

Implications of the future information environment for the UK's nuclear strategy and decision-making

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Preface

This report presents the findings of a three-month study on the implications of the future information environment for UK nuclear deterrence and decision-making. The study was funded by the UK Ministry of Defence as part of the Nuclear Deterrence Fund, which aims to 'stimulate wider UK expertise in nuclear deterrence issues and to generate a research base to support nuclear deterrence policymaking.'

The authors of the study are grateful for the support of subject matter experts who offered their time to participate in research interviews as part of the study. We are also thankful for the funding support provided by the Nuclear Deterrence Fund, and to Erik Silfversten and Paul van Hooft for their reviews of the report.

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Summary

About this study

UK Defence has recognised that 'information' represents an increasingly important lever for achieving tactical, operational and strategic advantage. The information environment in which UK Defence operates is evolving rapidly, driven by technological and socio-cultural trends, and giving rise to new risks, vulnerabilities and opportunities. However, research exploring the implications of the changing information environment on nuclear deterrence remains limited, including for the UK.

In this context, RAND Europe conducted a three-month study funded by the Nuclear Deterrence Fund to examine the key risks, vulnerabilities and opportunities stemming from the future information environment for UK nuclear deterrence and decision-making and to identify the factors and conditions that may amplify or mitigate these effects. The study drew on a review of existing literature alongside interviews with subject matter experts. A key output of the study was the development of a conceptual framework that presents mechanisms by which the evolving information environment affects nuclear deterrence outcomes.

Key findings

Changes in the information environment are multifaceted and reflect dynamics across and within individual information ecosystems.[1] Adopting an information ecology perspective, the study drew attention to changes occurring in the information environment across three layers:

- The tools and methods (i.e. technologies) that actors use – which are increasingly personalised and mobile.
- The conditions and factors (i.e. cognition) affecting individual information ecosystems, such as democratising information access and the significant increase in the volume of information disseminated through the information environment.
- Narratives and formats in which information is processed (i.e. information and discourse).

As visualised in Figure S.1 below, we identified four key ways in which changes in these layers shape nuclear deterrence outcomes:



They introduce greater **stress** into decision-making processes by compressing decision-making timelines.



They produce greater **complexity**, thickening the 'fog of war' and challenging decision-making through increasing ambiguity.



They increase levels of **risk** associated with information manipulation and disruption to data and information flows.



They provide greater **accessibility** of information and communication for and among public and senior decision-makers.

1 We defined the information environment as 'all informational processes, services and entities' through which 'humans and machines process information to make sense of the world.' Information ecosystems, meanwhile, represent information spaces among discrete communities, such as nation states (Floridi 2010; Wanless 2023: 55).

These mechanisms may produce escalatory and de-escalatory dynamics resulting from decision-making processes and the interaction between decision-makers along the chain of command and the public, both at the domestic and international (including adversary) levels. The key risks, vulnerabilities and opportunities associated with the mechanisms are summarised in Table S.1 below.

Figure S.1. Conceptual framework

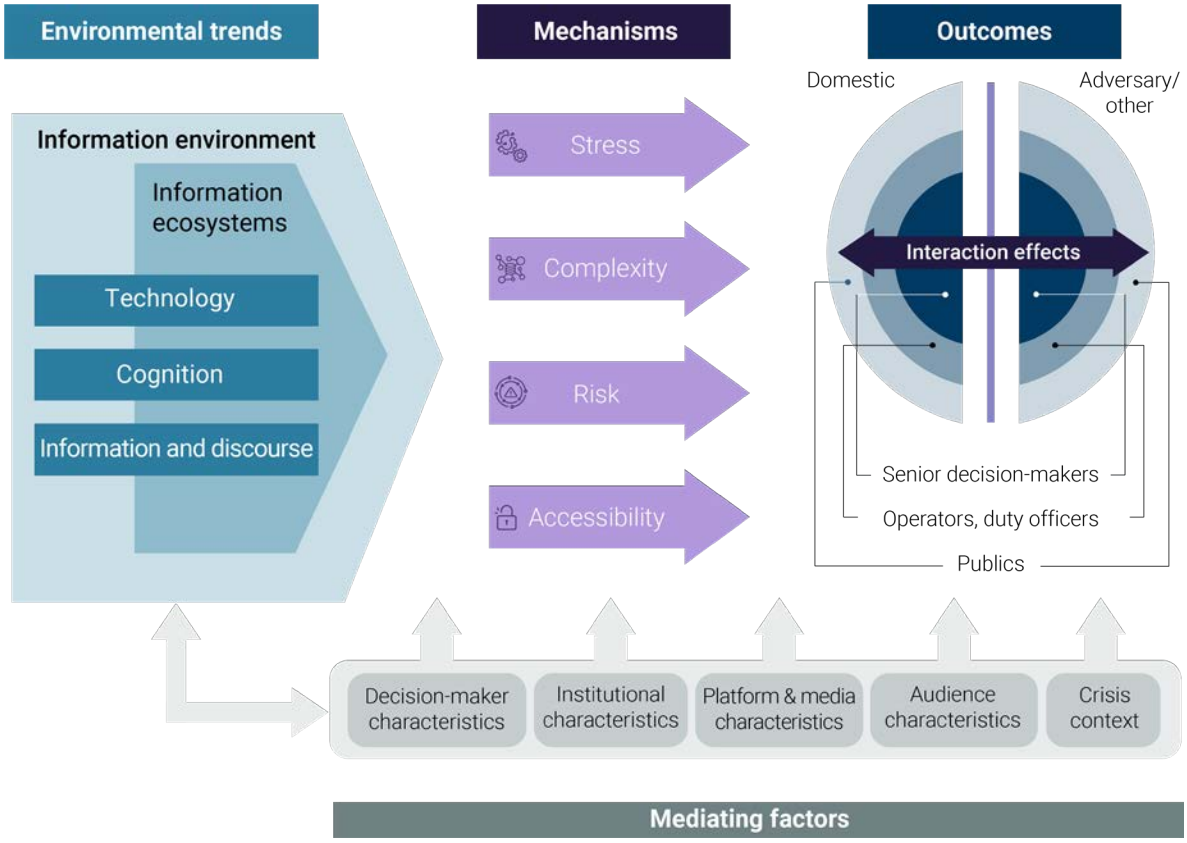

Table S.1. Summary of impact mechanisms

Mechanism	Key risks, vulnerabilities and opportunities relating to nuclear deterrence
Stress 	• Increasing speed and velocity of information exchange amplifies cognitive biases in nuclear decision-making and compresses decision-making windows. • Acceleration of news cycles may add pressure to decision-making processes, potentially removing options for deliberation, creating an atmosphere of urgency that may disrupt decision-making and generating real or perceived pressure on senior decision-makers to 'do something'.
Complexity 	• A combination of rapid growth and increased speed in information and its accessibility may amplify the risk of information overload, leading to an over-reliance on cognitive biases and heuristics in nuclear decision-making. • Information complexity raises concerns around information reliability and trustworthiness, thickening the 'fog of war' through uncertainty about information veracity. • Increasing 'noise' in the information environment can also shape public discourse and affect decision-makers' understanding of political palatability and trade-offs between policy options. • Messaging and signalling to different actors and audiences may be increasingly difficult to navigate and control, as the information environment features a greater number of actors with potentially obfuscated identities. The openness of communication channels also amplifies the challenges of cross-pollination among audiences, potentially leading to unintended consequences.
Risk 	• Rising threats from malign information manipulation, such as disinformation, may exacerbate the 'fog of war' and create confusion, undermining crisis management. Combined with other trends, the individualisation of information flows may also distort senior decision-makers' information ecosystems. • Growing reliance on data and persistent information presents vulnerabilities to malicious or accidental disruption of information and communication flows.
Accessibility 	• Improving both the quantity and quality of information can help nuclear actors gain better situational awareness. Greater data diversity also helps them better understand the factors that affect a crisis. • More direct, personal and informal communication between senior decision-makers can provide faster pathways for information exchange, address potential misconceptions and build trust among different actors. Communication technologies such as social media also contribute to greater publicisation of direct contact between senior decision-makers, potentially affecting decision-making contexts and dynamics. • More direct, unfiltered engagement between senior decision-makers and audiences may enable all decision-makers to better understand public sentiment. The public may also receive clearer, more frequent messages about government policy and actions. • However, more direct, open messaging between senior decision-makers and audiences may increase challenges with audience cross-pollination and encourage more aggressive, expansive rhetoric, which could have escalatory effects.

The way nuclear deterrence outcomes could be affected by these mechanisms is likely to depend on a range of situational factors and conditions specific to each situation. The study identified five such situational factors:

1. Individual characteristics of senior decision-makers, including pre-existing perceptions, preferences for communication and linkages with audiences.
2. Internal institutional processes as well as access to information, relevant tools and techniques for information processing and analysis.
3. The wider context of the type of crisis (e.g. pace or duration), as well as the broader geopolitical and security contexts.
4. Characteristics of audiences, both domestic and international, direct or indirect.
5. Characteristics of communication and information-sharing platforms used in a crisis context and the nature of the wider media landscape.

Key implications for UK Defence

The study findings have three key implications for UK Defence and deterrence policy:

1. There is a need for further, more systematic analyses of the information environment and individual information ecosystems to help UK Defence understand how information-related processes evolve, anticipate impacts on actors' behaviour in the international system, and avoid potential unintended consequences and misperceptions (e.g. stemming from audience cross-pollination).
2. Current and anticipated changes in the information environment emphasise a need for information resilience at the individual level, i.e. among relevant decision-makers along the chain of command. This may include investing in data, media and digital literacy to support decision-makers' ability, at all levels, to navigate new stressors and pressures on decision-making processes, such as information overload.
3. There is also a need for organisations including UK Defence to build information resilience at the organisational level, including through 1) ensuring access to effective tools to detect, verify and triangulate information, 2) maintaining resilience against disruption of data access and information flows, and 3) strengthening structural and procedural safeguards to reduce risk of accidents and inadvertent escalation, as well as fostering a robust information management culture.

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Abbreviations

AI	Artificial Intelligence
OSINT	Open-Source Intelligence
SME	Subject Matter Expert
UK	United Kingdom
UK MOD	UK Ministry of Defence
US	United States

Chapter 1. **Introduction**

1.1. Context

All policy- and decision-making processes, as well as the social and political contexts in which these take place, intrinsically rely on information. Information shapes public discourse on national security issues, such as nuclear deterrence, which can impact political support for alternative policy options. It is also at the core of how senior decision-makers understand the geopolitical and security environment in which they operate and make policy and state action decisions (see Box 2).

It is widely recognised that the way individuals generate, share and consume information is undergoing substantial change.[2] Understanding these dynamics is critical for UK Defence operations. As highlighted by the UK Ministry of Defence (MOD) in 2018, 'information is no longer just an enabler, it is a fully-fledged national lever of power, a critical enabler to understanding, decision-making and tempo, and a "weapon" to be used from strategic to tactical level for advantage.'[3] In the highly dynamic and increasingly competitive strategic context surrounding the UK's nuclear deterrence posture, understanding how the information environment affects deterrence and decision-making is thus essential.

Box 1. Defining the 'future information environment'

In this study, we defined the information environment as 'all informational processes, services and entities' through which 'humans and machines process information to make sense of the world.'[4] This definition recognises that assessing changes in the information environment involves understanding not only innovation in information and communication technologies, but also the broader social and cultural factors that shape how humans engage with information and communicate with others. This is further explored in Chapter 2 of this report. Given the significant uncertainty associated with future trends in the information environment, we focus on likely developments over the next 5–10 years (i.e. out to 2030–2035).

2 See Röttger & Vedres (2020), Kuznar (2023) and Slapakova et al. (2024).

3 UK MOD (2018).

4 Floridi (2005) and Wanless (2023).

Nevertheless, existing research on the implications of the changing information environment for nuclear deterrence and decision-making is limited. This research has predominantly focused on the escalatory and de-escalatory effects of increasing social media use among the public and senior decision-makers, with an overwhelming focus on the United States (US).[5] More recently, attention has shifted to the implications of maturing AI capabilities and their adoption in nuclear decision-making contexts.[6] Though these technologies are critical to the dynamics of the contemporary information environment, other technologies, as well as non-technological trends and their implications, appear largely overlooked.

Additionally, the impacts of technological and non-technological trends in the information environment are not linear or uniform across all national and regional contexts. Instead, factors such as the domestic media landscape and geopolitical and socio-cultural conditions affect how developments unfold and the impact they have in crises and broader deterrence contexts. However, little is known about the factors that may underlie those risks and the mediating or amplifying roles they may play in the evolving information environment.

1.2. Research objectives

This research aimed to advance understanding of how the future information environment affects nuclear deterrence and decision-making. In particular, it sought to explore how and under what conditions the future information environment may impact the UK's nuclear deterrence strategy and decision-making processes. The research's overarching rationale was to help enable the UK's ability to effectively deter contemporary and potential future threats by supporting the following objectives of the Nuclear Deterrence Fund:

1. Advance the UK's understanding of the evolving security environment for nuclear deterrence.
2. Improve understanding of the psychology and contemporary realities of nuclear decision-making.

The research sought to address the following research questions:

- What are the key risks, vulnerabilities and opportunities from the future information environment for the UK's nuclear deterrence strategy and decision-making?
- What factors and conditions may increase the UK's vulnerability to risks and negative impacts of the future information environment in relation to nuclear deterrence?
- What factors and conditions may strengthen the UK's resilience and enable it to maximise opportunities associated with the future information environment in relation to nuclear deterrence?

