Executive Summary

Context

In January 2021, the Cabinet Office Civil Contingencies Secretariat (CCS) commissioned the Royal Academy of Engineering to undertake an external review of the National Security Risk Assessment (NSRA) methodology. It directly supports the priority action in the Integrated Review[1] which commits to reviewing the UK's approach to risk assessment and making resilience a national endeavour, so that the country is prepared for the next crisis, whatever it might be.

The NSRA methodology is reviewed at each cycle. This is the first time the methodology has been externally reviewed, and this review is being conducted alongside an internal review led by CCS, and an independent inquiry by the House of Lords Risk Assessment and Risk Planning Committee. The Academy was asked to address a number of priority questions (Figure A), focused on scenarios, concurrent and compound risks, and interdependencies, assessment timescales, and cross-cutting issues such as data, expert input and diversity and inclusion, detailed in Section 0. The review was asked to deliver **evidence-based, practical, and implementable recommendations** for improvement.

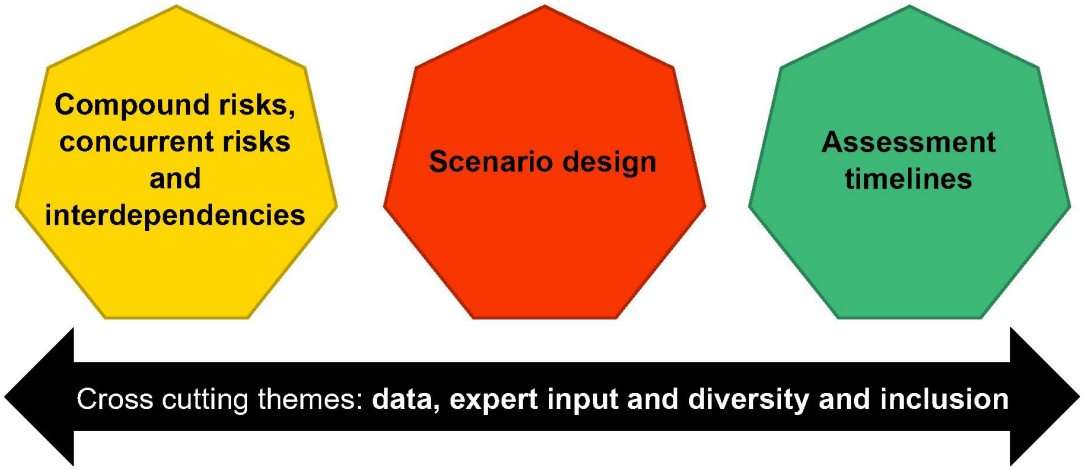


Figure A. CCS priority topics for the external review

This report sets out our approach to our review, including the evidence gathering, testing and validation, and our final recommendations. Both are summarised in this executive summary. We hope by documenting the review process and its findings in detail, we will enable greater transparency and build a better understanding of the basis of our recommendations on a complex subject. To safeguard against corporate memory loss and implications of staff turnover, this report and its annexes can function as an audit trail for the approach taken in the review.

[1] Global Britain in a Competitive Age: The Integrated Review of Security, Defence, Development and Foreign Policy, Cabinet Office, 16 March 2021.

Lords Risk Assessment and Risk Planning Committee. The Academy's processes for iterative feedback and quality assurance are outlined in Annex J.

Improving the NSRA methodology

Developing practical and implementable recommendations required a specific focus on **understanding the needs** of the NSRA's stakeholders and applying our **key findings** across different parts of the NSRA.

Understanding user needs

The NSRA has a broad range of stakeholders, invested in the process, its outcomes and how their different needs are met. At its core, the NSRA is intended to deliver at both national and local levels:

- **Nationally**, the NSRA is builds a picture of risks facing the UK in the near-term for decision-making to prioritise investment, predominantly for emergency response.
- **Locally**, the NSRA informs risk management plans and the provision of proportionate response capability by providing an evidenced picture of risk.

The overall outcome of these actions should be better UK preparedness for future emergencies.

Key findings

This report highlights a number of key findings which have emerged from our evidence synthesis, they are reflected in the final recommendations, and can be applied across the whole of the NSRA process.

We have identified three parts of the NSRA where our key findings can be usefully applied **i) the bigger picture - wider approach to risk management ii) the methodology, and iii) the processes through which the NSRA is undertaken**, illustrated in figure C.

The bigger picture

Our review identified ways in which the wider approach to risk management and resilience at national, local and organisational level could be strengthened.

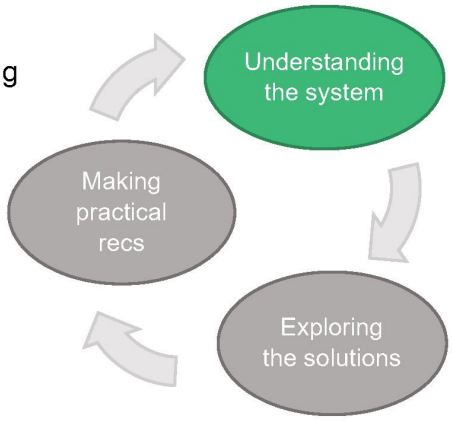
To consider resilience holistically, it is not enough to understand the risk and its different possible manifestations this has to be **translated into action** across prevention, response, mitigation and recovery, and must reduce vulnerabilities at both the national and local levels. A **joined-up systems approach is needed** to engage with interdependencies and strengthen links across the risk and resilience landscape.

