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Hazards Forum Workshop – Record of meeting

Cascading and Interconnected Hazards

9 October 2025

Costain, Manchester Business Park, Aviator Way, Manchester M22 5TG

Executive Summary

The aim of the workshop was to explore the far-reaching and diverse subject of cascading and interconnected hazards, through interdisciplinary thinking.

As a community, understanding hazards and how we can mitigate their impacts is at the heart of what we do. Considering hazards that co-occur, interact, and compound - either simultaneously or in succession - adds a new layer of complexity to data analysis and traditional risk management.

Often, language is used interchangeably, and definitions vary across our spheres of interest: natural hazards, engineered systems, and emerging technologies.

This challenge is growing as populations, infrastructure, and processes become more interconnected than ever; and against a backdrop of digital, political, and environmental change.

Examples of these challenges can be seen in UK and global events, such as:

- Natural – Japan Earthquake and Tsunami Fukushima Daiichi Disaster (2011), Beast from the East (2018), California Mudslide (2022).
- Engineered Systems – Deepwater Horizon Oil Spill (2010), Nationwide GSM-R Radio System Failure (2024), Spain and Portugal Power Outage (2025).
- Emerging and Future Technology – Eurocontrol ETFMS Failure (2018), Uber Self-Driving Car Fatality (2018), Texas Winter Storm – AI ERCOT (2021).

Presentations were provided on each of the topics from experts in a range of disciplines followed by group discussions on each of the topics. Further detail on these discussions can be found in the body of this report. The key points from the workshop are summarised here:

- **Holistic approach:** Participants highlighted the need for more cross-sector sharing and learning activities such as the workshop as an important vehicle in developing approaches for our complex and changing scenarios
- **Communication:** Communication challenges featured throughout the three discussion themes - between engineers and senior leaders, intra and inter disciplines. Participants felt that this limited the development of risk management approaches
- **Competence:** Participants highlighted competence in exercising judgement and in communications about risk and appreciation of limits of competence as further challenges.
- **What does good look like:** In turbulent, uncertain, novel and ambiguous (TUNA) circumstances, there was an understanding that ‘what got us here wouldn’t get us there’ and that we had very limited understanding of ‘what good looks like’.

Opening Keynote

Presentation

Professor Roger Kemp (Emeritus Professor, Lancaster University) highlighted juxtaposition of achieving resilience and efficiency drawing on examples of natural, engineered and malicious hazards leading to cascading and complex events.

Discussion 1: Assessing hazards - are current methods appropriate?

The focus of this discussion was the consideration of:

- *Resilience to the outcomes of hazards - when does likelihood matter?*
- *What do we need to know to make a decision? Risk and loss appetite.*

Presentation

Richard Roff (Costain) considered cascading hazards and risk interactions and questioned how complex assessments should be and highlighted the importance of consequence as a driver of risk management decisions.

Andy Abu Bakar (Costain) provided a thought provoking presentation on infrastructure project risk illustrating that this required looking beyond risk events to identify common causes and unstable assumptions, avoiding biases when assessing likelihood and impact and adopting methods which simulate the combined effect of risks.

Break out group discussions

We asked groups to address the following questions:

- Risk and loss appetite. What do we need to know to make a decision? When does likelihood matter?
- What do we still not understand, need to know more of, is the priority research area for the next 2, 5, 10 years?

The top themes that emerged from the discussions on current methodologies are provided below.

- **Likelihood matters:** Likelihood helps to prioritise risk and is a mechanism by which judgement is made. However, estimating the likelihood of an event occurring is problematic because it relies on individual perception or judgement and there may be large error bars. However, it was thought that likelihood at times could be diluted.
- **Alternatives to likelihood:** It may be better to consider inherently safer designs which avoid potentially hazardous consequences. Furthermore, such a consequence-based approach should have a bias towards preventing catastrophic outcomes
- **Focus on consequences:** In assessing hazards, it may be better to start with the consequences in mind (the right-hand side of the bow-tie diagram) and consider whether the barriers are sufficient to prevent the consequences being realised. This may be a better approach than attempting to foresee all the initiators of an event (left hand side of bow-tie diagram). Furthermore, if an increased focus on the right-hand side of the bow tie was needed, this could lead to better understanding of the benefits of control measures. The recent Spanish power grid outage highlighted issues of lack of resilience in such systems leading to widespread consequences. A simpler localised power supply system would not have suffered such a failure.
- **Consequences of not acting:** The need to consider the consequences of not acting, i.e. could hazards increase, as in the case of legacy nuclear waste management and climate change was also highlighted.