Nuclear deterrence and decision-making are multi-dimensional phenomena involving a complex web of actors and processes. Given the study's focus on understanding the evolving ways in which people engage with information, the concept of *nuclear decision-making* was particularly central to the research. Box 2 introduces the study's approach to this concept, and Chapter 3 provides a more in-depth discussion of nuclear decision-making dynamics.

5 See Jablanski et al. (2020), Williams & Drew (2020), Narang & Williams (2023) and Chiriac (2022).

6 See Favaro (2021), Osinga & Sweijs (2021) and Johnson (2022a).

Box 2. Defining 'nuclear decision-making'

This study focuses on decision-making in the context of a) nuclear deterrence policy, such as the determination of nuclear postures, b) crises, including decisions about crisis escalation and de-escalation, and c) the use and non-use of nuclear weapons. We do not consider decision-making around the initiation of a nuclear weapons programme and acquisition of nuclear weapons, due to the significantly different dynamics of this policy process,[7] and thus focus on decision-making among existing nuclear actors.

The decision-making processes of concern to this study are understood to involve an increasingly narrow set of senior decision-makers. Senior decision-makers are responsible for the most consequential decisions regarding nuclear strategy, including nuclear use and non-use. Lower-level decision-makers along the chain of command (e.g. intelligence officers) play a distinct but relevant role in the decision-making process by making decisions that affect how crises evolve (e.g. whether to escalate issues or share information up the chain of command). Finally, the public can exert indirect influence on the decision-making process by shaping perceptions of threats and the political palatability of various policies and courses of action. Chapter 3 discusses these dynamics further.

Importantly, the decision-making process is understood as an interplay between these different actors and a function of:

Perceptions, i.e. how individuals understand the information environment, and *communication*, i.e. the nature of messages and the dynamics of messaging that individuals put out into the information environment.

Interaction effects arising from the interaction between domestic and adversarial/other international actors.

As detailed in the next section, this research drew on a review of existing literature and eliciting insight from subject matter experts (SMEs) to address these questions. Rather than providing conclusive answers or predictions about future developments, the aim was to develop a comprehensive conceptual framework that would facilitate and structure future research into the effects of the information environment. The rationale for developing a conceptual framework was also the absence of a systematic and coherent narrative in existing research on the implications of the information environment for nuclear deterrence, and thus a need to better draw together existing scholarship.

1.3. Research approach, caveats and limitations

We used a structured multi-method research approach to answer the research questions, combining a literature review with expert elicitation via semi-structured interviews.

The first phase of the study consisted of a narrative literature review to take stock of existing knowledge on the impact of the evolving information environment on nuclear deterrence and decision-making. A narrative literature review is a non-systematic form of literature review that synthesises research

7 See Koch (2023).

evidence.[8] We deemed this a suitable method given the nature of the research questions, the timeframe, and the study's available budget. We identified relevant sources via two strategies: 1) Google Scholar searches using Boolean search strings (based on keywords linked to the research questions), and 2) reference harvesting (i.e. identifying sources through the selected sources' references). The search strings and inclusion and exclusion criteria we applied to identify the most relevant sources for the review are presented in Tables 1 and 2 below.

Table 1. Literature search strings

String	Search terms
Search string 1	"nuclear deterrence" OR "nuclear decision-making" OR "nuclear psychology" OR "crisis stability" AND "information environment" OR "information ecosystem" OR "media" OR "digital environment"
Search string 2	"nuclear deterrence" OR "nuclear decision-making" OR "nuclear psychology" OR "crisis stability" OR "nuclear signalling" OR "nuclear conflict" OR "nuclear age" OR "nuclear risk" OR "escalation" AND "information environment" OR "information ecosystem" OR "media" OR "digital environment" OR "social media" OR "internet" OR "mass communication" OR "misinformation" OR "disinformation" OR "information disorder"

Table 2. Literature inclusion and exclusion criteria

Criteria	Inclusion	Exclusion
Focus of source	The source addresses the impact of the changing information environment on nuclear deterrence and related concepts (e.g. nuclear decision-making and crisis stability). The source discusses the impact of the changing information environment on decision-making in national security contexts.	Sources that do not address issues specified in the inclusion criteria. Sources discussing the implications of the changing information environment on the civilian nuclear energy sector.
Type of source	Peer-reviewed academic literature. Non-peer-reviewed grey literature based on sound research methodology. Doctoral theses.	MA or BA theses. News articles. Opinions and editorials.
Date of publication	Sources published during or after 2010.[9]	Sources published before 2010.
Language	Source published in English.	Source published in languages other than English.

8 Sukhera (2022).

9 We chose a 2010 publication cut-off to capture research on social media's impact on nuclear decision-making. Older sources were considered less relevant to current and future information trends.

Following source screening, we considered 32 sources eligible for inclusion and reviewed and extracted them using a structured coding framework. Reviews were facilitated using the MAXQDA qualitative analysis software. Information extracted from literature sources focused on:

- Current and anticipated trends in the information environment.
- Implications of the information environment for nuclear deterrence.
- Implications of the information environment for wider crisis stability and conflict dynamics.
- Mediating factors and conditions determining the scope and nature of the information environment's impact.

In the second phase of the study, we completed eight in-depth interviews with SMEs. We identified interviewees based on their expertise to capture diverse insights into trends in the future information environment, as well as issues such as the psychology of nuclear decision-making, implications of emerging technologies for nuclear deterrence, and the role of public opinion in national security. Interviews were conducted remotely using a semi-structured interview protocol that included questions mirroring the research questions and the literature review extraction framework. We also asked interviewees about key narratives in existing research on how the changing information environment affects nuclear deterrence and decision-making. We sought their views on whether these impacts have materialised and on where evidence and knowledge gaps remain.

We then analysed interview data inductively to identify shared themes, with data management supported by MAXQDA. Analysis from the literature review and SME interviews was subsequently integrated and synthesised to develop an analytical framework mapping trends in the information environment, mechanisms of impact on nuclear deterrence, and potential enabling/constraining factors and conditions. The research team held two analytical workshops to support the analysis process and discuss key emerging themes.

This study's findings are subject to the following caveats, limitations and assumptions:

- Although we consolidated insights from existing literature through a narrative literature review and SMEs' informed opinions, budgetary and timeline constraints limited the scope, the review was non-systematic, and we only interviewed a limited number of SMEs. The study findings thus inherently reflect the interviewed SMEs' expertise. To minimise these limitations, we triangulated findings from the literature with insights from the interviews.
- We aimed to identify potential trends in the future information environment and their impact on nuclear decision-making. Given the pace of technological change and the uncertainty surrounding their future use and performance, our findings are not specific predictions. Instead, they offer insights into broad anticipated trends and key mechanisms of impact that may shape future nuclear decision-making.
- We sought to determine the factors and conditions that can shape how nuclear decision-making and deterrence processes are affected by changes in the information environment. Due to the project's limited scope, however, the study does not examine every possible situation in which nuclear decisions are made. Instead, it focuses on the broad impacts of these factors to help clarify debates about the information environment's future implications.
- We developed an analytical framework to show how future changes in the

information environment can shape nuclear decision-making and deterrence. This framework should be refined and tested to ensure its usefulness, applicability and replicability.

Readers should consider these methodological limitations when interpreting the findings. Chapter 4 discusses ways to build on, refine and validate this report's findings.

1.4. Structure of this report

Further to this introductory chapter, this report features three analytical chapters:

- **Chapter 2** examines the concept of the information environment and how it and its effects on policy and decision-making can be assessed. Adopting perspectives from information ecology provides a conceptual basis for a subsequent discussion of key trends and anticipated future developments in the information environment relevant to nuclear deterrence and decision-making.
- **Chapter 3** presents the conceptual framework for understanding implications of the information environment for nuclear deterrence and decision-making, and describes its constituent elements. This focuses on four mechanisms through which the information environment shapes decision-making and broader structural processes: changes in levels of stress, complexity and risk, as well as changes in the availability of information. The chapter discusses the impacts of these trends on nuclear decision-making, with a particular view on escalatory and de-escalatory dynamics between nuclear actors.
- **Chapter 4** examines the factors that shape how information changes will affect nuclear deterrence and decision-making. It covers five groups: characteristics of senior decision-makers, the institutional and organisational context, the crisis type and context, audience characteristics, and the nature of communication platforms and the media.
- **Chapter 5** summarises the study's conclusions and discusses implications for UK Defence, particularly the preparedness of senior decision-makers and organisations to navigate a more complex information environment. Noting this research's scope, this section also outlines future priorities and research paths to strengthen the UK's understanding of these effects and dynamics. This includes thorough analyses of developments in the information ecosystem and an assessment of decision-maker behaviours in complex information environments through experimental research.

Chapter 2. **The information environment and its evolution**

This chapter explores the concept of the information environment, how it is perceived to be changing, and its future evolution. This provides a conceptual and contextual grounding for later discussions of how this evolving environment affects nuclear deterrence and decision-making.

2.1. What is the information environment?

Despite the increasing attention it receives in defence and security policy debates, the concept of 'the information environment' is often left undefined. This leads to inconsistencies in how we discuss developments in this environment and its impacts on policy, including nuclear deterrence.

In the broadest sense, **the information environment** can be understood as 'all informational processes, services and entities' through which 'humans and machines process information to make sense of the world.'[10] These processes, services and entities involve informational agents, both individuals and organisations, and their relations and interactions thus shape the information environment. Core aspects of the information environment refer to the ways in which individuals and organisations process, generate, share and interact with the information they encounter through social transmission and social networks (e.g. conversations), as well as through formal media (e.g. news outlets) and communication platforms (e.g. social media). In this sense, we understand the information environment to encompass the ecosystem of interactions between individuals and information.

The information environment is inherently dynamic, and its evolution is not uniform.[11] Information processes can develop differently across national, regional or alternative socio-cultural contexts.[12] Given this, it is useful to distinguish the information environment from individual **information ecosystems**. Information ecosystems are 'informational spaces identified by communities with shared traits and interests comprised of entities who can communicate intelligibly with each other'.[13] Since researchers have only recently begun systematically studying individual information ecosystems to better understand their changes over time,[14] our understanding of these ecosystems remains limited.

Existing research offers several frameworks that break down the information environment and individual information ecosystems, clarifying their components. One prominent framework uses an **information ecology perspective**[15] to characterise the information environment. It highlights three layers that clarify disruptions and changes in this environment (see Figure 1 below).[16]

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10 Floridi (2010); Wanless (2023).

11 Röttger & Vedres (2020); Wanless et al. (2025).

12 Floridi (2010).

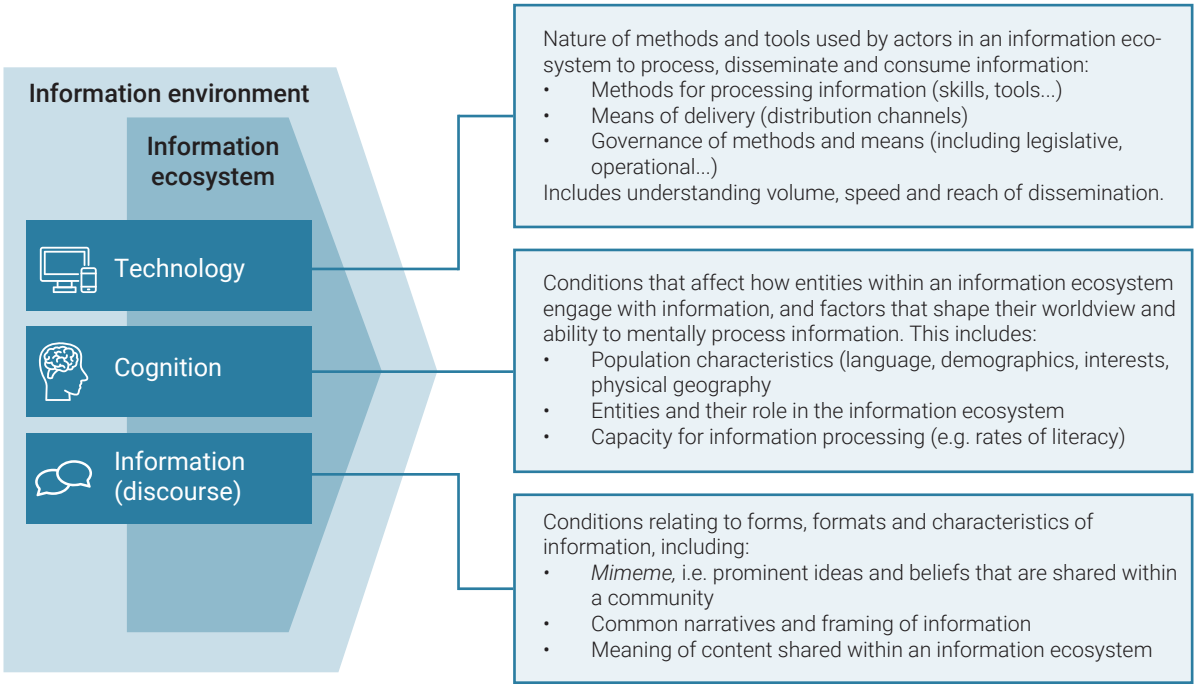
13 Wanless (2023).

14 Wanless et al. (2025).

15 Information ecology is defined as 'the study of the information environment, including the entities within it and their relation to each other and the wider system' (Wanless 2023). For additional discussion, see Norris & Suomela (2017).

16 Wanless (2023).

Figure 1. Information environment layers (information ecology)



Source: Wanless (2023: 70–71).