The 'resilience thinking' case studies in Section 8 explore how organisations define a risk appetite and **build an organisational culture that embeds resilience in their thinking**, preparing to manage the uncertainties around different risks rather than around specific risk manifestations.

4 Understanding the system

This section presents the understanding of the NSRA process built through the review, exploring the following questions from the framework presented in Figure 2:

- Why are we doing this?
- What are the problems? What do we do well?
- What are the elements?
- Who are the stakeholders, and what are their needs?



4.1 Why are we doing this?

Working with the CCS, a shared problem statement was developed. This statement forms the basis for the review:

> *The NSRA methodology is always reviewed between iterations to ensure the latest thinking from HMG, academia, and industry is incorporated alongside learning from real-world events, thus enabling more accurate planning.*
>
> *The COVID-19 pandemic has, inevitably, focused attention at all levels of government and beyond on the importance of risk assessment, planning, and preparedness. The moment therefore demands a more thorough inspection of the methodology underpinning the NSRA than would typically be undertaken, and, to achieve this, the opening up of the methodology to external, expert review.*
>
> *Alongside considerations such the use of data, likelihood calculation, and accounting for vulnerability, three priority areas for this external review have been identified; namely, assessment timescales, RWCS development, and risk interdependencies.*

4.2 What are the problems? What do we do well? How does the system perform?

The NSRA is widely recognised as valuable and leading practice. However, risk assessment at national level is complex and challenging, and there are areas that can be improved.

The 2019 National Security Risk Assessment highlighted a number of methodological challenges:

- **The confidence in the likelihood assessments varies.** The confidence is greater for risks where there is a long and reliable history of incidence, whereas confidence in the likelihood assessment of malicious risks is limited as the landscape changes very fast.

- **RWCS vary in specificity across different categories of risk.** One RWCS is chosen but there could be numerous variations with significantly different likelihood/impacts scores, which can mask cumulative risk.
- **Comparing chronic and episodic risks is challenging.** Defining the RWCS and quantifying the impact for something that does not typically take the form of a discrete event is difficult.

Conversations with a range of individuals in the Academy's networks, including current and past chief scientific advisors (CSAs) and risk experts with varying degrees of involvement with the NSRA process, highlighted some perceived limitations in the NSRA process. Many of the points raised reinforce the initial questions and priority areas that were set out by the CCS prior to the commission, so insights have been grouped relative to these themes. These reflections also **support the need for adopting a systems approach** to this work, which encourages evidence gathering that draws upon the widest, most diverse perspectives, including those that can be critical and challenging. These initial insights are presented in Annex B.

To build on these initial insights, interviews were carried out with a diverse range of stakeholders from LGDs, CSAs, supporting government agencies, devolved administrations, LRFs, and different parts of the CCS, as well as academic and industry experts. These interviews explored how the current NSRA process works, identifying the perceived strengths and weaknesses in the methodology. The interviewees are listed with the stakeholders engaged in Annex C while Annex D presents the note from the LRF engagement session. The insights gathered from these conversations are thematically presented below.

4.2.1 Impact

Impact can be easier to assess for events that have occurred in recent memory, as the consequences (and potential cascade effects) are better understood. Drawing on international examples is helpful. When extrapolating from data-rich historical examples, it is difficult to be confident in the outputs when exploring potentially more impactful manifestations of a risk that have not yet happened.

The mitigations that are assumed in the scenario are not explicitly stated, which may create a barrier to understanding the impacts of the scenario and its use in planning at the national and local levels. Using hospital beds as an example, if the assumed spare capacity (mitigated scenario) was higher than the real relative capacity at a local level, there is a risk of being unknowingly underprepared for a similar event. These metrics are affected by the context of the day (eg, a bad winter, with high hospital bed occupancy or preventing travel to work) or mitigations proposed by other departments, such as closed schools reducing staffing levels more than assumed in the scenario.

Concerns were also raised about the approach of simple averaging across various impact categories, and how this translates into comparative impact scores for risks with a small number of high-scoring impacts and risks with many medium-scoring impacts. The need for comparable scales between different measures was highlighted, but the extent to which the current NSRA impact measures capture this is unclear. The ONS has developed

mechanisms for collating indicators for their health impacts and crime index that may be transferable.[8]

Whether the impact and likelihood should be capped at five on the matrix was questioned. Instead, it was suggested that these should be open ended, going as high as they need to go on a logarithmic scale.

At a local level, impacts are translated proportionally based on population numbers and infrastructure. This is done manually by re-typing the content on Resilience Direct, the secure platform used to share NSRA documents with LRFs. This was viewed as resource intensive and a significant duplication of effort.

4.2.2 Likelihood

Likelihood assessment is especially challenging to quantify for threats and for something that has never happened. For natural hazards, the probability of an event will vary depending on the defined timescale over which it can take place (eg, a flood has a probability *X* of occurring within a year or a probability *Y* of occurring within five years). Likelihood can be derived based on historical precedent, although this should also include input for changing circumstances – for example, climate change impact, which will change the accuracy of history-based probability. While historical data is very effective for quantifying the likelihood of events that happen relatively frequently, such as flooding, understanding the likelihood of infrequent events, such as pandemic influenza, with fewer data points is more challenging.

4.2.3 Concurrent or cascading risks and interdependencies

Concurrent or cascading risks and interdependencies are terms that are not used consistently (if at all) across government – there appears to be no agreed terminology. It is recognised that this is a key element that is missing from the current methodology and the solution has been to list potential compound risks at the bottom of the risk summary – however, this is not comprehensive.