- **Risk appetite and risk tolerance:** To better understand and communicate what we mean by risk appetite, we need to be presenting it as something tangible. Risk appetite is the overall amount of risk an organisation is willing to accept to achieve its strategic goals, while risk tolerance is the specific amount of variation from that appetite it can accept for individual risks or objectives. Risk appetite is strategic and qualitative, setting the big-picture philosophy, whereas risk tolerance is tactical and quantitative, establishing the specific operational boundaries and limits for everyday decisions. Discussion questioned whether organisations were connecting their appetite and tolerance and what was accepted.
- **Future/Information needs:** Demands for information to inform assessments will always exceed the available information. Discussion questioned whether we understand the worst-case scenario, where we are vulnerable and what we should do about it. Cause and effect break down when the reality of complex systems is introduced. There was a need to ensure redundancy in a project.
- **Reliance on people vs systems:** Could we use the human factors approach (or similar) to deconstruct risk assessments and processes to determine the reliability of systems. How reliant are we on people vs systems, and is this a problem?
- **Communication needs:** Pro-active communications by engineers to decision-makers on hazard related matters were needed to ensure that decision-making is suitably informed. Engineers should push relevant information to decision-makers in an easily understood way and in turn decision-makers should actively seek the input of subject matter experts.

Discussion 2: Overcoming limitations of data availability

The focus of this discussion was the consideration of:

- *The role of engineering judgement.*
- *Communicating uncertainty as risk professionals: to colleagues, to regulators, to Government, to the public.*

Presentations

Prof Dr Jana Sillmann (University of Hamburg) provided insight into the complex nature of risk, and the different aspects that are required for risk to be realised (natural hazard, vulnerability, exposure and response). In addition, she identified how events can cascade from one sector into another sector (e.g. water, health and economic sectors).

Katie Barnes (National Preparedness Commission) addressed issues of risk communication, data integrity and judgement in turbulent, uncertain, novel and ambiguous (TUNA) circumstances currently faced. Katie also identified that the sphere of control is becoming more fragmented, and that judgement skill is still needed, but demands a different way of thinking.

Break out group discussions

We asked groups to address the following questions:

- What is the role of engineering judgement?
- What examples (if any) are there for when qualitative assessment is insufficient?
- How do you communicate uncertainty to different stakeholders?
E.g. Senior leaders, regulators, investors, public

The top themes that emerged from the discussions on data limitations (engineering judgement and communications) are provided below.

- **Engineering judgement:** The exercise of engineering judgement is about making pragmatic decisions in the absence of a complete set of data. There is a role for engineering judgement as part of a hybrid approach which also considers relevant standards and analysis. While it plays an important role in such an approach to plug gaps in information, its application needs

competence and critical thinking skills. A key consideration is to what extent organisations are receptive to decisions made on engineering judgement.

- **Having data is not always enough:** Even where data exists, it may not be valid in predicting future risks. Indeed, our ability to characterise hazards and risks is becoming more difficult due to their increasingly complex nature. This is exemplified by bow-tie depictions (linear cause and effect) versus the increasing reality of highly interdependent systems with multiple feedback and interference loops (e.g. as applicable to climate change hazards). Hence judgement must be applied in relation to the validity of data. Models will always be limited and already have judgement built in.
- **Competency:** The competence of individuals exercising such judgement is inextricably linked to the quality of decision making based on judgement. Limitations in individuals' experience can therefore impact the quality of decisions based on judgement. Limits of competence need to be understood since knowledge does not necessarily translate to being able to make the necessary judgement.
- **Quantitative vs qualitative:** Consider shifting the balance between reliance on numbers and thinking about what could go wrong and how.
- **Communications:** Messages should be targeted to how you want people to react to the information they are receiving. Importantly, putting something on a website does not mean that it is being communicated. Communications need to be framed in terms that the intended audience will understand.
 - Public: It is important to recognise that there is more than one 'public' and that they have different needs and wants. We need to be mindful of unintended consequences of communication. For example, post Fukushima people stopped eating bananas because the radiation levels in the community was compared to eating 5 bananas. So, people took that to mean that bananas were radioactive, rather than what they were trying to show which was that the radiation levels were okay. Use of sensitivity analysis to replace judgement.
 - Regulators: Regulators have different backgrounds, which may influence the way in which we need to communicate.
 - Boards/investors: Challenge is to ensure their understanding of risk issues with technical accuracy and brevity. In scientific disciplines, it can be really challenging to distil into something the board can understand, but not lose important information. Rethink design if accurate data is needed.
 - Stakeholder risk appetite: important to understand for communications.