Other frameworks in military and defence policy research divide the information environment into physical, virtual and cognitive dimensions. The physical area comprises the physical infrastructure underpinning informational processes, i.e. the 'ecosystem of machines that communicate with other machines.'[17] The virtual dimension, enabled by physical infrastructure, includes all non-physical ways information is shared, such as through media channels (including social media) and between people. The cognitive domain concerns how people take in, understand and act on information.[18] In this report, we use the information ecology framework because it highlights socio-cultural trends in the information environment, which are often overlooked in other research.

The dimensions of the information environment are inherently intertwined, with developments or disruptions in one likely to ripple through to changes in another. For example, the development of portable communication devices facilitated the rise of social media, which, in turn, is associated with an amplification of cognitive biases,

17 Kuznar et al. (2023).

18 This dimension highlights various cognitive biases that shape how individuals are likely to engage with information, e.g. motivated reasoning (interpreting information to fit pre-existing worldviews) and confirmation bias (the tendency to seek out information that confirms existing worldviews).

particularly confirmation bias and recency bias (i.e. the tendency to place greater emphasis on recent over past events).[19] However, the information ecology perspective shows that technological innovation does not solely drive change in informational processes. Cultural, biological and cognitive factors also shape information agents' perceptions, attitudes and behaviours, which define how they interact with technologies.[20]

Box 3. Summary of key terms: The information environment

- The information environment can be defined as 'all informational processes, services and entities' through which 'humans and machines process information to make sense of the world.'[21]
- Though we can detect broad, strategic changes in the information environment, the environment and its changes are not uniform. Instead, how people and communities engage with information and communicate with each other differ across information ecosystems, i.e. information spaces within discrete communities, such as nation states.
- This report uses an information ecology lens to describe recent and anticipated trends in the information environment. It explains that changes or disruptions can be understood by examining three layers: cognition, technology and information. While many disruptions stem from technological change, non-technological factors such as demography, culture and politics also play a role.

19 Cao et al. (2021).

20 Wanless (2023); Slapakova et al. (2024).

21 Floridi (2010); Wanless (2023: 55).

2.2. How is the information environment evolving?

Several strategic trends have shaped informational processes in recent history. The next sections discuss these trends within the information ecology framework, focusing on those pertinent to nuclear deterrence and decision-making.

2.2.1. Technology

Existing research has characterised the current context for nuclear decision-making as one of 'a large-scale technology transition', underpinned by several technological developments.[22]

The first is the gradual **shift from fixed communication devices (e.g. desktop computers) to highly mobile, personalised devices (e.g. smartphones)**.[23] Improved connectivity has facilitated the democratisation of information access. People can now communicate persistently, over greater distances, and at a higher pace within information ecosystems, driven by an increased demand for connectivity and data. As a result, today's information environment features an exponentially larger number of interconnected communication devices and users who primarily consume information via mobile phones (mobile-first users).[24]

The second, related development is the **emergence of social media platforms**. Social media has gained primacy in many information ecosystems as the channel through which people access information and communicate.[25] As a result, many communities today identify social media as a primary gateway for accessing news.[26] These evolving trends, which are explored further in Chapter 3, include:

- The increased volume and velocity of information flow, because it is cheaper and easier to make and share content.[27]
- The faster pace of news cycles, directly tied to global real-time news coverage enabled by innovations in electronic communication technologies.[28]
- More direct and informal communication among audiences as well as between the public and governments.[29]
- Amplification of information threats, as malign state and non-state actors disseminate narratives and content more widely, cheaply and rapidly.[30]
- Increased challenges in detecting and verifying information.[31]

Although social media is often discussed as a collective of communication platforms, recent trends suggest it is **increasingly fragmented**, with users shifting their platform preferences and communication purposes. Recent data

22 Stanley Center for Peace and Security (2017).
23 Kuznar (2023).
24 Chin et al. (2019); Röttger & Vedres (2020).
25 Röttger & Vedres (2020).
26 Newman et al. (2024).
27 Kavanagh & Rich (2018); Stanley Center for Peace and Security (2017).
28 Gilboa (2005).
29 Stanley Center for Peace and Security (2017); Williams & Drew (2020); Newman & Cherubini (2025).
30 Ajir & Vailliant (2018).
31 Stanley Center for Peace and Security (2017).

suggests a decline in Facebook's use for news access in Europe and the US as users turn instead to private messaging apps and video networks.[32] At the same time, communication methods are changing, driven by greater **anonymisation** enabled by technologies such as cryptography and blockchain.[33] While these advances strengthen information security and data protection, they also complicate the detection and attribution of information manipulation (discussed in Section 2.2.3 below).

Though this is currently limited, future trends in the social media layer of the information environment may include integrating **augmented, mixed and virtual reality** into social networks.[34] These technologies could extend virtual interactions into real-time, persistent digital engagement in more immersive or simulated realities. Experts disagree about how widely augmented, mixed and virtual reality will be used in the near future, and how many use cases they will have. Nevertheless, the technologies are expected to increase many of the challenges associated with contemporary social media use, such as more potent disinformation and societal manipulation. They may also make it harder for individuals to distinguish between facts and fiction and between authentic and inauthentic content.[35]

Against this backdrop, many recent and anticipated future changes and disruptions in the information environment have been linked to the **maturing and increased use of AI technologies**. Many experts interviewed for this study associated the future information environment with developments in AI and its applications across the wider media and news ecosystem, as well as decision-making among governmental elites.[36] Some interviewees expressed profound uncertainty about AI's trajectory and implications for the information environment.[37] Research has already highlighted challenges stemming from AI's amplification of misleading narratives in online media and increased difficulties in detecting AI-enabled mis- and disinformation.[38] Interviewees also noted that AI's pervasive integration into other technological systems makes it a focal point,[39] introducing additional challenges, such as limited end-user understanding of its inner workings, which can foster misuse.[40]

In addition, as generative AI technologies mature, they are enabling the creation of larger quantities of high-quality synthetic data and content, posing both opportunities and challenges.[41] The use of AI to generate synthetic data is gaining interest as a cost-effective way to improve the development and training of AI models, including in defence contexts. As AI models become more complex, the lack of high-quality, diverse, real-world datasets required to train AI systems poses an

32 Newman & Cherubini (2025).

33 Slapakova et al. (2024).

34 Slapakova et al. (2024).

35 Marler et al. (2023); Slapakova et al. (2024).

36 Research interview INT01; Research interview INT05; Research interview INT06; Research interview INT07.

37 Research interview INT01.

38 Computational and Mathematical Organization Theory (2025).

39 Research interview INT05.

40 Research interview INT06; Research interview INT05.

41 Slapakova et al. (2024).

important barrier, which could be mitigated by using AI to generate synthetic data.[42]

However, AI-generated content, particularly 'deepfakes',[43] also raises concerns over end-users' ability to detect and recognise artificially generated content and false or intentionally misleading information. As discussed in Chapter 3, these difficulties may make it challenging for individuals to interpret and use information in decision-making. At the macro-level, it may also contribute to distrust in information sources, with evidence already showing growing concern among individuals about distinguishing between 'real' and 'fake' news and between trustworthy and untrustworthy content on online platforms, alongside widespread suspicion about the use of AI in news reporting.[44]

AI advances are closely linked to the development of technologies that facilitate connection and information exchange between humans and machines, i.e. **human-machine interfaces.** Though still in the early stages, such technologies will likely evolve into increasingly seamless communication between humans and technological systems, potentially assisting in information processing.[45] In the future, they may also extend to technology-assisted interpersonal communication through brain-to-brain communication.[46] Both human-machine and brain-to-brain communication technologies are accompanied by extensive ethical and regulatory debates, given their technologically intrusive nature and the sensitivity of the data collected (defined as 'neurodata').

Although discussed infrequently in current research on the information environment and its effects, **space-based technologies** have also played an increasingly important role in enabling information transfer and communication.[47] This extension of the information infrastructure into the space domain has complemented other technologies in providing connectivity, and the reliance on space-based services for connectivity is expected to increase due to growing demand and decreasing access costs to space and, as a result, space-based services.[48] As discussed in Chapter 3, while mature space technologies have improved connectivity, growing dependence on space-based services increases the risk of disruptions.

2.2.2. Cognition

As noted in Section 2.1, the cognition layer captures 'conditions that affect how entities within an information ecosystem engage with information, and factors that shape their worldview and ability to mentally process information.'[49] Though these conditions vary considerably across national and subnational contexts, due to factors such as language and literacy levels, several overarching trends emerge.

First, the proliferation of internet access, the transition from fixed to mobile communication tools, the growing accessibility of space-enabled connectivity, and other technological

42 Deng (2023).

43 'Deep-fakes' are synthetic media that use machine learning (an AI technique) to convincingly manipulate audio and video content. The term 'deep-fakes' is commonly associated with content forgery with a malign intent.

44 Newman et al. (2024), Slapakova et al. (2024).

45 Depp & Sharre (2024).

46 Binnendijk et al. (2020).

47 Slapakova et al. (2024).

48 Black et al. (2022).

49 Wanless (2023).

developments have generally expanded access to information.[50] This substantial democratisation of information access has signalled improved capacity among the public and senior decision-makers to seek out and access the information they require to guide their actions and behaviours. Alongside the increasing quantity and accessibility of information, technological developments have also expanded the diversity of data, with accompanying innovation in methods for data analysis and integration.

Alongside widespread benefits, this trend has posed challenges for informational capacity due to **increasing saturation and 'noise' in the information environment** and a corresponding amplification of the cognitive biases underpinning human decision-making.[51] Cognitive biases are a consistent characteristic of human cognition and thus a static factor in any information environment. However, since they can be amplified or mitigated by trends such as technological change, their impact on the information environment can fluctuate. For example, research shows that algorithmic advances embedded in many social media platforms are associated with:

- Echo chambers, where individuals' attitudes are reinforced through interaction with like-minded end-users
- Filter bubbles, which algorithmically filter information to end-users' information flows.[52]

These algorithmic features can reinforce common biases, such as confirmation bias and motivated reasoning.[53] As we discuss in Chapter 3, this affects how the public and decision-makers along the chain of command make decisions, including during crisis scenarios, as well as the public's and elites' vulnerability to malign influence.

The amplification of cognitive biases in the contemporary information environment is linked to **poor levels of media/digital/news literacy** among most populations. This is associated with the increased demands on people to be media-literate and navigate a more complex information environment, and with pressures on education systems in highly digitised countries such as the US, which have seen a reduced emphasis on civic education, critical thinking and similar skills.[54] The result is a mismatch between requirements for better media/digital/news literacy and a lack of capacity (or availability of effective approaches) to deliver relevant training and education.

Additionally, the democratisation of information access has not been uniform. Significant **economic, social, and demographic divides** exist in information access and in how information is accessed across different communities globally. For example, internet use in the Global North is substantially higher than in some regions of the Global South (e.g. Africa).[55] From a demographic perspective, there are significant inter-generational differences in individuals' engagements with the information environment. While younger generations,

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50 Jablanski et al. (2020).

51 Research interview INT07; Jablanski et al. (2020). Cognitive biases can be defined as 'ways in which a person's beliefs, attitudes, reasoning or decisions can deviate from reality or strict rationality as a result of patterns and tendencies in human processing' (Kavanagh & Rich 2018, based on Haselton et al. 2005).

52 Röttger & Vedres (2020).

53 Nyhan & Reifler (2010); Flynn et al. (2017).

54 Kavanagh & Rich (2018).

55 International Telecommunication Union (2019) in Röttger & Vedres (2020).

such as Generation Z, are described as digital natives who predominantly consume news through social media and smartphones, older generations frequently access news through traditional media channels such as TV, radio and print.[56] These digital exclusion patterns may be amplified in the future as the sophistication of digital communication technologies continues to increase.[57] Additionally, some informational ecosystems feature deliberate restrictions on information access (e.g. censorship or firewalls), indicating that political determinants are also significant in determining information access.[58]

Regarding actors and entities in the information environment and their roles, technological innovation has underpinned the **expanding reach of private companies**, particularly social media platforms, across information ecosystems.[59] Private actors' growing agency and control over the information environment, including highly empowered elites with ownership of large media markets, correspond to a decrease in state and governmental actors' control in this domain. This has consequences for the information ecosystem, its governance, and how individuals interact with it. Most notably, private companies play an essential role in managing the dissemination of mis- and disinformation in the information environment through content moderation, with states relying on private companies' cooperation to effectively mitigate the effects of influence operations targeting public audiences.[60] Similar dynamics exist in other technological areas, such as the development of AI models and tools, where companies play an essential role in setting the course for future innovation and AI governance.[61]

Social media companies' rising influence parallels the **drastically changing roles of traditional media and news organisations** in the national and international information ecosystems.[62] Commercial pressures, driven by the proliferation of free online content, have reduced the media's traditional gatekeeper role, particularly in local journalism. Additionally, news cycles have accelerated, and profit motives have intensified, prompting consolidation in national media landscapes – now largely controlled by a few big players.[63] As a result, news reporting has shifted from strictly factual accounts to focusing on attracting bigger audiences through narrow reporting, explicit framing and bias, or opinion-based commentary. Media companies are now incentivised to match audience preferences and sensationalise stories, increasing the amount of extra-factual content in information spaces.[64] Further analysis of these trends and their impact on news reporting and public discourse follows in the next section.

2.2.3. Information and discourse

Ideas, beliefs and common narratives within the information environment inherently reflect the unique characteristics of each community,

56 Neuman et al. (2019); Research interview INT06.
57 Slapakova et al. (2024).
58 Research interview INT01.
59 Trinkunas et al. (2020).
60 Research interview INT02.
61 Research interview INT01.
62 Röttger & Vedres (2020).
63 Kavanagh & Rich (2018).
64 Mitchell & Holcomb (2016); Gentzkow & Shapiro (2006).

making it difficult to generalise information trends across the entire environment. Nevertheless, several broad trends in information and discourse relevant to nuclear deterrence have emerged.