There is a need to think about the **interactions, cascades, and transfers** between risks. Advancing multi-hazard assessment methods can provide techniques to analyse these interdependencies. However, quantifying the interdependencies between elements in the system is very challenging. Consideration of **concurrent or cascading risks and interdependencies would require a significant change in mindset**, compared to the current focus on individual risks. Consideration needs to be given to how complex interdependencies across risks are presented, so that it has a practical use or application for planning and response.

[8] Developing the health index for England: 2015 to 2018, ONS (accessed 16 August 2021).

At the local level, there is interest in giving greater consideration to compound risks as they form the basis of local contextualisation to assess the requirements **for capacity, capability, and resilience**.

4.2.4 Assessment timelines

Assessment timelines can change likelihood. The NSRA needs to be accompanied by longer-term foresighting and forecasting techniques to ensure there is enough time to establish the strategic mitigation capabilities. If the NSRA assessment timeline is longer than two years, the responsibility for action with regard to mitigation, prevention, and preparedness can become unclear. **Assessing risk over a longer timeline – for example, five years while still reviewing every two years** – can provide confidence that the magnitude of the risk is still understood even if the two-year review timelines are proving challenging to meet. This approach has been adopted by the Scottish Risk Assessment.

For many LRFs, the top risks have remained the same despite numerous methodology changes. Staying up to date with the changes can be a challenge, and a longer review period or different ways of working would make this workload more manageable.

4.2.5 Reasonable worst-case scenario

RWCS may place too much weight on a single scenario. RWCS are often defined following the RWCS in the previous cycle and reviewed for changes rather than being generated each time. Few LDG risk owners interviewed were aware of the provenance of their RWCS. Development of the RWCS should be as much about the process as the numerical outputs. Certain events are better dealt with using probabilistic assessments to stress test a system under a range of possible events.

If the RWCS are intended to ensure that mitigation capabilities are in place for lower-impact events, this isn't necessarily the case for all risks, as different manifestations of the risk require different response or mitigation capabilities.

There were concerns that, despite common frameworks, the RWCS did not account for comparable severity across the risks.

4.2.6 Data

The role of data varies depending on the risk. Data can be used to inform the likelihood assessment of risk, provide early warning of the imminent potential emergency and to monitor the emergency once it happens. Data is critical for some risks where there are local, national, or international examples or modelling that inform the RWCS. For other risks, data or high-quality models may be less available or accurate, requiring an additional layer of qualitative assessment with expert judgement, such as a high-profile cybercrime incident. Where new data and models are used, the confidence in the data must be

6 Risk interdependencies

6.1 Introduction

Hazards and threats don't occur in a vacuum. Interdependencies exist between risks; for example, one risk triggering another (eg, a tsunami following an earthquake), between the systems the risk will affect (eg, electricity and communications networks), and between the consequences (disruption to transport disrupts the provision of health care with staff absences). These interdependencies can result in a chain of cascading effects and unintended consequences. A number of methods exist to map and assess interdependencies in general, and between risks, with methods of particular interest explored in more detail below.

6.1.1 Terminology

An **interdependency** is a physical, digital, geographical, or organisational link that enables transfer or sharing of risk, failure, or mitigation.[9] Interdependency is a pre-condition for cascading risks or consequences – these terms are further defined in Annex G. There can be layers of linkages, referred to as second- and third-order interdependencies, and, with each layer, the complexity increases.[10]

Multi-hazards and **hazard interactions** are growing research areas. There are a range of definitions and classifications. The United Nations Office for Disaster Risk Reduction (UNDRR, previously UNISDR) definition is as follows:

> *Multi-hazard means (1) the selection of multiple major hazards that the country faces, and (2) the specific contexts where hazardous events may occur simultaneously, cascadingly, or cumulatively, and taking into account the potential interrelated effects.*[11]

The type of relationship between hazards is considered with regard to effects on likelihood and/or impact of hazards. One classification of these relationships is from the British Geological Survey review:[12]

- **triggering relationship** – one hazard triggering other hazards, or a series of triggering relationships forming a cascade or domino event
- **amplification relationship** – one hazard changing the landscape and thereby increasing the probability of other hazards occurring

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[9] Critical capabilities: Strengthening UK resilience, Royal Academy of Engineering, 2021, p. 60. See also Annex G for risk terminology.
[10] C40 infrastructure interdependencies + climate risks report, C40 and AECOM, Spring 2017.
[11] 'Hazard', Terminology, UNDRR.
[12] Review of environmental multi-hazards research and risk assessments (Engineering Geology & Infrastructure Programme Open Report OR/18/057), British Geological Survey, 2018.

- **compound hazards** – hazards coinciding in space and/or time with impacts greater than the sum of the two. This could be due to a primary hazard triggering multiple secondary hazards within a given time frame, or the coincidence of two independent hazards.

These definitions are focused on hazards; however, they can also be applied to threats, while making note of any potential differences or gaps.

6.1.2 Risk assessment context

Interdependencies may exist across different systems and **systems of systems**. In the case of risk assessment, interdependencies in a system of systems may include:

- **interdependencies between risks** – for example, rainfall may trigger flooding and landslides
- **interdependencies across the impacts or consequences of hazards and threats** – for example, fatalities may cause public outrage or rubble and debris may result in casualties
- **interdependencies between the response capabilities** – for example, emergency services and access to medical supplies
- **interdependencies between the systems** – for example, flooding and rubble may hinder rescue efforts and travel of medical personnel.