Discussion 3: Knowledge sharing

The focus of this discussion was the consideration of

- *Sharing different sector approaches to the challenge.*
- *Multi-disciplinary approach - what skills does industry need?*

Presentations

David Quincey (Network Rail) highlighted that interdependencies are problematic and key challenges are resources, technology and data.

Brychan Corrigan (EDF) interdependencies are problematic and key challenges are resources, technology and data.

Break out group discussions

We asked groups to address the following questions:

- How does your organisation approach identification, mitigation and management of complex hazards?
- What skills does industry need?
- Who would be a valuable (stakeholder/organisation/sector) to engage with, outside of your current industry/organisation, to learn something new?
- How do you stay up to date with best practice and emerging methodologies?

The top themes that emerged from the discussions on sector approaches and the industry skills needs are provided below.

- **Techniques & approaches:** There are fundamental differences in approaches within the nuclear sector but also between high hazard sectors for example nuclear and oil and gas. Approaches are also shaped by client demands based on their expectations and perceived needs.
 - Scenario planning was used by some but unclear whether this was used widely. Involving designers when infrastructure is constructed and operated to ensure real life meets the intention was also practised by some.
 - Networking is vital to sharing and proliferating experience and learning about what works. Widespread. It was noted that this was most likely to occur in non-competitive environments.
 - Other systematic approaches were described, e.g. HAZOP or activity-based hazards assessments. In some cases, these integrate internal and external hazards and in other cases they are considered separately. A question was raised as to the extent to which these traditional methods can deal with the non-linear and interdependent nature of complex systems. Such systems are, by their nature are unpredictable and therefore the focus switches more to resilience as the means of risk mitigation
 - Knowledge throughout life cycle: The importance of organisations maintaining an up-to-date knowledge of hazards and risks throughout the lifecycle of an asset, e.g. by re-doing assessments periodically was emphasised. Such assessments should also be part of due diligence in mergers and acquisitions
 - Multidisciplinary approach: It was considered important to involve a broad range of disciplines in risk and hazard assessment studies and to integrate both design (office-based) and operational (site based) perspectives, to ensure the quality of the study outputs
- **Skills/Competence/CPD:** In terms of skills needed for knowledge sharing, good communications skills were seen as vital, including: (i) knowing your audience, (ii) adjusting your style or method of communication according to the audience, and (ii) clarifying terminology and meaning. Linked to good communications is the need to create a safe space for people to raise ideas and concerns. Context was considered important in relation to competence. Context may change so the competence to be able to flex and react is needed. Knowing the limits of individual competence and having the courage to admit to not knowing the answer were considered vital.
- **Stakeholder examples:**
 - The aviation industry was cited as a good example of learning from experiences.
 - An example was given of systems thinking approach used to identify interdependencies and associated risks between different elements of an organisation's activities
 - An example of in-depth operational knowledge of how a plant worked resting with one plant operator. Having this depth of knowledge is vital for decision-making on

off-normal conditions, including response to alarms. However, to reduce the reliance on a single individual this knowledge needed to be developed more widely.

- o Examples of how such knowledge can be built were discussed, including trials or “dummy runs” of hazardous activities, supervised activities and continuing professional development programmes. Such activities help build experience beyond initial training and qualification.
- **Keeping up to date with best practice -benefits and challenges:** Engineers had a responsibility to know what relevant good practice is on a particular topic.

Summary

Recognising that we are operating in a turbulent, uncertain, novel and ambiguous (TUNA) environment, there was a need for more cross-sector sharing and learning through vehicles such as workshops to develop approaches for our complex and changing scenarios.

Communication was identified as a key overarching theme of the day, featuring in all three discussion themes.

While engineering judgement still provides an important role, care must be taken to ensure knowledge remains up to date with changes in methods and available data, especially in the context of complex systems. A wider discussion was warranted on whether focus should be on consequence or risk. Appreciating the limits of competence and having the humility to admit to being uncertain in situations of judgment was critical.