Existing research and expert interviews for this study highlight an ongoing trend. The information environment is increasingly described as **'post-truth.'** In this context, people rely more on emotion than on facts as 'the most readily accessible, accurate and immediate source of truth.'[65] RAND researchers have called this 'Truth Decay', in which facts play a reduced role in public discourse in the 'post-truth' environment.[66] This trend includes:

- Declining agreement about facts and analytical interpretations of facts and data.
- A blurring of the line between opinion and fact.
- The increasing relative volume and resulting influence of opinion and personal experience over fact.
- Declining trust in formerly respected sources of factual information.[67]

Discourse in the information environment reflects these aspects in several ways. There is greater fragmentation and disagreement about factual touchpoints between individuals and communities. Discourse is also increasingly saturated with opinion-based content rather than factual or analytical content, driven by an interplay of factors discussed in the previous two sections, including the amplification of cognitive biases enabled by technological innovations. **Increasing socio-demographic and political polarisation** also plays a role.[68] These trends manifest in how individuals engage with the information environment. For example, across many countries, consumers increasingly focus on partisan commentators, influencers and young news creators, decreasing the role of traditional news brands and journalists.[69] Increasing polarisation is seen to cause and reinforce the above-described trends of Truth Decay, with socio-demographic and political groupings becoming increasingly insular in their interpretation of information.[70]

Alongside variations in information and discourse at the community level, several anticipated technological developments are also believed to contribute to the **individualisation and personalisation of information flows**.[71] For example, algorithmic changes in social media platforms and the maturing of AI enable greater tailoring of information flows and user experiences by analysing and responding to individual user data. Similarly, the potential emerging use of augmented, virtual, and mixed reality technologies allows information to be customised based on users' interactions in those environments. Together, these technological changes adapt information to the characteristics and preferences of individual end-users, leading to the emergence of **micro-communities defined by new shared**

65 McDermott (2020) in Jablanski et al. (2020).

66 Kavanagh & Rich (2018).

67 Kavanagh & Rich (2018).

68 Kavanagh & Rich (2018).

69 Newman et al. (2024).

70 Kavanagh & Rich (2018).

71 Slapakova et al. (2024).

identities.[72] This trend is further amplified by changes in many national media landscapes, where information consumption has shifted from local to national or global scales. For instance, as more individuals now consume news online rather than through local news media, geographic cultural delineations (e.g. nation-state identity) diminish in significance, while sub- and transnational cultures formed through digital interactions gain prominence.[73]

Relatedly, the personalisation of information flows presents a challenge to communities, even at a micro-level, in establishing **common cultural touchpoints and identities.**[74] The implications of this for defence and security policy have yet to be explored. However, they may include increased challenges for governments and other traditionally trusted messengers to effectively communicate with audiences, as well as a diminishing government control over national information ecosystems. Nevertheless, closer interactions between senior decision-makers and publics facilitated by social media and other developments are also believed to make it easier for governments to 'distribute messages, segment and narrowly target messages to different groups, shape political narratives and interpret or whip up public support.'[75] There are, therefore, conflicting indications about the level of control that public institutions may have over the future information environment.

2.3. Summary: The information environment and its evolution

Table 3 below summarises the key trends and anticipated future disruptions across the three layers of the information environment. The next chapter discusses how these trends are understood to affect nuclear deterrence and decision-making.

Table 3. Summary of identified characteristics of the changing information environment

Information environment layer	Key trends and anticipated future disruptions
Technology: *Nature of methods and tools used by actors in an information ecosystem to process, spread and consume information*	• A shift from fixed communication devices (e.g. desktop computers) to highly mobile and personalised devices (e.g. smartphones). • Increasing relevance of social media platforms and primacy of social media for news consumption. • Maturing and proliferating use of AI technologies, including for synthetic data generation. • Increasing importance of space-based technologies for connectivity.

72 Research interview INT01; Research interview INT02.

73 Slapakova et al. (2024).

74 Slapakova et al. (2024).

75 Stanley Center for Peace and Security (2017).

Information environment layer	Key trends and anticipated future disruptions
Cognition: *Conditions that affect how entities within an information ecosystem engage with information, and factors that shape their worldview and ability to mentally process information*	• Democratising access to information, coupled with economic, social and demographic divides in information access. • An increasing quantity of information, resulting in greater information availability as well as 'noise.' • The expanding reach of private companies, particularly social media platforms, across information ecosystems. • Increasing distrust of traditional information sources and concern over recognising 'real' and 'fake' content, as well as truthful and misleading information.
Information and discourse: *Conditions relating to 'forms, formats and characteristics of processed information', including commonly shared narratives and framing of ideas shared through communication channels and platforms*	• Emergence of a 'post-truth' information environment. • Increasing socio-demographic and political polarisation in public discourse. • Increasing individualisation and personalisation of information flows, with the potential to diminish communities' ability to establish common cultural touchpoints and identities. • Novel delineation of information ecosystems formed around micro-communities with shared cultural identity rather than geographic boundaries.

Source: RAND Europe literature review and interview analysis.

Chapter 3. **Understanding implications of the future information environment for nuclear deterrence and decision-making**

Having set out the context of the changing information environment, this chapter discusses the implications for nuclear deterrence and decision-making. We first elaborate on our understanding of nuclear decision-making processes before discussing how the information environment affects them through four key mechanisms: changes in informational stress; the complexity of the information environment; levels of risk stemming from information threats; and the availability (accessibility and directness) of information and communication channels.

3.1. Conceptualising nuclear decision-making in evolving information environments

As outlined in Chapter 1, this study approached the question of how the information environment affects nuclear deterrence and decision-making with a specific interest in decisions made in relation to three areas of policy and state behaviour: 1) nuclear deterrence policy, such as the determination of nuclear postures, 2) crises, including decisions about crisis escalation and de-escalation, and 3) use and non-use of nuclear weapons. Decision-making in each of these contexts involves a wide range of decisions, from procedural decisions such as changing readiness levels and relaying information to other actors to hugely consequential decisions such as the launch of a nuclear strike. Importantly, decisions involve not only interpreting facts and other actors' behaviours, but also deciding how to communicate with them, including adversaries, to signal resolve.

Existing research acknowledges that decision-making in these contexts is highly complex and dependent on many interconnected actors, structures and variables.[76] Though some nuclear deterrence theory assigns significant weight to structural factors (e.g. polarity of the international system) to explain how nuclear states behave, historical research has shown that human judgement, i.e. individuals making decisions, plays a deciding role in how nuclear crises develop.[77] Human judgement by several actors can override standard procedures and processes to escalate or de-escalate a crisis.[78] The main actors in this context are senior decision-making elites, e.g. senior military commanders, ministers, heads of state or government. These actors are responsible for most consequential actions that shape a national security crisis, including decisions about nuclear use and non-use.

Additionally, a wider range of lower-level decision-makers, such as duty officers, intelligence personnel and operators, can influence how nuclear decision-making unfolds. These actors have agency over

76 Unal et al. (2022).

77 Lewis et al. (2014); Unal et al. (2022).

78 See Lewis et al. (2014) for a historical analysis of cases of near-nuclear use.

lower-level decisions that can influence crisis outcomes, such as what information to pass to more senior leaders and whether to escalate issues up the chain of command based on their understanding of the threat environment. However, across nuclear policy, decision-making involves fewer principals as decisions become more consequential.

Much of deterrence theory relies on the assumption that decision-makers behave rationally in all settings, including nuclear crises.[79] However, researchers have increasingly drawn attention to the role of complex behavioural and psychological factors in crisis decision-making, questioning the notion that decisions are made purely on rational grounds.[80] Such factors include threat perception and understanding of national security objectives and imperatives, shaped by a variety of environmental influences, including beliefs, culture, religion, education and upbringing.[81] Decisions are also informed by psychological processes, such as ranking preferences (i.e. considering the relative advantages and disadvantages of various policy options) and assessing the probability of events (e.g. how an adversary may act).[82] It has increasingly been recognised that cognitive biases, as well as innate factors such as intuition and 'gut feeling', significantly affect how those psychological processes unfold and ultimately result in decisions and behaviours.[83]

The declining number of principals involved in nuclear decision-making does not necessarily diminish the importance of psychological processes such as cognitive biases and misperceptions. Though highly consequential decisions are likely to be based on carefully curated intelligence, senior decision-makers will also likely be increasingly isolated in the decision-making process, particularly in regimes with highly centralised institutional structures.[84] As such, while the probability of misperception may decrease, the consequences of misperceptions increase due to the agency that senior decision-makers hold over nuclear outcomes.

Public audiences can also influence nuclear decision-making, albeit indirectly. Public opinion is a key element of the information environment as senior decision-makers (i.e. political elites) understand it. However, it can also be influenced by decision-making dynamics (e.g. statements senior leaders make publicly). Though public opinion is understood to play a less direct role in shaping policy outcomes in nuclear deterrence, public discourse is still likely to shape senior decision-makers' understanding of threats and the relative political desirability of various policy decisions.[85] The public can also be a direct and indirect audience of signalling between nuclear actors, thus influencing how messages and communication are received and interpreted. Lastly, public cohesion and trust in institutions can also influence how governments navigate national security crises and how national security, including deterrence policy, evolves in the longer term.[86]

79 Borrie (2020).

80 Unal et al. (2022).

81 Unal et al. (2022).

82 Borrie (2020).

83 Borrie (2020); Unal et al. (2022).

84 Borrie (2020).

85 Holsti (1992).

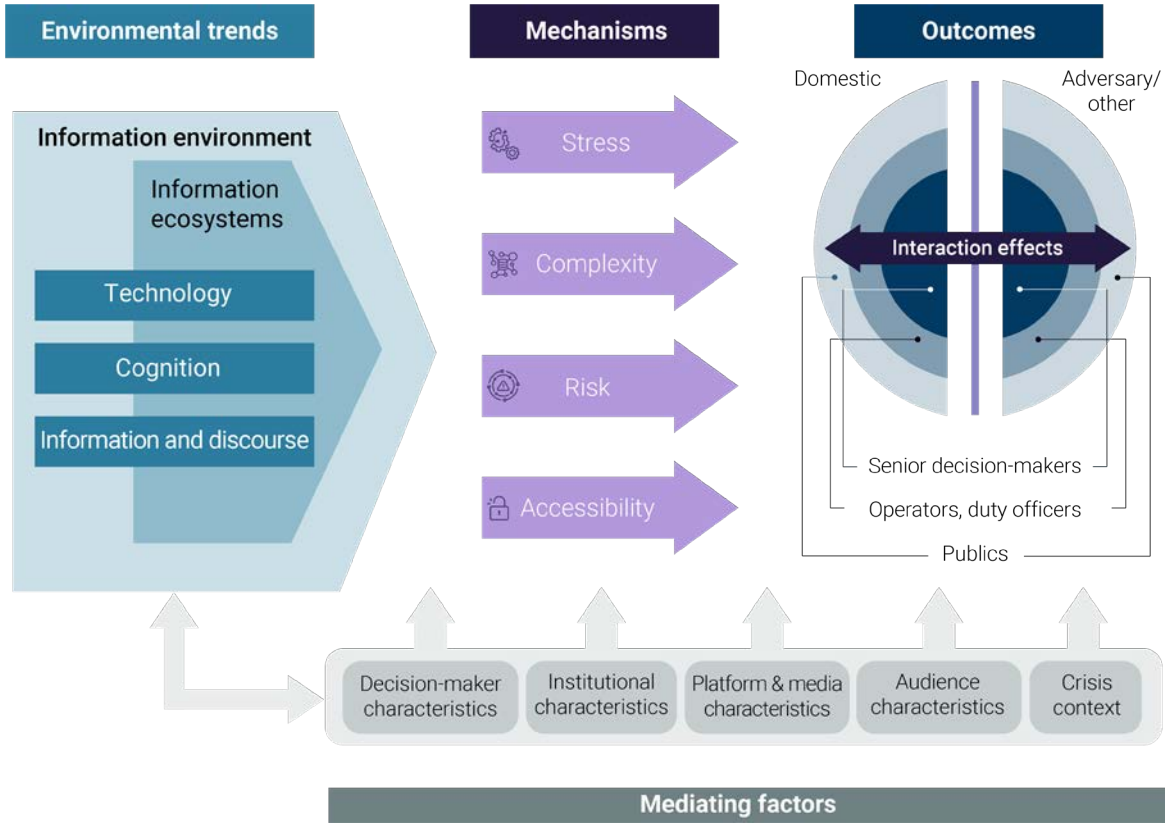
86 Favaro (2021); Narang & Williams (2023).

Building on this, Figure 2 below presents the conceptual framework, which articulates the overarching logic of these effects. It shows how the information environment's impacts on nuclear deterrence and decision-making can be systematically analysed, and captures the following key arguments:

- As discussed in Chapter 2, making sense of **environmental trends** that may affect nuclear deterrence can be achieved by adopting an information ecology perspective. This involves assessing the changing technology landscape, cognition-related conditions, and trends in information and discourse. Though this report focuses on the information environment at large, analyses can become more targeted by focusing on trends in individual information ecosystems.
- Four key **mechanisms** capture the effects of the information environment on nuclear deterrence, comprising changes in:
  - Levels of informational stress
  - The complexity of the information environment
  - Levels of risk stemming from information threats
  - The availability of information and communication channels, defined by their accessibility and directness.
- **Nuclear decision-making outcomes** arise from interactions between domestic and international actors, including 1) senior decision-makers, 2) lower-level decision-makers across the chain of command, and 3) the public. Though these actors exercise different levels and types of agency over decision-making outcomes, interaction effects between them generally arise from *perceptions*, i.e. how individuals understand the information environment and their resulting objectives and motivations, as well as *communication*, i.e. the nature and dynamics of messaging that individuals put out into the information environment.
- The extent to which these mechanisms affect outcomes depends on five **situational mediating factors**: the individual characteristics of decision-makers (senior and low-level), their institutional environments, the platforms and media involved, the audience, and the specific crisis scenario. Chapter 4 discussed how these factors mediate the effects of information environments.