6.2 Case studies

The field of interdependency analysis is still developing. The British Geological Survey's review of the environmental multi-hazards research and risk assessment found that limited literature and practice exist for multi-hazard assessments.[13] **A range of qualitative, semi-quantitative, and quantitative multi-hazard assessments** have been carried out, including some applied to simulated environments, with examples found in civil and structural engineering or for critical infrastructure such as energy.[14]

This section outlines a number of different approaches to understanding interdependencies and uses pragmatic case studies developed through practitioner interviews to share insights and identify lessons. These include:

- **hazard interaction frameworks**
    - case study 1 – regional multi-hazard frameworks, with an application to Guatemala

[13] Review of environmental multi-hazards research and risk assessments (Engineering Geology & Infrastructure Programme Open Report OR/18/057), British Geological Survey, 2018.
[14] A review of quantification methodologies for multi-hazard interrelationships, A. Tilloy et al., *Earth-Science Reviews*, 196, 102881, September 2019.

- **Bayesian networks**
  - example 1 – modelling causes and consequences across the UK risk landscape [Official Sensitive]
- **network modelling**
  - case study 2 – BEIS EU exit negotiation interdependency analysis [Official Sensitive]
  - case study 3 – government science and technology network mapping pilot [Official Sensitive]
  - case study 4 – resilience study research for NIC: systems analysis of interdependent network vulnerabilities
- **hazard impact modelling**
  - case study 5: Met Office weather warning system
- **interdependencies and data**
  - case study 6 – COVID-19 population risk assessment
- **scenarios and narrative**
  - example 2 – strategic vulnerability assessment.

Following the case studies and examples, **the key lessons for analysing interdependencies** are outlined, including the benefits, limitations, and challenges.

6.2.1 Hazard interaction frameworks

Hazard interdependency matrices are qualitative or semi-quantitative approaches used to examine the relationships between hazards. Relevant hazards within the defined boundaries for the matrix – for example, geographical boundaries – are identified and then their relationships to each other examined, producing a matrix mapping out interactions and the influence of a hazard on others. Only a small number of regional hazard interaction studies exist.[15]

The matrices often draw on a mix of multidisciplinary information, including historical data, modelling, interviews, and workshops, to bring in experience from those on the ground and expert consultation. Quantification and probabilities can be included, although this may be limited by the data and modelling available.[16] An example of this process is outlined in Case Study 1.

[15] Construction of regional multi-hazard interaction frameworks, with an application to Guatemala, J. C. Gill et al., *Natural Hazards and Earth System Sciences*, 20, pp. 149–180, 14 January 2020.
[16] A review of quantification methodologies for multi-hazard interrelationships, A. Tilloy et al., *Earth-Science Reviews*, 196, 102881, September 2019.

Although this process can be viewed as resource intensive, it is vital to understand these links to understand the risk and make informed decisions. Part of the **value of the process is the convening element, bringing together different groups and perspectives to the discussions**.

Case study 1 – Regional multi-hazard frameworks, with an application to Guatemala[17]

Key themes: design for wide participation, bringing data together, visualise the interdependencies, diversity of input

Interviewee: Dr Joel Gill, International Development Geoscientist, British Geological Survey

Description: This study is an interdisciplinary approach to developing comprehensive, systematic, and evidenced syntheses of potential natural hazard interactions at regional scales (national and subnational). The potential interactions between natural hazards are documented into a matrix. The study also aimed to bring together relevant stakeholders, fostering a coproduction and dialogue process to encourage stakeholders to think outside siloes.

Use: This study is part of a body of work started in 2011 that seeks to address some of the underlying challenges of looking at single hazards in isolation, especially when agencies responsible are separated and an integrated perspective can be beneficial.

Research commenced in Guatemala in 2014, with further engagement activities in 2018–2019 to move the research toward practice. The latter aimed to embed the research into relevant organisations (academic, public sector, intergovernmental agencies), encouraging stakeholders to reflect on interdependencies between hazards and identify steps they could take to translate it into a usable tool at the national and local levels. Examples include local hazard interaction matrices for municipalities and the integration of multi-hazard interactions into existing warning tools and public communications.

Scenarios: The evidence collected to populate the matrices included several multi-hazard case studies that provide scenarios of what could occur in the future. Such scenarios can be used to understand how vulnerability and exposure may change between successive hazards. The work did not produce a comprehensive and systematic list of all possible scenarios at this stage. Rather, stakeholders were encouraged to view and reflect on the matrices to identify scenarios that they had not previously considered in their work; for example, landslides triggering tsunamis in Guatemala's lake systems, resulting in flooding. Visualisation of scenarios can be done through flow diagrams and event trees, especially highlighting linear and non-linear events.

Interdependencies: The interdependencies between natural hazards for Guatemala were examined. The potential interactions between them were documented and qualified as

[17] Construction of regional multi-hazard interaction frameworks, with an application to Guatemala, J. C. Gill et al., *Natural Hazards and Earth System Sciences*, 20, pp. 149–180, 14 January 2020.

7 Scenarios

7.1 Introduction

RWCS are a critical component of the current NSRA methodology. They are used to illustrate a manifestation of the risks in the NSRA by providing context, describing how the incident would play out, and quantifying the impact and likelihood of such an occurrence. RWCS are intended to be read as a scenario, not a prediction, and are often subject to significant uncertainty.[39] In the NSRA, the RWCS for a particular risk functions as a data point with a likelihood and impact score for comparison between risks and prioritisation to inform decision-making.

Scenarios are an established part of many international risk assessment processes as well as for national risk assessments,[40] across industry, organisations, and industrial processes.[41] 'Scenarios' is a term for a suite of techniques for developing models of what might happen in the future.[42] In the case of risk assessment, scenarios can help identify risk and explore uncertainty, consequences, and interdependencies. Often, there is a focus on realistic but extreme or worst-case scenarios – terms that are defined by the specific user or organisation.