Next steps

Based on the workshop outputs, Hazards Forum intends to adopt a workshop methodology to consider the communication and competence aspects in the context of the complex systems involving a range of targeted stakeholders.

These workshops will be developed through our Technical Advisory Committee and Interest Groups and seek the input of our key strategic partners.



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APPENDIX 1

Hazards Forum Workshop

Cascading and Interconnected Hazards

Thursday 9 October 2025

Costain House (2nd Floor), 1500 Aviator Way, Greater Manchester M22 5TG

PROGRAMME:

1000 - 1030 *Arrival, refreshments and networking*

1030 - 1040 Welcome and introduction

Luise Vassie, Chair of Technical Advisory Committee
Harry Moss, Technical Lead, EEMUA

1040 – 1055 **Introduction to our topic: cascading and interconnected hazards**

Megan Pearce, Frazer-Nash Consultancy

Providing the context of discussions amongst the HF to date and outlying the format and structure of the day.

Keynote speaker

Roger Kemp, Emeritus Professor, Lancaster University

1055 – 1200 **Discussion 1: Assessing hazards - are current methods appropriate?**

- *Resilience to the outcomes - when does likelihood matter?*
- *What do we need to know to make a decision? Risk and loss appetite.*

1055 – 1115 Richard Roff, Group Process Safety Director, Costain
Andy Abu Bakar, Group Risk and Assurance Director, Costain

1115 – 1145 Breakout groups

1145 –1200 Group feedback and discussions

1200 – 1305 **Discussion 2: Overcoming limitations of data availability**

- *The role of engineering judgement.*
- *Communicating uncertainty as risk professionals: to colleagues, to regulators, to Government, to the public.*

1200 – 1220 Prof. Dr Jana Sillmann
Professor of Climate Statistics and Climate Extremes
University of Hamburg (virtual)

Katie Barnes
Executive Director, National Preparedness Commission

1220 – 1250 Breakout groups

1250 – 1305 Group feedback and discussions

1305– 1340 *Lunch and networking*

1345 – 1450 **Discussion 3: Knowledge sharing**

- *Sharing different sector approaches to the challenge.*
- *Multi-disciplinary approach - what skills does industry need?*

1345 – 1405 David Quincey, Climate Change Adaptation Manager,
Network Rail

Brychan Corrigan, Safety Case Engineer, EDF

1405 – 1445 Breakout groups

1445 – 1500 Group feedback and discussions

1500– 1510 **Summary, next steps and closeout**

1510 – 1545 ***Refreshments and Networking***

1545 – 1630 Hazards Forum Planning 2026 Discussion – Optional Attendance



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APPENDIX 2

Hazards Forum Workshop

Cascading and Interconnected Hazards

Thursday 9 October 2025

Participants:

Andy Abu-Bakar Costain

Steve Askham Costain

Katie Barnes National Preparedness Commission

Guy Bertrand The Engineering Equipment and Materials Users Association (EEMUA)

Harry Brook Sellafield Ltd

Alex Carroll EDF Energy

Ken Chilcott Chartered Institute of Ergonomics and Human Factors (CIEHF)

Brychan Corrigan EDF Energy

Jessica Dautelle Sellafield Ltd

Deovonne Ferreira The Engineering Equipment and Materials Users Association (EEMUA)

Michael Graham Frazer Nash Consulting

Roger Kemp Lancaster University

Jonny Krzyzosiak Mott MacDonald

Granson Lee Assystem

Andy Mackiewicz Institution of Chemical Engineers (IChemE)

Ben Masheter Costain

Marc McBride Office for Nuclear Regulation (ONR)

Lee Morris Sellafield Ltd

Janice Morrison BAE Systems (Submarines)

Harry Moss The Engineering Equipment and Materials Users Association (EEMUA)

James Nuttall Sellafield Ltd

Sean O'Sullivan Institution of Chemical Engineers (IChemE)

David Quincey Network Rail

Luke Robinson Costain

Richard Roff Costain

Aimee Russell RAS Ltd

Ian Scott IOSH

Nick Shaw Hazards Forum

Mehjabeen Sheriff Cavendish Nuclear

Jana Sillmann University of Hamburg (joining remotely)

Pete Stewart AtkinsRealis

Luise Vassie Hazards Forum

Jill Wilday Health and Safety Executive (HSE)

Ruth Wilkinson Institution of Occupational Safety and Health (IOSH)

Ana Zabala bp