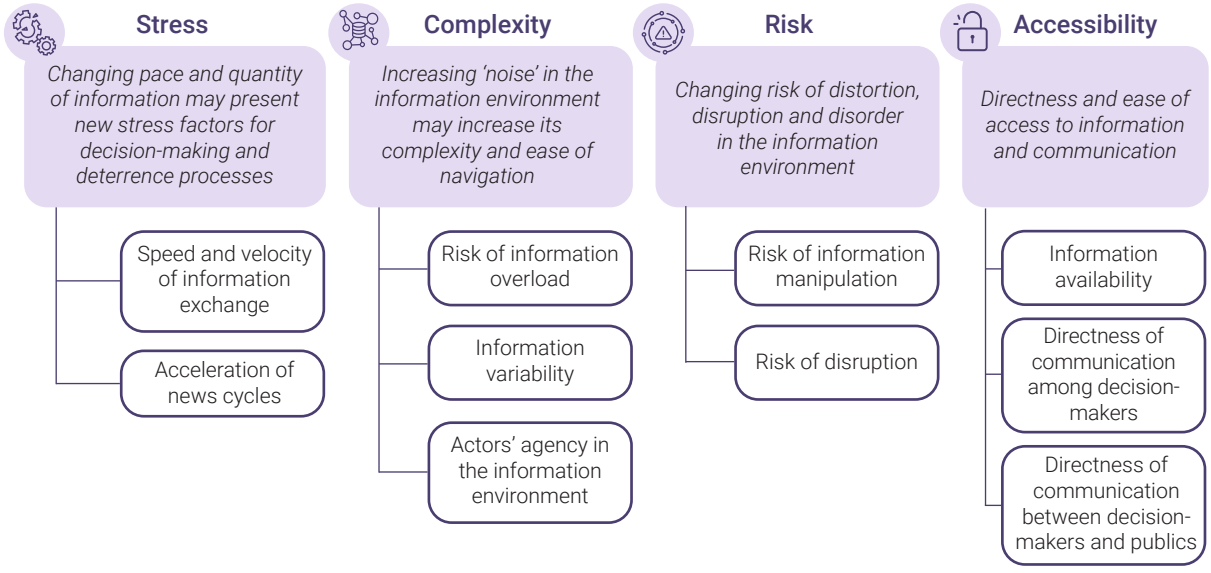
Figure 3 breaks down the four mechanisms by which the future information environment impacts nuclear deterrence. Multiple developments, whether technological, socio-cultural, or otherwise, can give rise to these mechanisms. In many ways, the mechanisms coexist and produce joint, interlinked effects on decision-making and deterrence processes. As such, the relationships between changes in the information environment and nuclear deterrence and decision-making outcomes are complex and not necessarily linear.

Figure 2. Conceptual framework



Source: RAND Europe literature review and interview analysis.

Figure 3. Mechanisms of effect



Source: RAND Europe literature review and interview analysis.



3.2. Stress

Several trends in the information environment appear to be increasing time-based pressures on decision-making, particularly the changing pace and volume of information that individuals, including senior decision-makers, encounter.

The **increasing speed and volume of information exchange** manifest in several ways and impact decision-makers' cognitive abilities, as well as institutional intelligence, analysis, and communication processes central to deterrence and crisis management. As information is shared and disseminated more rapidly, information flows, and the pace at which decision-makers engage with information may become increasingly difficult to manage, increasing pressure on senior decision-makers to interpret and act on information at pace.[87] Psychological research has highlighted the impact of the increased pace of information flow, as well as the increasing 'noise' in the information environment, on senior decision-makers' propensity to adopt 'fast' or Type 1 thinking and take rash actions.[88] Dual process theory differentiates between 'fast' Type 1 thinking and 'slow' Type 2 thinking in human decision-making[89]:

- Type 1 thinking relies on heuristics, intuition and prior expectations, typically leading to quick decisions in the face of immediate stressors.
- Type 2 thinking involves slower, more deliberative and analytical thinking, which requires more mental effort and is thus unlikely to be activated when humans make decisions during crises.

Human decision-making can be flawed and affected by cognitive biases during both Type 1 and Type 2 processes. For example, analytical thinking can still be affected by motivated reasoning and fallacies such as confirmation bias.[90] The potential impact of increased propensities for Type 1 among senior decision-makers is, however, particularly pertinent to nuclear deterrence, as this dynamic could amplify crisis escalation.[91] Compressed decision-making windows and reliance on intuition can increase the speed of action taken by nuclear actors, thereby reducing the time for de-escalation and increasing the risk of both horizontal and vertical escalation.[92]

An increased propensity for Type 1 thinking and the risk of accelerated, rash decision-making are associated with several trends in the information environment, including growing social media use in public communications and the adoption of AI across an increasing number of domains, including national security.[93] Developments in non-information technologies, including kinetic anti-satellite capabilities and hypersonic missiles, compound this dynamic by accelerating the speed of conflict and compressing decision-making timelines in crisis contexts.[94] However, our literature review and study interviews identified several

87 Jablanski et al. (2020).

88 Slovic & Lin (2020).

89 Evans (2019); Evans & Stanovich (2013).

90 Röttger & Vedres (2020).

91 Johnson (2022a).

92 Schneider (2019); Slovic & Lin (2020); Johnson (2022a).

93 Slovic & Lin (2020).

94 Research interview INT08; Favaro (2021).

mitigation mechanisms, including decision-support tools such as AI to build battlefield awareness, which may help commanders carve out more time to make decisions during conventional conflicts – thus aiding senior decision-makers in potentially identifying de-escalation options that may otherwise not appear available.[95]

In addition, the **acceleration of news cycles** discussed in Chapter 2 further stresses decision-making processes. As innovation in media technologies and the increased use of social media for news consumption encouraged quicker, continuous news delivery, 'time' and the immediacy of reporting have emerged as more important factors in news production.[96] This likely adds pressure to decision-making, potentially removing options for deliberation and creating an atmosphere of urgency that may disrupt it. Considering a counterfactual of the Cuban Missile Crisis, for example, researchers have previously described the following:

> …. during the Cuban Missile Crisis, President Kennedy and his key advisors sequestered themselves for over a week to think through and carefully deliberate their options. Despite being heavily pressured by military officials to strike Soviet nuclear installations in Cuba (a step that could very well have precipitated a larger war) or accept a permanent Soviet nuclear presence in Cuba, Kennedy and his officials were able to find a third way through the crisis. This opportunity may not be open to future decision-makers who will find themselves constantly harassed from multiple information sources and the media.[97]

In addition, social media discourse and the persistence of news reporting may create real or perceived pressures for senior decision-makers to 'do something.'[98] Both senior and low-level decision-makers often feel these pressures at the onset of a crisis, which can be exacerbated by the immediacy of news reporting and social media discourse during emergent crises. However, the rapid availability of information may also mitigate the risk that all decision-makers take a worst-case scenario view of an escalating crisis, as can happen in the absence of reliable information.[99]

Finally, interviewees also suggested that extra-factual information (comprising false or unverified information such as rumours, propaganda or false and misleading information[100]) 'travels faster' and is more adherent than other forms of information.[101] It is therefore more likely to influence public opinion during a crisis and to increase the general sense of threat. This pressure can, in turn, push decision-makers to act, creating a 'use it or lose it dilemma.'[102] As several trends in the information environment are expected to exacerbate challenges around the spread of extra-factual information (including AI adoption and the potential proliferation of augmented, mixed and virtual reality spaces), these dynamics may be amplified in the future.

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95 Johnson (2020a).

96 Saltzis (2012).

97 Steff (2020).

98 Lin (2012).

99 Lin (2012).

100 Greenhill (2020).

101 Research interview INT05.

102 Research interview INT05.

However, nuclear crises have always been characterised by time pressure, and pressures stemming from heightened stress in the information environment may be less pronounced in the nuclear context than in other types of national security crises. Moreover, trends in the future information environment may not only exert acceleratory pressures on decision-making. For example, a recent study exploring the effects of AI integration in national security decision-making found that decision-making slowed when AI was incorporated.[103] While AI systems can process and organise information more quickly, decision-makers presented with AI output may seek assurance about how the AI arrived at it before considering the prescribed course of action. Additionally, the increasing complexity of the information environment – as discussed in the next section – may slow decision-making timelines, allowing information to be assessed more carefully.



3.3. Complexity

Several trends in the information environment also appear to be increasing its complexity. The interaction between the increased speed and accessibility of information has increased the quantity of information and data to which individuals, including high- and lower-level decision-makers, are exposed, exacerbating the **risk of information overload**.[104] Though the concept of information overload and concerns about its effects predate the emergence of digital information, the digital age has been associated with greater challenges.[105] In national security and nuclear decision-making contexts, existing research associates risks of information overload with the increasing volume of information flow from both bespoke or classified intelligence sources and open-source information. Though the information senior decision-makers receive in unfolding crises is highly curated, decision-makers across the chain of command are still exposed to a larger volume and diversity of information that needs weighing and interpreting,[106] including outputs from AI decision-support systems and signals from the public and constituencies via open communication channels.[107] The effects of information overload for all decision-makers are multifaceted, including:

- An increased likelihood that individuals ignore, avoid or selectively filter information
- A reduction in decision-making accuracy, quality and effectiveness
- Increased pressure on individuals' well-being, including through cognitive strain
- Reduced efficiency and productivity at individual and organisational levels.[108]

Correspondingly, existing research on nuclear decision-making processes highlights concerns about how information overload will affect all decision-makers' ability to avoid over-reliance on cognitive biases and heuristics, as well as their ability to engage in complex, deliberate problem-solving,

103 Chivvis & Kavanagh (2024).
104 Jablanski et al. (2020).
105 Shahrzadi et al. (2024).
106 Chivvis & Kavanagh (2024).
107 Johnson (2020b); Jablanski et al. (2020); Chivvis & Kavanagh (2024).
108 Shahrzadi et al. (2024).

particularly during crises.[109] These risks, if unmitigated, increase the risks of inadvertent escalation through misperceptions.[110]

The increased cognitive pressures caused by a growing volume of information flow are compounded by **increasing concerns around information reliability and trustworthiness**. This is linked to several drivers, including:

- The politicisation of information, reflection of social and political polarisation in the media, and the growing prevalence of opinion-based over fact-based reporting.[111]
- The increasing adoption of AI technologies in content development, including the generation of text, imagery, audio and video, makes it increasingly difficult to distinguish authentic content from AI-generated content.[112]
- A greater number of actors with potentially obfuscated identities means that the information environment is inherently flooded with more narratives from various sources.[113] As new technologies offer increased anonymisation of online interactions, this will be amplified by increased difficulties in establishing attribution and accountability for actions taken in online spaces.[114]

These trends are believed to decrease individuals' ability to effectively distinguish between facts and extra-factual information, increasing uncertainty about available facts and mistrust of information sources. Together, these factors increase the propensity to rely on heuristics and cognitive shortcuts.[115] Though nuclear decision-making is inherently reliant on highly curated intelligence, risks such as information manipulation and obfuscation through 'deep-fakes' may also affect this decision-making context[116] – particularly due to uncertainty arising from a lack of confidence in information integrity. Intelligence provided to senior decision-makers may enable them to have an acute understanding of adversaries' activities (e.g. through satellite imagery), though not necessarily their underlying motives and rationale. Therefore, senior decision-makers must balance information from a variety of sources.

The effects of an increasing 'noise' in the information environment are also linked to the **effects of public discourse on decision-makers' understanding of imperatives and trade-offs** in contexts such as crisis escalation. Psychological research has previously drawn attention to the centrality of psychological processes such as psychic numbing,[117]

109 Johnson (2022b).

110 Johnson (2022b).

111 Kavanagh & Rich (2018).

112 Slapakova et al. (2024).

113 Narang & Williams (2022).

114 Slapakova et al. (2024).

115 Johnson (2022a).

116 Favaro (2021); Jablanski et al. (2020).

117 Psychic numbing describes the emotional desensitisation individuals may experience when presented with abstract information about a traumatic or severely consequential event, leading them to devalue human lives as the number at risk increases.

compassion fade[118] and dehumanisation[119] to decisions around crisis escalation and nuclear use and non-use.[120] More widely, these processes reflect the importance of emotions and feelings, such as affect (i.e. the sense that something is good or bad), in human decision-making and behaviour.[121] As affect conveys meaning to information and thus motivates behaviour, it is central to understand how planners and decision-makers across the chain of command consider trade-offs, such as between military objectives and the likely value of collateral damage.[122] Emotion-based psychological processes also shape how senior decision-makers understand imperatives that can guide decision-making, particularly in crisis contexts.[123]

Perceptions of potential damage, its consequences and the imperatives are based on socially constructed ethical concepts and perceptions of social order (e.g. social group identities). They are weighed against the understanding of national security imperatives, which are similarly grounded in national discourse and perceptions of political desirability and palatability of various policy actions. It is therefore evident that national discourse, including its forms and dynamics, shapes decision-making outcomes. In this regard, previous research has highlighted the possibility that a wide-ranging, polarised national debate over the use of nuclear weapons may impede the ability of high- and low-level decision-makers to take highly consequential crisis-related decisions.[124]

Current and anticipated developments in the discursive layer of the information environment may be exacerbating these dynamics for several reasons. They may amplify the variance and complexity of signals, shaping how decision-makers across the chain of command build their understanding of the desirability and costs of different outcomes. This effect stems from increasingly democratised, potentially ungoverned digital spaces, growing political and social polarisation, and the individualisation of information flows. The potential socio-cultural fragmentation resulting from these trends may magnify societal divisions over issues such as ethics and desirability of nuclear use and non-use, increasing the complexity of the ethical touch-points and decision-makers' understanding of imperatives. This scenario is particularly likely as social media exposes senior decision-makers to audiences and public discourse more directly.[125]

Finally, as the roles of various actors in the information environment evolve, managing relationships and communications among these actors and their respective audiences may become increasingly complex and challenging. Previous research has noted

118 'Compassion fade', or 'compassion collapse', refers to the tendency for individuals to feel less empathy and to care less as the number of people at risk increases. In this phenomenon, people may value the loss of a large group less than the loss of a single individual.