Beyond risk assessment, scenarios are part of a set of futures and foresighting tools used to explore uncertainty for user design testing through to futureproofing of infrastructure.[43,44] These scenarios are typically developed in participatory exercises to create hypothetical but plausible illustrations of different possible futures. This can provide a sense of how a desired outcome could be constrained in the future.

7.2 Case studies

Scenarios can be used to help refine strategic thinking, as decision-making tools, or as the basis of practical exercises, such as wargaming to test skills, experience, and ability to respond to future threats. The subsequent sections discuss some of these applications

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[39] Reasonable worst-case planning scenario, Scientific Advisory Group for Emergencies, 2020.
[40] Working with scenarios, risk assessment and capabilities in the national safety and security strategy of the Netherlands, H. Bergmans et al., 2009.
[41] Case studies 12 and 13.
[42] Risk management – risk assessment techniques, BSI, BS EN IEC 31010:2019, British Standards Institution.
[43] Scenario development and foresight analysis: Exploring options to inform choices, K. Wiebe et al., *Annual Review of Environment and Resources*, 43, pp. 545–570, 2018.
[44] Aspirational city futures: A short review of Foresight approaches, D. V. L. Hunt and C. D. F. Rogers, Foresight Future of Cities Project, 2019.

Case study 11 – Red teaming

Key themes: process for participation, diversity of input, expert scrutiny

Interviewees – Name Redacted Analyst, Development, Concepts and Doctrine Centre (DCDC), and Name Redacted Assistant Head of Futures, DCDC, Ministry of Defence

Description: 'Red teaming' is the application of a range of creative and critical thinking techniques to complex problems.[57]

Use: Red teaming provides an independent and structured scrutiny that can enable a thorough analysis of the facts, leading to more informed decision-making, and produce a more robust product and confidence in the clarity of communication.

This mindset or approach can help uncover biases, challenge assumptions, identify flaws in logic, widen the scope, identify alternatives, and stress-test plans.

Process: The group tasked with red teaming need to have a level of independence from the project to enable objective review and remove any defensiveness. The toolset associated with red teaming provides a framework for the conversation enabling the brief and its inherent biases to be challenged. Tools should be chosen for the particular project and are often based on the four phases of decision-making: information gathering, sense-making, decision-taking, and planning.

Resources: A sponsor should initiate the red team process and set the scope for the analysis and objectives for the process. The red team should be made up of a diverse group of subject matter experts and non-experts who are analytical thinkers and can offer a different perspective. A credible leader should be appointed to facilitate the activity. It is important to create the time to do the activities in the way they were designed and be able to pause and reflect.

7.2.3 Exploring variation

Scenarios can be a useful tool to explore alternative futures; however, it can be challenging to capture all possible variation and uncertainties will inevitably remain. Providing structure to how uncertainty is explored offers a systematic way of ensuring the different variables are considered and provides a way to sense check scenario outcomes. Examples 3, 4, and 5 provide illustrations of how this has been approached in government and in the private sector.

[57] Red teaming handbook (third edition), Ministry of Defence, 2021.

Models: To manage uncertainty, different models are used to model the same risk to identify gaps and quantify a range of uncertainty. The different models can be calibrated based on observed data and then weighted based on trust to produce a probability distribution that enables greater confidence in the decision-making. Extensive effort is put toward understanding all elements of any models used in this process to avoid over-reliance on external opinion, ensure they are appropriately used, with a heavy focus given to understanding the limitations, assumptions, and uncertainties that have gone into the model.

Data: Data is a vital component of insurance industry risk assessments. The limitations of historical data are recognised for not telling the full story and are supplemented with models that can forecast or simulate possible outcomes.

Emerging risks: Emerging risk scanning has been embedded throughout insurance organisations, with everybody having a role to play to help turn 'unknown unknowns' into known unknowns. Underwriters can keep an eye on trends and escalate what they hear from clients on the ground. Risk functions carry out horizon-scanning exercises and literature reviews to identify areas for further investigation. The market as a whole comes together to prioritise emerging risks and monitor trends. The regulator can also encourage action and provides an important feedback loop following events.

External input: Expert opinion is drawn upon as another layer on top of models and data, especially for complex risks that are challenging to model – for example, those with human behaviour elements such as cyberterrorism. The regulator requires that expert judgement is recorded, challenged, and tested. This robust framework ensures that those decisions based on people's opinions are clearly known, as well as how crucial that decision is and how much difference the opinion makes.

Challenges: The insurance industry generally works on yearlong policies for which there is a huge amount of data available – for example, car accidents. However, for longer-term or less frequent risks, it can be a challenge to align industry interests and price the risk in. Systemic risks such as climate change and financial stability are requiring the integration of climate models with catastrophe models to try to quantify the longer-term implications.

Case study 15 – Well integrity management system[67]

Key themes: bringing data together, visualisation

Interviewee: Liane Smith FREng, Director, Larkton

Description: Data-driven monitoring system to manage oil well integrity

Process: Real-time pressure and temperature data from oil wells is brought together to understand the potential risk, inform the priority actions for planning and maintenance, and to see progress over time. The risk was linked to emergency escape plans: when the warning light is red, evacuation is initiated. The compound risk is also considered; for

[67] Improving shale gas safety with well integrity management, Scottish Energy News.

