on severe space weather;
  - considering and testing multiple scenarios in addition to the reasonable worst-case scenario, and consider the compounding and cascading impacts and identify points of failure; and
  - carrying out a command-post exercise on severe space weather, involving sectors and local responders, in the next three years.

- e DSIT should add detail and precision to its plans to encompass a whole-of-society approach by March 2027. This should include:
  - concluding its work developing a severe space weather communications plan for UK businesses and citizens in the event of an emergency;
  - considering how it can best support local responders and civil society to participate in planning;
  - identifying what specific preparedness work it needs the government to undertake as a result of its strategic analysis, and what risk-generic work it should rely on;
  - working with other departments to ensure that all sectors understand how to interpret and use Met Office's notifications, and that the Met Office understands the information needs of those sectors; and
  - working with other departments to map what actions sectors could take to prevent or reduce impacts prior to an event's arrival; this should include defining which actions would require direction from the government.