119 Dehumanisation refers to the psychological effect of perceiving or treating individuals or groups as less than human, denying them human qualities. It is often associated with tribalism, i.e. an 'us versus them' dynamic between different social groups.

120 Slovic & Lin (2020).

121 Slovic (2007).

122 Slovic (2007); Slovic & Lin (2020).

123 Imperatives here are defined as 'forceful calls to action that feel so obviously correct that deeper analysis seems unnecessary' (Mazarr 2016).

124 Slovic & Lin (2020).

125 Slovic & Lin (2020).

that the openness of many social media channels may be creating new risks around **unintended consequences and misperception of messaging between nuclear actors**.[126] The co-existence of multiple audiences on social media makes the effects of messaging more difficult to target, as 'messages intended for domestic consumption [may] have unintended consequences if misinterpreted by the leaders of the adversary.'[127] While one message disseminated on social media in a crisis scenario may have a de-escalatory or calming effect on one audience, another might interpret it differently, raising the risk of unintended consequences. In addition, reshares in the mesia ecosystem reframe messages, adding a 'collateral messaging effect' to the potential risks of misperception.[128]

The adoption of technological tools that rapidly disseminate information to broader audiences, including across language barriers, may inadvertently exacerbate these challenges. A recent survey of media professionals found that an increasing number of media organisations are adopting AI tools to translate news articles into different languages, promising to disseminate content to wider audiences faster.[129] This development might increase cross-pollination between audiences, as content dissemination becomes less restricted by language barriers.



3.4. Risk

While many of the dynamics and impacts discussed in previous sections concern incidental or inadvertent effects, nuclear deterrence and decision-making can also be affected by intentional manipulation of the information environment. This concerns particularly: **1) the potential for information manipulation or disinformation to distort decision-making processes**, and **2) the vulnerability of publics and governments to disruption through severance of communication- and information-related services**.

As discussed in Chapter 2, several technological and non-technological factors are associated with **increasing threat levels stemming from malign information manipulation, including the spreading of disinformation**. These concerns are associated with social media's amplifying effect on the reach and scale of disinformation and information manipulation, as well as the increasing difficulty in distinguishing between authentic and inauthentic content, enabled by technological advances in AI and augmented, mixed and virtual reality.[130] The increasing speed with which information is disseminated to large audiences also means that any single piece of information is less likely to be challenged, increasing the risk that false information pollutes the information ecosystem.[131] These threats may affect deterrence on several levels:

- Information manipulation activities may be oriented to exacerbate the general 'fog of war' and distort decision-making during a crisis, leading to disorientation and a climate of confusion in which

126 Williams & Drew (2020); Narang & Williams (2022).

127 Narang & Williams (2022).

128 Williams & Drew (2020).

129 Newman & Cherubini (2025).

130 Bessi & Ferrara (2016); Vosoughi et al. (2018); Garcia-Camargo & Bradshaw (2021).

131 Wardle & Deakhshan (2017).

decision-makers across the chain of command may struggle to make sense of available facts and courses of action.[132] This development may affect decision-making at the national level and upset deliberation and coordination with allies, thereby disrupting alliance dynamics.[133]

- From a societal perspective, information manipulation often aims to exploit societal vulnerabilities and exacerbate or sow new divisions, including amplifying distrust of democratic institutions and media platforms.[134] This may increase pressure on senior decision-makers in evolving crises and undermine societal cohesion, which is considered central to crisis management.
- As both high- and low-level decision-makers are themselves consumers and users of social media and other open information sources, the risks of information manipulation through open communication channels may directly affect them.[135] For example, one expert interviewed in the study highlighted that personalised information flows may make it easier to target decision-makers and influence their understanding of unfolding events.[136] This risk may also be magnified by the greater ease of integrating diverse open-source datasets, including social media data, which can yield richer insights into individuals. Populist senior decision-makers who rely more heavily on social media for audience engagement and information-gathering may be more vulnerable to such manipulation.[137]

As previously recognised, the effects of information population on nuclear decision-making are likely to be uneven, as decision-makers have access to highly authoritative and curated intelligence in certain information domains (e.g. physically observable adversary actions). However, in other areas (e.g. adversary motivations and intentions), intelligence may be disputed or unclear. In the latter area, information pollution may have a disproportionate impact, amplifying the challenge of interpreting adversarial tactics and strategies. It may also increase challenges around nuclear signalling: as one expert interviewee explained, mis- and disinformation makes it difficult to separate legitimate messaging from wider 'noise.'[138] It may also encourage a highly insular policymaking process based on a manipulated version of reality.[139]

The second aspect of risk in the information environment is the increased vulnerability of institutions, governments and the public to **disruptions in information and communication flows.** As many processes, services and operations across society and government (including defence) become increasingly reliant on connectivity and access to information and communication technologies, information networks and infrastructure may become

132 Ajir & Vailliant (2018); Jablanski et al. (2020); Narang & Williams (2023).

133 Cimbala (2017).

134 Ajir & Vailliant (2018).

135 Filippidou (2020); Johnson (2022b).

136 Research interview INT03.

137 Johnson (2022b).

138 Research interview INT08.

139 Research interview INT04.

more vulnerable to disruption.[140] Such disruption, particularly against high-fidelity communications in a crisis scenario, could have physical, mechanical or behavioural elements.[141] Disruption of information flow may have far-reaching consequences across nuclear decision-making structures, affecting nuclear communication, command and control, and engagement between public audiences and decision-making bodies.[142] Such risks can increase the likelihood of escalation by presenting senior decision-makers with a 'use it or lose it' dilemma that encourages them to launch a first strike before their capability to do so is diminished.[143] Although these risks are significant, the likelihood of significant disruptions materialising, particularly to nuclear command and control, is low due to the highly escalatory nature of any such actions.[144]



3.5. Accessibility

The final mechanism through which we understand the information environment affecting nuclear deterrence is the increased accessibility of information and communication across the nuclear decision-making structure. This comprises three underlying dynamics: **information availability; the level of directness and formality of communication among decision-makers across the chain of command; and the directness of communication between senior decision-makers and the public.**

As discussed earlier, more information is accessible to individuals at any given time as technological innovation enables more borderless, persistent communication and information sharing. In Section 3.2, we discussed how this may be amplifying experiences of information overload. Recognising this challenge, greater information availability also presents an opportunity for nuclear actors to improve their situational awareness and understanding of factors that can affect a crisis. The speed of information dissemination on social media may provide decision-makers with more immediate information, helping them avoid miscalculation and escalation.[145] For the public, information accessibility can also help seek certainty during an emerging crisis. Innovation in communication technologies, such as the integration of AI and the potential adoption of augmented or virtual reality, could offer further advantages in this regard by enabling decision-makers across the chain of command to gain better insight from larger volumes of data and to simulate crisis developments in synthetic environments.

These stabilising mechanisms assume that available information is factual and useful to both audiences. As such, 'pollution' of the information environment with extra-factual information can also counteract these dynamics, leading to the challenges associated with informational complexity discussed in Section 3.2. Organisations also need to consider the risks of potential over-reliance on persistent data availability, as such availability may be lost through adversarial interference or through incidental damage to data infrastructure, adding

140 Bellasio et al. (2021).

141 Cimbala (2017).

142 Cimbala (2017).

143 Research interview INT08.

144 Research interview INT08; Cimbala (2012).

145 Williams & Drew (2020).

to disruption risks outlined in Section 3.4. Such incidents of data loss may have practical, immediate and wider psychological implications for decision-makers, particularly in the context of increasingly data-rich information environments. Direct impacts may include decision paralysis, in which decision-makers feel unable to decide in the absence of information that would otherwise be available to them. As discussed previously, cognitive biases, such as false optimism, may be amplified in decision-making when clear factual information is absent, influencing how decision-makers identify and assess available courses of action. In the wider sense, data loss may reduce decision-makers' trust in information and lead them to fear that other information sources are compromised or untrustworthy.

Therefore, alongside the benefits that can stem from increased data availability, it is necessary to consider the potential impacts and mitigating measures to foster resilience against loss of data access.

Regarding the directness of communication, channels like social media can provide opportunities for **more direct personal and informal communication between senior decision-makers** that wider publics may also see. Such communication may provide faster pathways to information exchange and address potential misconceptions between different actors. The informality of social media communication can also increase trust between senior decision-makers as it facilitates 'more personal engagement and frank dialogue.'[146] Such trust can be essential for effective signalling and confidence-building measures, particularly in crisis management.[147] However, changes in communication styles can also present risks. One expert interviewed suggested that decision-makers responding to nuclear scenarios have previously relied on a 'common language' for effective signalling.[148] In an environment where communication is subject to broader influences and interpretations, even small perceived changes in the language leaders use can create feelings of threat.

Social media and other open communication channels also offer opportunities for **more direct, unfiltered engagement between senior decision-makers and audiences**. As discussed in earlier sections, this may present opportunities for senior decision-makers to be informed about public sentiment, and for the public to have access to clearer, more frequent messages about government policy and action.[149] However, challenges may also stem from the closer proximity of decision-makers to public discourse (which may be highly polarised). In addition, the directness and openness of messaging between decision-makers and publics may increase challenges around audience cross-pollination, i.e. if messages intended for one audience are received and misinterpreted by another, with unintentional consequences.[150] As discussed in Section 3.2, cross-pollination challenges may be exacerbated by technological advances such as AI-enabled translation. In an information environment that can elevate the platforms of non-experts, directness between senior decision-makers and the public can also present challenges.[151] Social media can amplify arguments based on their popularity rather

146 Wiliams & Drew (2020); Wheeler (2018).

147 Wheeler (2018).

148 Research interview INT04.

149 Schreiner (2018); Narang & Williams (2023).

150 Narang & Williams (2023).

151 Research interview INT04.

than their factual integrity, and decision-makers can be drawn into popularising debates rooted in misinformation.

3.6. Summary: Risks, vulnerabilities and opportunities for nuclear deterrence

This chapter discussed changing levels of stress, complexity, risk and information availability in the information environment and the effects of these dynamics on nuclear deterrence and decision-making. Reflecting the complexity of nuclear decision-making dynamics discussed at the beginning of this chapter, the dynamics emerging from these mechanisms are multifaceted and rarely exert linear impacts on decision-making outcomes. However, several key risks and vulnerabilities can be identified based on the analysis, particularly regarding the information environment's impact on amplifying crisis escalation:

- The increased complexity of the information environment and the prevalence of extra-factual information may shape discourse in ways that directly or indirectly affect decision-makers' threat perceptions and understanding of national security imperatives across the chain of command. Although nuclear decision-making relies on highly curated intelligence, the existing literature and the study interviews confirmed that decision-making is shaped by emotional factors rather than pure rationality[152]; this emotionality may be directly or indirectly skewed, shaping resolve, interpretations of facts and messaging to other audiences.
- The amplification of the 'fog of war' and information overload may lead both high- and low-level decision-makers to rely excessively on heuristics and amplify the effects of cognitive biases. It may also lead these decision-makers to assume a 'worst-case scenario' due to a perceived lack of trustworthy information. There is also an overarching risk that the assumption of rationality in nuclear deterrence may be undermined, thereby making actions harder to predict.[153]
- The openness of information and communication channels may lead to unintended consequences in messaging and signalling due to cross-pollination among audiences. In particular, leaders may feel incentivised to use more aggressive or inflammatory rhetoric to mobilise domestic political support, and open communication channels may increase the risk that secondary or unintended audiences misinterpret messages.[154] As emerging technologies overcome current barriers to information dissemination (e.g. language), actors may lose control over the interpretation of their messaging and face a greater risk of misperception, leading to escalation.[155]
- The compression of decision-making timelines may drive leaders to feel they must 'do something' and make rash decisions without fully considering available courses of action or their consequences.[156]

152 Borrie (2020); Unal et al. (2022).

153 Research interview INT03.

154 Greenhill (2020).

155 Williams & Drew (2020).

156 Lin (2012); Narang & Williams (2022).

In contrast, de-escalatory tendencies are associated with the following mechanisms:

- The open and direct nature of contemporary communication channels may help increase trust between senior decision-makers and create better opportunities for de-escalation. They can also help improve decision-makers' situational awareness and facilitate more informed assessments of crisis dynamics.
- Increased 'noise' and ambiguity in the information environment may also provide face-saving paths to de-escalation.[157] This assumes that organisations and decision-makers along the chain of command can buy themselves time in a developing crisis and mitigate, at least to some extent, the compression of decision-making timelines.