9 Learning applied to the NSRA methodology

It is important to consider the key findings from the evidence collected on interdependencies, scenarios, and resilience thinking in the context of the NSRA, the process, its users and their needs, and the progress toward the overarching purpose of the NSRA. This section presents a summary of the key findings and explores how they map to the NSRA process. From this exercise, emerging recommendations were identified to respond to the initial questions posed by the CCS and with consideration of user needs.

9.1 Summary of the key findings

To consider resilience holistically, it is not enough to understand the risk and its different possible manifestations – this has to be **translated into action** across prevention, response, mitigation, and recovery, and reduce vulnerabilities at both the national and local levels. A **joined-up systems approach is needed** to engage with interdependencies and strengthen links across the risk and resilience landscape.

The 'resilience thinking' case studies in Section 8 explore how organisations define a risk appetite and **build organisational cultures that embed resilience in their thinking**, preparing to manage the uncertainties rather than specific risk manifestations.

Consideration of interdependencies is a widely acknowledged gap in the NSRA. Beyond evidence gathering, the **interdependency mapping** case studies in Section 6 illustrate the **benefits of a process bringing stakeholders together** to map interdependencies, as it raises awareness of the links, builds relationships, and encourages stakeholders to consider interdependencies more widely in their work. Interdependency mapping also provides a method to **bring together chronic and acute risks** and explore how they might interact and compound each other while putting in place the risk management best suited to these different categories of risk.

Actively exploring uncertainty is invaluable in scenario development to understand risk, different possible outcomes, and **breadth of impact**, which can enable **strategic, least regrets decision-making**. The 'scenario' case studies in Section 7 identify how principles and frameworks, such as red teaming, grim storytelling, and 'what if' analysis, can help identify different parameters of a risk and help to overcome individual biases. **Likelihood** is not typically considered in scenario development; rather, the focus is on building decision-making capability to manage risks as they arise and change.

Risks evolve at different paces, as societies, technologies, and the climate change. Analysis of **near misses, foresighting, and horizon scanning** can be brought together to build a picture of emerging risks and agility in the system, considering risk velocity and identifying trigger points for action to ensure resilience.

The review timelines for industry risk assessments are based on the needs of the system, risk, or subsequent decisions. Given the resources available to deliver the NSRA are limited and some risks don't change significantly biennially, there is an opportunity to be more targeted with the risk assessment resources.

- This should not be implemented at the expense of chronic risks. Chronic risks should remain linked to the NSRA through interdependency analysis (recommendation 3) and a wider systems approach to resilience (recommendation 1).
- Presentation of chronic risks alongside acute risks should be carefully considered, as direct comparison in a matrix may be inappropriate.
- Where a chronic risk has acute manifestations – for example, a spike in air pollution or contaminated drug supply – these acute components of the risk should be considered for inclusion in the NSRA as well as being assessed using an appropriate chronic risk methodology. They must fulfil the criteria set out for inclusion of a risk in the NSRA (which should be clearly communicated).

Implementation milestone: clear and agreed definition of chronic risk and the removal of any risks that do not have an acute manifestation of a scale that warrants inclusion in the NSRA

→ **Links to** recommendation 1 – taking a systems approach, recommendation 3 – interdependency mapping, recommendation 7 – clearer communication

11.3 Recommendation 3: The methodology – interdependency mapping

A collaborative cross-government study is needed to map the interdependencies between risks and in response and capability planning.

There is an opportunity to develop, clearly define, communicate, and engage stakeholders across and beyond government to undertake a qualitative or semi-quantitative assessment of **interdependencies arising between risks and response planning.** This could be used as a way to encourage two-way communication between LRFs and departments, as well as external experts, and bring groups together to better inform the **national planning assumptions** and the associated **common consequence planning** for different regions.

This approach has the potential to bring about a culture change, moving from what can often be perceived at departmental level as a box-filling exercise or replication at the local level to a more **collaborative risk assessment** that builds whole-society resilience.[83,84] It may also help identify areas where there is duplication of effort and offer an opportunity to explore those risks not included in the NSRA but which still require planning and response by local and devolved administrations.

For a particular risk, how it interacts with another risk and the potential for cascade failure can be examined with **qualitative or semi-quantitative approaches**. The effect on **likelihood** or **impact** of that risk could be considered in simple terms (eg, increases, decreases, or remains the same). It may be possible to develop this into a quantitative assessment; however, this will be challenging and may introduce assumptions and limitations that require appropriate consideration and understanding. **The risks with**

[83] Global Britain in a competitive age: The integrated review of security, defence, development and foreign policy, Cabinet Office, 16 March 2021.
[84] Critical capabilities: Strengthening UK resilience, Royal Academy of Engineering, 2021.

greatest interdependencies should inform red teaming and emergency response exercises.

Consideration of **interdependencies between risks and vulnerabilities** could capture some elements of chronic risks relevant to response planning. For example, chronic risks such as increasing use of class A drugs may have links to malicious attacks, and societal issues such as homelessness and poverty may be linked to population demography. Exploring these interdependencies may help to better understand any secondary effects.

11.3.1 Why?

Consideration of interdependencies is a recognised limitation of the NSRA. The world is increasingly interdependent, and this applies to risks and vulnerabilities. A single disruption or event can trigger cascading effects or concurrent events in time and/or space, resulting in additional challenges for emergency response. These challenges may not ordinarily be revealed if risks are assessed in isolation. While the planning assumptions recognise some of the common triggers and cascades of consequences, the extent to which these are useful and given detailed consideration in planning is unclear.