The extent to which changes in the information environment or its individual components independently influence these risks should be interpreted with caution. The complexity of nuclear decision-making challenges our ability to assign causal significance to any individual factors or variables.[158] Indeed, although the level of risk associated with any of these individual dynamics may be low, the combination of multiple small increases in risk and vulnerability in the decision-making process may ultimately interact to produce a collective detrimental effect on deterrence outcomes, including through accidental or inadvertent escalation.[159] Additionally, the information environment is ultimately a collection of individual and collective behaviours and interactions that are ultimately the chief determinant of how information trends affect policy. Correspondingly, some interviewees stressed that while the changing information environment complexifies decision-making processes and stretches established assumptions, it does not wholly undermine established nuclear deterrence concepts.[160]

The next chapter discusses several situational factors likely to affect the degree to which these dynamics materialise.

157 Narang & Williams (2022).

158 Unal et al. (2022).

159 Research interview INT02.

160 Research interview INT03.

Chapter 4. **Situational factors**

As discussed in previous sections, how the changing information environment affects nuclear deterrence outcomes will likely depend on a range of situational factors and conditions, i.e. factors unique to specific situations, such as unfolding crises. Specifically, these relate to the way individual senior decision-makers and their audiences interact with the information environment based on their preferences; the wider context in which nuclear deterrence and a given emerging crisis occur; and the characteristics of the platforms and media used in a given situation.

4.1. Decision-maker characteristics

As discussed in Chapter 3, nuclear decision-making is dependent on a variety of interconnected factors, including personal characteristics.[161] The individual backgrounds of decision-makers (both senior and lower-level), including culture and upbringing, all shape decision-making outcomes in interaction with consistent psychological processes, such as cognitive biases. Our interviews and literature review identified three factors that are particularly noteworthy in information environment engagement: pre-existing perceptions and attitudes, communication preferences and audience linkages. The latter two chiefly affect senior decision-makers.

4.1.1. Pre-existing perceptions and attitudes

The way decision-makers at all levels receive information is likely to be shaped by their pre-existing beliefs and attitudes.[162] Decision-making psychology has consistently highlighted the role of emotions in how individuals perceive risk, evaluate alternative actions and engage with facts and evidence. They can 'create an overriding bias against objective facts or interfere with support mechanisms of decision-making such as one's working memory, or the lessons we draw from past experience.'[163] Pre-existing perceptions and attitudes also contribute to confirmation bias, which is the tendency of individuals, including both senior and low-level decision-makers, to interpret new information in a way that aligns with their prior beliefs.

Pre-existing attitudes may also affect all decision-makers' ability to consider counterfactuals in evolving crisis scenarios. Counterfactuals allow leaders to consider a range of plausible alternative scenarios and reactions that adversaries could pursue – another potentially de-escalating factor.[164] Decision-makers' pre-existing beliefs may lead them to overestimate their control over other actors or struggle to consider alternative courses of events, potentially limiting the number of de-escalation pathways available in an evolving crisis.[165]

161 Unal et al. (2022).

162 Narang & Williams (2022); Williams & Drew (2020).

163 Borrie (2020).

164 Johnson (2022a); Research interview INT07.

165 Pauly & McDermott (2023).

4.1.2. Communications preferences

As a result of the changing information environment, decision-makers have access to a greater variety of communication channels (e.g. social media) and information technologies (e.g. AI analytical tools).[166] At the individual level, decision-makers may have different preferences for using these technologies, as well as varying capacities to navigate technological change within them (e.g. varying levels of media and digital literacy). Some decision-makers may place a greater emphasis on communicating directly with the public, particularly when adopting more populist stances, and may prefer to publicise their signalling to reduce the risk of misperception in evolving crises.[167] Others may prefer to communicate privately to reduce pressure and exposure, as a means of de-escalation.[168]

These general preferences may translate into nuclear senior decision-makers' willingness to engage with the public on deterrence-related issues, as well as the levels of exposure and vulnerability that those across the chain of command may have to information manipulation.[169] Differences in communication preferences and information engagement may be fully personalised. However, they may also reflect demographic factors and wider socio-cultural trends in how social groups engage with information (see Section 2.2.2).[170] These collective patterns may be increasingly difficult to monitor and understand, as information ecosystems potentially become more fragmented and delineated by a wider range of socio-cultural factors rather than national geography.[171]

4.1.3. Audience linkages

In addition to a decision-maker's communication and information-engagement preferences and habits, senior decision-makers can also have varied relationships with domestic audiences, which may impact how leaders engage with publics in the context of nuclear deterrence. Though this varies across political systems, many senior decision-makers are elected officials and thus maintain closer relationships with their constituencies.[172] As discussed in Chapter 3, these linkages may affect the nature of rhetoric these decision-makers adopt in evolving crises – particularly those with close relationships with segments of domestic audiences, who may be motivated to adopt more expansive and aggressive rhetoric, with consequences for how other actors, including adversaries, interpret messages.[173]

Audience linkages may also mediate the effects of evolving public discourse on high- and low-level decision-makers' preferences, understanding of objectives, and imperatives, as discussed in Section 3.2. Combined with the use of more direct, unfiltered communication channels, close connections between decision-makers and their domestic audiences could amplify the influence of public discourse on senior decision-makers' understanding of an evolving crisis.

166 Research interview INT03.

167 Research interview INT03; Research interview INT05; Research interview INT07.

168 Research interview INT07.

169 Research interview INT01; Research interview INT05.

170 Research interview INT06.

171 Slapakova et al. (2024).

172 Research interview INT02.

173 Narang & Williams (2023); Chiriac (2022).

4.2. Institutional characteristics

Two factors at the institutional level may further mediate the impact of individual decision-maker preferences and characteristics, as well as a state's ability to mitigate risks and capitalise on opportunities stemming from the information environment. Those are 1) institutional structures and processes, and 2) access to information- and communication-related tools and techniques.

4.2.1. Institutional structures and processes

There are significant differences in how institutions, such as government departments, are organised and in how their processes unfold. In relation to nuclear deterrence, it is particularly pertinent to consider the level of centralisation in decision-making on nuclear policy, which may reflect organisational structures and strategic and organisational culture. As highlighted by one expert interviewee, nuclear decision-making can be centralised, with decisions made by a single individual. In other settings, nuclear decision-making can be collective, involving several individual decision-makers.[174] The level of centralisation may affect the impact of individual leaders' pre-existing attitudes in policy processes, the degree of filtering or unfiltered communication between decision-makers and audiences, and the level of deliberation and challenge when engaging with new information and intelligence in a crisis scenario. Institutional structures and processes are also influential, as they can affect individuals' behaviours through socialisation. However, the implications of institutional centralisation for nuclear decision-making appear understudied and thus require further examination.[175]

4.2.2. Access to information, tools and techniques

Chapter 3 discussed three particular challenges stemming from the evolving information environment: increasing time-related stressors, increasing information complexity, and increased risk of manipulation and disruption.[176] Various tools and techniques can be used by governments to mitigate these challenges, particularly by harnessing technological advances to improve situational awareness, analysis, information verification and detection/attribution of information manipulation.[177] The extent to which institutions have access to these tools and techniques, as well as data and information itself, is a function of various factors, such as resources (i.e. ability to procure suitable tools and techniques), organisational process (e.g. ability to effectively engage with commercial suppliers) and organisational culture (e.g. attitudes towards innovation and experimentation, risk appetite and trust in technology).

Importantly, any given communication tools and systems may be vulnerable to disruption by adversaries, either physical (e.g. damage to cables or satellites) or non-kinetic. Actors' ability to safeguard information and to enhance the resilience of communication systems against potential disruption is, therefore, another significant mediating factor in the potential impacts of evolving information

174 Research interview INT06.

175 Research interview INT06.

176 Narang & Williams (2023).

177 Williams & Drew (2020); Scharre (2020); Johnson (2020).

environment risks (see Section 3.3); institutions must safeguard access to relevant tools and technologies and ensure their resilience against potential disruption stemming from the loss of such access.

4.3. Crisis and context characteristics

The wider context in which nuclear deterrence takes place, including the geopolitical context, the actors involved and the characteristics of a given crisis, may shape the impact of the information environment.

4.3.1. Nature of the geo-political context

Potential escalatory dynamics arising from informational stress, complexity and risk can be significantly amplified by the geopolitical climate and pre-existing tensions between the involved actors.[178] In particular, crises occurring during protracted periods of geopolitical tension may be accompanied by heightened risk perceptions. These perceptions may be very stable, reducing the potential for other actors to influence decision-maker preferences and behaviours (including through information manipulation and interference).[179] However, high levels of pre-existing tension and mistrust between actors and decision-makers across the chain of command will likely amplify any escalatory dynamics arising from the information environment, while diminishing potential de-escalatory tendencies. This is pertinent in the current security environment, which has been described as the 'Third Nuclear Age', characterised by multipolarity and diversification of threats to strategic stability.[180]

The future geopolitical landscape for UK nuclear deterrence could involve the collapse of non-proliferation regimes, potentially resulting in the spread of nuclear weapons to states that are currently non-nuclear. Combined with the multidirectional spread of information across various audiences (decision-makers or public, domestic or international, direct or indirect), a multiplication of potential nuclear actors could increase the risk of escalation.[181]

4.3.2. Duration and pace of crisis developments

Research examining the effects of social media on crisis stability has found that the duration and pace of crisis developments can significantly mediate the escalatory and de-escalatory tendencies emanating from social media use.[182] However, the effects of crisis duration and pace may be contradictory. For example, crises that unfold over a longer period may provide actors with more opportunities to make sense of the information environment, engage in deliberation and share accurate information.[183] However, they may also lead to an accumulation of information 'noise' and to extra-factual information or deliberate information manipulation taking hold.[184]

Crisis duration may also mediate interaction effects between publics and decision-makers across all levels of responsibility. Shorter crises may give actors greater agency over the information environment, offering opportunities

178 Lewis et al. (2014); Unal et al. (2022).
179 Research interview INT07.
180 See Kroenig (2024).
181 Narang & Sagan (2022).
182 Narang & Williams (2023).
183 Narang & Williams (2023).
184 Research interview INT07.

to withhold information from public audiences and to enable 'behind-the-door' interactions between decision-makers. For example, during the Cuban Missile Crisis, the US government blocked journalists and media outlets from publicising information.[185] The same inoculation of events may not be possible over longer crises.

A further distinction can be made between discrete crises linked to a specific security event (e.g. a terrorist attack and the explosion in the port of Beirut in August 2020) and ongoing crises. During the latter, there may be more opportunities for malicious actors to manipulate the information environment.[186]

4.3.3. Actor capabilities

Over the last 30 years, nuclear states such as the United States or Russia have reduced their nuclear arsenals, reducing the prospects of nuclear accidents. However, as other conventional systems and cyber capabilities continue to develop, the risk of nuclear deterrence against adversaries persists.[187] The level of conventional, nuclear or cyber capabilities could also affect nuclear decision-making processes. Specifically, the advancement of cyber capabilities may enable adversaries to escalate crises, exploit time compression and disrupt cyber defence systems. For example, attacks may evade timely detection, or adversaries could introduce false attacks. However, differences in cyber capabilities may increase vulnerabilities in the information environment to misuse or manipulation.[188]

The development of AI-enabled systems could also change the perception of conventional weapons in crisis management and further compress decision-making windows.[189] In particular, innovation in delivery vehicles, such as hypersonic missiles, may exacerbate challenges with informational stress, as discussed in Section 3.1.[190] Additionally, short decision-making timeframes may make it more difficult to detect biases embedded in technological systems.[191]

4.4. Audience characteristics

In the context of nuclear deterrence, various audiences interact at both the domestic and international levels. While analysing information ecosystems can help identify general audience characteristics (e.g. audience size and demographics), it is important to consider these characteristics specifically in relation to an evolving crisis or deterrence context.

4.4.1. Domestic vs international audiences

Existing research posits that whether open communication channels, such as social media, lead to changes in deterrence dynamics depends on whether the audience is domestic or international. This interacts with two other factors: the duration of a crisis (Section 4.3) and the nature of the communication platforms used (see Section 4.5). Table 4 below captures the interaction effects between these three factors, showing hypothesised effects of social media use on nuclear crises.

185 Research interview INT07.

186 Narang & Williams (2023).

187 Cimbala & Lowther (2024); Pauly & McDermott (2023).

188 Cunningham (2022); Cimbala & Lowther (2024); Research interview INT04.

189 Johnson (2022a); Research interview INT01; Research interview INT03.

190 Favaro (2021); Research interview INT08.

191 Research interview INT07.

Table 4. Interaction effects between audience, platform and crisis characteristics

	Domestic audience	International audience
Short crisis		
Open platform	Proliferation of misinformation	Alerting international actors (risk of spillover)
Closed platform	Fearmongering	Diasporic nationalism
Long crisis		
Open platform	Information improves	Deterrence/coercion signalling (risk of spillover)
Closed platform	Preexisting beliefs/conspiracy theories	Diasporic patriotism

Source: Narang & Williams (2023: 73).

Importantly, both domestic and international audiences can be subjected to manipulation in the information environment, either by malicious actors or inadvertently, as messages or signals escape the control of their emitter. Understanding audiences' resilience to information manipulation is, therefore, an additional mediating factor to account for when considering the effects of different communication and information flows on crisis scenarios.

4.4.2. Direct vs indirect audiences

As discussed in Chapter 3, challenges may arise from the spillover effects of messaging between primary and secondary audiences. Messaging directed at primary audiences (e.g. to gain support for policy positions or specific decisions) could be misinterpreted by secondary audiences, increasing the risk of escalation.[192] The multiplication of actors can also limit decision-makers' and broader actors' ability to tailor their signalling to the intended audience.[193]

Audience mapping may therefore help mitigate potential risks around audience cross-pollination and unintended consequences stemming from those dynamics.