11.3.2 Testing phase findings

- This was viewed as valuable, and would be a helpful resource for scenario design and exercises.
- The mapping and findings needs to be clearly defined in scope and communicated.
- A gap analysis would be a helpful product, especially identifying weaknesses and pinch points.
- Interdependencies between planning assumptions would be really helpful to the local tier.
- This will likely be very resource intensive and challenging, but worth trying.

11.3.3 Considerations for successful implementation

- Initially, a pilot interdependency study should be scoped across a defined group of risks and consider the questions the interdependency map and its analysis should answer. This should explore considerations for a wider interdependency analysis, with defined boundaries and method of refinement and framework for implementation in government. It should be a collaborative exercise with diverse stakeholders.
- The mapping of multiple layers and the connections in between should be considered. The types of interdependencies should consider vulnerability, with clearly stated assumptions and evidence. The interdependency study could include three layers:
    i. interdependencies between risks (how they influence likelihood or impact of one another)
    ii. interdependencies between impacts (how one impact may trigger another)
    iii. interdependencies between planning assumptions or core capabilities.

This map will be complex – how it is built, analysed, and then communicated will need careful consideration and should involve external expert input throughout.

- Opportunities to review and iterate should be included at key points of the pilot and as the process is rolled out.
- This analysis could usefully inform scenario development, exercises, and identify compound risk events.

Implementation milestone: expert-reviewed, evidence-based interdependency map developed through extensive stakeholder engagement with lessons learned for more extensive mapping

→ **Links to** recommendation 1 – taking a systems approach, recommendation 2 – focusing the scope and recommendation 10 – encouraging external expert participation

11.4 Recommendation 4: The methodology – a range of scenarios

For each risk, a range of scenarios should be generated to explore uncertainty and additional planning requirements, improve the output, and deliver maximum value from the overall process. Where appropriate, the range of scenarios should be included in the NSRA.

A more holistic view of planning is required, where, for each risk, the scenarios should **explicitly consider prevention, mitigation, response, and recovery.** Using tools such as bow tie diagrams can help communicate the cascades of consequences and the mitigations required. The scenario process should identify variations in the nature of the risk to help with planning and identifying the range of different capabilities that might be needed. A feedback loop between risk assessment and prevention, mitigation, response and recovery should also be created.

Shared principles or best practice on the use of scenarios in the NSRA would ensure a degree of uniformity and set an expected standard(s). Additional scenarios that cover different manifestations of the risk should be examined alongside the RWCS. There is a need to establish a culture that continuously asks, **"What if our assumptions are wrong?"** and **"Can we make things less uncertain?"**

Additional scenarios should be developed to explore the uncertainties of red risks, setting out and explaining the anticipated worst-case scenario and **the possible variations, rather than just the RWCS**. This would support an exploration of the potential cascading risks and consequences of red risks, which can have a more systemic impact, and create a playbook covering a range of scenarios accompanied by effective response capabilities to improve overall resilience to red risks. **A playbook of scenarios** could be a helpful tool to support better and least-regrets decision-making ahead of and in the early moments of an emergency, when uncertainty is high. For red risks, it will be important to understand what decisions need to be made, to help identify and enable access to best data and evidence to support the decision-making process.

To ensure **diverse perspectives** are heard and considered, these scenarios should be developed with **trained facilitators** and involve stakeholders inside and outside of

- Scenario variations could be used to prompt discussion to explore interdependencies and uncertainties.
- A range of scenarios could be perceived as exhaustive, and has to be counterbalanced with the current situation where one scenario can be viewed as the only manifestation of the risk.
- Scoring the range of scenarios in order to place the risk on the matrix needs to be carefully considered. Using maximum scores across several scenarios or aggregation could oversimplify or distort the score of the risk.

11.4.3 Considerations for successful implementation

- There should be a cross-government initiative asking risk owners to consider what risk scenarios exist or are in development across the department to identify gaps and those areas where a range of scenarios is already in existence to reduce duplication of effort.
- Guidance or best practice with clear criteria for producing more than one scenario should be shared. This should be focused on identifying where additional capability would be required.
- Additional work should be carried out to determine how the range of scenarios can be included and communicated in the NSRA, including how they are represented on the matrix.
- Adequate resource should be allocated where necessary to develop and maintain robust new scenarios.
- The scenarios should be subject to external challenge and scrutiny and where possible trained facilitators should be used to encourage open discussion and debate.

Implementation milestone: defined set of criteria for multiple scenarios and mechanisms for presentation and process for incorporation into the risk matrix

→ **Links to** recommendation 1 – taking a systems approach, recommendation 5 – focus on impact and recommendation 10 – encouraging external expert participation

11.5 Recommendation 5: The methodology – focus on impact

To create a culture of preparedness, likelihood should not be the main driver for prioritisation as this can be difficult to assess with a high degree of confidence across all risks. Decision-making should be driven by impact and preparedness linked to capability across prevention, mitigation, response, and recovery.

To better manage uncertainty, many organisations **assess impact and their ability to respond and recover or prefer preparedness as a measure rather than likelihood**. These metrics should inform the prioritisation of risk planning. This mindset can **enable a risk management culture** that focuses on identifying those key planning actions that are required rather than concentrating on the likelihood of a particular event happening, where the exact nature of an emergency can be difficult to predict.

11.5.1 Why?

For many risks, likelihood is challenging to assess with confidence. It is often focused on the probability of that single (reasonable worst-case) event/scenario taking place rather than a range of similar scale events occurring. The focus on likelihood can drive the wrong behaviours and prioritisation. Some risks are less well considered because of high uncertainty; they are less well understood and characterised and there is limited data upon which to make an assessment or the risks are viewed as too unlikely.

The comparison of risks based on likelihood also introduces a communication challenge because of the large variation in uncertainty that exists for the assessment of individual risks. This uncertainty can arise from something random happening or be the result of incomplete knowledge. For example, the likelihood of a flood may be assessed with much more confidence than a terror attack and these are then compared with little acknowledgement of the variation in assessment in likelihood.

11.5.2 Testing phase findings

- Communicating risk without likelihood will be a challenge, as most people view risk in terms of likelihood and impact.
- Likelihood was viewed as an important tool for prioritisation, while recognising limitations due to the level of confidence in assessments and the challenge of not preparing for 'black swans'.
- Some departments and Scotland also use measures of preparedness for prioritisation. It was noted that developing robust measures of preparedness may be challenging.
- There are different approaches to planning: those prioritised based on likelihood assessment and others based on preparedness. For those risks requiring specific response capabilities, a likelihood of 100% is effectively assumed to ensure the capability is in place should the risk occur.
- A preparedness index would be interesting to consider; however, it needs to be robust and generate the right behaviours. There is concern that risks that are well prepared for could be neglected.
- Some departments already acknowledge limited preparedness for the RWCS.

11.5.3 Considerations for successful implementation

- The weight given to likelihood in decision-making should be more transparent. There are examples where likelihood with high confidence can drive proportionate prioritisation and other examples where the capability required is so specific that action is taken as if likelihood was 100%. The influence of likelihood scores on decisions should be clearly stated and reviewed where appropriate. Examples of good practice from the intelligence community should be learned from more widely across government.

Annex G: Risk terminology

Initial definitions are drawn in part from the Royal Academy of Engineering 'Safer Complex Systems' project, the National Risk Register, the Natural Hazards Partnership and British Geological Survey review of environmental multi-hazard research and risk assessments, POSTbrief on evaluating natural hazards, and the World Health Organization. Many of these definitions were iterated by the CCS for inclusion in the national resilience strategy consultation.[89] The agreed terminology is outlined below.

Amplification effect: the occurrence of hazard event A can change the likelihood and/or impact of hazard event B in the future

Capability: the people, infrastructure, and assets that provide the ability to be resilient

Concurrent risk: when two or more events coincide in space and/or time

Compound risk: when two or more events coincide (either in the same place, or at the same time) causing impacts greater than the sum of the individual risks

Cascading risk: the knock-on impacts of a risk that cause further physical, social, or economic disruption; for example, severe weather could cause flooding, which then causes damage to electricity infrastructure, resulting in a power outage that then disrupts communications service providers

Emergency: an event or situation that threatens serious damage to human welfare, the environment, or war, or terrorism, which threatens serious damage to security. As defined in more detail in the Civil Contingencies Act 2004:

- acute – time-bound, discrete events (eg, a major fire or a terrorist attack)
- chronic – continuous challenges that gradually erode our economy, community, way of life, and/or national security (eg, money laundering, antimicrobial resistance)

Hazard: non-malicious risks such as extreme weather events, accidents, or the natural outbreak of disease

Impact: scale of harm or damage to human welfare, the environment, or the security of the UK

Interdependency: physical, digital, geographic, or organisational links that enable transfer or sharing of risk, failure or mitigation – interdependency is a pre-condition for cascading risk

Likelihood: probability of an emergency occurring annually

Multi-hazard event: the specific contexts where hazardous events may occur simultaneously, cascadingly, or cumulatively over time, with potential for interrelated effects (UNDRR)

Preparedness: actions taken in anticipation of an emergency to facilitate rapid, effective, and appropriate response to the situation

[89] National Resilience Strategy: Call for evidence , Cabinet Office, 13 July 2021.

Residual risk: the risk of harm that remains once risk reduction measures have been implemented

Resilience: the UK's ability to anticipate, assess, prevent, mitigate, respond to, and recover from natural hazards, deliberate attacks, geopolitical instability, disease outbreaks, and other disruptive events, civil emergencies, or threats to our way of life

Risk: the combination of the likelihood and scale of impact to human welfare, the environment, or the security of the UK

Risk appetite: the amount of risk an individual, business, organisation, or government is willing to tolerate

Threat: malicious risks such as acts of terrorism, hostile state activity, and cybercrime

Transferable risk: transfer of risk from one component in the system to another due to mitigation

Triggering risk: a primary event causes one or more secondary events; the secondary events might be identical or different from the primary event

Vulnerability: the quality or state of being more prone or exposed to the impacts of hazards or threats; vulnerabilities could affect individuals, communities, assets, or a whole system and may be caused by physical, social, economic, and environmental factors or processes

Vulnerable groups: populations with physical, psychological, social, or geographic characteristics that limit their ability to anticipate, cope with, resist, and recover from the impacts of disasters, or result in a disproportionate share of the burden associated with emergencies:

i. *physical* – includes the chronically ill and physically disabled, and persons living with immunodeficiency; pregnant women

ii. *psychological* – includes those with chronic and non-chronic mental conditions that may impair judgement in a crisis; attention-deficit/hyperactivity disorder, as well as those with a history of alcohol and/or substance abuse and those who are suicidal or prone to homelessness

iii. *social* – includes those living in abusive families, the homeless, immigrants, and refugees, those living in poverty and suffering from its common consequences

iv. *geographical considerations* owing to geography creating barriers and exacerbating inequality and creating vulnerable groups (eg, isolation and slow response time in the Outer Hebrides; risks will be responded to differently in the Brecon Beacons compared to the centre of Bristol)

v. We should also take into account where vulnerability is created or enhanced by *race*, *ethnicity*, *age*, *sex*, and *income*.