4.5. Platform and media characteristics

Communication platforms and the media can have distinct characteristics that make it more or less likely that the effects discussed in Chapter 3 will occur. In particular, it is important to consider 1) the character of communication and information-sharing platforms that are used in a crisis context, and 2) the nature of the media landscape and potential cross-pollination between information and communication platforms.

4.5.1. The nature of communication and information-sharing platforms

In the digital communication and information-sharing space, some platforms are open, while

192 Narang & Williams (2023).

193 Research interview INT01: Research interview INT07; Narang & Williams (2023).

others are closed.[194] Open platforms (e.g. X [formerly Twitter] and YouTube) enable users to engage with content and information that is visible to all. Both the public and high- and low-level decision-makers can see the information shared on open platforms. Conversely, information on closed platforms (e.g. WhatsApp and Telegram) is shared in a more restricted manner (i.e. with a smaller number of people, through actively sought interpersonal engagement). As a result, different dynamics may emerge on open versus closed communication platforms. For example, while open social media platforms may be more likely to cause or amplify complexity and ambiguity of information spaces (see Section 3.2), as messages and information are shared in a wider and less filtered manner, closed platforms may have more potent effects in reinforcing pre-existing audience views and thus enable actors to catalyse domestic public opinion during a crisis.[195]

It is also worth noting that the character of platforms and their use by different audiences is highly dynamic and constantly in flux.[196] For example, some platforms are increasing in use as primary channels for consuming news, while use of other platforms is decreasing in that capacity, meaning that audience communication and information-seeking behaviours on those platforms change accordingly. As such, understanding evolving trends, particularly around social media use, may help all decision-makers anticipate which effects are more or less likely on different communication platforms.

4.5.2. The level of cross-pollination across the information ecosystem

As previously highlighted, audience cross-pollination is an important consideration in signalling and decision-making dynamics around nuclear crises. While audience cross-pollination can be a function of platform characteristics (e.g. it is more likely when communication channels used during a crisis are open), we must also consider media cross-pollination, i.e. the extent to which traditional or mainstream media amplify or mediate discourse on social media.[197] In particular, media organisations' ability to conduct information gatekeeping, fact-checking and verification may significantly affect how interaction effects between decision-makers and publics evolve.

4.6. Summary: Factors and conditions mediating information environment effects

Figure 4 summarises the five situational factors identified from our literature review and expert interviews.

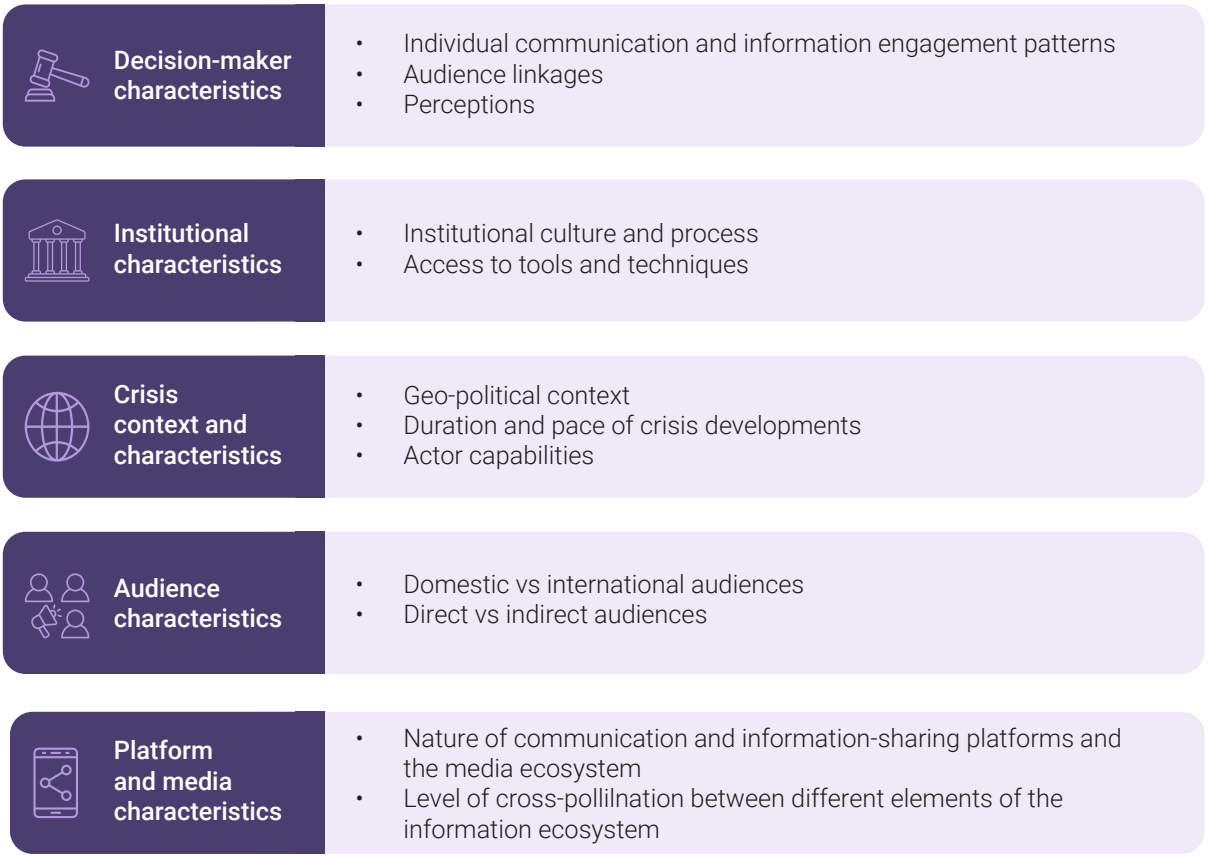
194 Narang & Williams (2023). It should be noted that some platforms, such as Facebook, can combine both open and closed features, including groups that are only accessible via requests or invitations.

195 Narang & Williams (2023).

196 Newman & Cherubini (2025).

197 Narang & Williams (2023).

Figure 4. Situational mediating factors



Source: RAND Europe literature review and interview analysis.

Chapter 5. **Conclusions and implications for the UK**

5.1. Key findings and implications

This study sought to advance current understanding of how the information environment affects nuclear deterrence and decision-making. Drawing on existing literature and expert interviews, we developed a conceptual framework to synthesise, organise, and refine current knowledge of these impacts. In particular, the framework emphasises that:

- There is a need to understand the evolving information environment through an ecological perspective, considering technological trends, developments that affect social cognition and the nature of public discourse, and the importance of distinguishing between trends in the information environment at large and the characteristics of individual information ecosystems.
- There are four key ways in which the changing information environment affects nuclear deterrence outcomes: 1) it introduces greater stress into decision-making processes by compressing decision-making timelines, 2) it produces greater complexity and ambiguity, thickening the 'fog of war', 3) it increases levels of risk associated with information manipulation and disruption to data and information flows, and 4) it provides greater accessibility of information and communication for and among publics and senior decision-makers. These mechanisms may produce escalatory and de-escalatory dynamics, resulting from decision-making processes and the interaction between senior decision-makers and publics, both at the domestic and international (including adversary) levels. The risks, vulnerabilities and opportunities associated with each identified mechanism are summarised in Table 5 below.
- The effects of the information environment on nuclear deterrence outcomes should be contextualised in specific crisis contexts. We identified five groups of mediating situational factors that can change how the framework's mechanisms and outcomes materialise: 1) decision-maker characteristics, 2) institutional characteristics, 3) platform and media characteristics, 4) audience characteristics, and 5) the nature of the crisis and wider deterrence context.

Table 5. Summary of impact mechanisms

Mechanism	Key risks, vulnerabilities and opportunities relating to nuclear deterrence:
Stress 	• Increasing speed and velocity of information exchange amplifies cognitive biases in nuclear decision-making and compresses decision-making windows. • The acceleration of news cycles may add pressure to decision-making, potentially removing options for deliberation, creating an atmosphere of urgency that may disrupt decision-making, and generating pressures (real or perceived) for decision-makers to 'do something'.
Complexity 	• The increasing speed and accessibility of information may amplify the risk of information overload, leading to overreliance on cognitive biases and heuristics in nuclear decision-making. • Information complexity raises concerns around information reliability and trustworthiness, thickening the 'fog of war' through uncertainty about information veracity. • Increasing 'noise' in the information environment can also shape public discourse and correspondingly affect decision-makers' understanding of political palatability and trade-offs among policy options. • Messaging and signalling to different actors and audiences may be increasingly difficult to navigate and control, as the information environment features a greater number of actors with potentially obfuscated identities. The openness of communication channels also amplifies the challenges of cross-pollination among audiences, which can lead to unintended consequences.
Risk 	• Increasing threat levels stemming from malign information manipulation, including the spreading of disinformation, may exacerbate the 'fog of war' and instil a climate of confusion, undermining crisis management. Combined with other trends, the individualisation of information flows may also raise the risk that decision-makers' information ecosystems will be distorted. • The growing reliance on data and persistent information creates vulnerabilities to disruptions in information and communication flows.
Accessibility 	• Improving the availability of information, in terms of quantity and the quality/diversity of data, can present an opportunity for nuclear actors to gain better situational awareness and a better understanding of the factors that affect a crisis. • Direct communication between senior decision-makers can provide faster pathways for information exchange, address potential misconceptions and build trust among different actors. • More direct, unfiltered engagement between senior decision-makers and audiences may offer decision-makers the opportunity to be informed about public sentiment and for the public to access clearer, more frequent messages about government policy and action. • However, directness and openness of messaging between senior decision-makers and the public may increase challenges around audience cross-pollination and encourage the use of more aggressive and expansive rhetoric, which may have escalatory effects.

Source: RAND Europe literature review and interview analysis.

These findings have three key implications for UK policy:

1. Enabling systematic analyses of key information ecosystems
2. Building information resilience at the individual level
3. Building information resilience at the organisational level.

5.1.1. Enabling systematic analyses of key information ecosystems

This study has highlighted the importance of considering the implications of the information environment for the future of UK nuclear deterrence and the dynamics of nuclear decision-making in this changing environment. While we sought to advance UK Defence's understanding of these issues, this area remains underresearched, and further analysis is required to enable organisations to mitigate risks and capitalise on opportunities in an evidence-based manner.

Beyond supporting future research (discussed in Section 5.2), UK Defence should ensure sufficient capacity and capability to track the evolving nature of information ecosystems that are particularly relevant to nuclear deterrence (e.g. key adversaries). As discussed in Chapter 2, assessing national information ecosystems and how they change over time is essential for a nuanced understanding of how information-related processes evolve and the impact they may have on actors' behaviour in the international system. Beyond focusing on technological innovations, these assessments must take a broader view of socio-cultural, political and wider dynamics in societies.[198] UK Defence should thus invest in systematic analyses of key national ecosystems (e.g. those of key adversaries) to better understand national security cultures, threat perceptions and dynamics between foreign decision-makers and their domestic audiences. A failure to account for key dynamics in national information ecosystems among the UK's allies and adversaries may undermine the UK's nuclear deterrence strategy in the future.

Organisations and decision-makers across the chain of command should also be aware of the potential risks arising from a changing information landscape, including unintended consequences of signalling and public communication, such as audience cross-pollination. Effective audience analysis is essential for identifying unintended consequences and providing a better understanding of situational risk factors that may exacerbate misconceptions and escalatory dynamics. This analysis should also support UK Defence in its ability to target and control the impact of messaging in developing crisis scenarios, which is particularly essential in contexts of increased geopolitical tension and other conditions more prone to escalation.

5.1.2. Building information resilience at the individual level

As discussed throughout this report, neither high- nor low-level decision-makers are immune to the challenges associated with the information environment's increasing complexity, 'noise' and potential manipulation. While the information senior leaders receive to support deterrence-related decision-making is likely to be highly curated, decision-makers across organisational hierarchies may still face challenges such as information overload, manipulation and other risks.

198 A recent RAND study provided a framework for understanding the cultural impact of technological change, which captures the rationale as well as the mechanism for such analyses. For more information, see Slapakova et al. (2024).

Therefore, Defence needs to invest in information resilience across the chain of command and in the long-term development of the next generation of senior decision-makers, equipping them with the skills to effectively navigate the information environment. This includes training and opportunities for decision-makers to develop digital and data literacy (i.e. the ability to engage with digital technologies and understand as well as use data from various sources) as well as mental strategies to mitigate information overload (e.g. effective information filtering, structured approaches for information analysis, and memory training, among others).[199] The development of next-generation decision-makers should also encourage governmental organisations to build a range of analytical skills, such as counterfactual thinking, to foster a robust information management and decision-making culture, as well as a collective ability to navigate crisis contexts effectively.[200] Embedding the development of these skills into training may help institutionalise good practices regarding information engagement and reduce risk at an organisational level.

5.1.3. Building information resilience at the organisational level

In addition to supporting the development of information resilience among decision-makers across the chain of command, organisations can also utilise several levers to build institutional resilience against key risks magnified by trends in the information environment, particularly in the following two areas:

- **Mitigating information manipulation and pollution caused by extra-factual information**: While governmental organisations may have enhanced access to advanced intelligence-gathering and analysis tools, increased challenges in detecting, verifying and triangulating information can still affect an organisation's ability to build and maintain situational awareness, particularly in crisis contexts. This is particularly due to persistent technical limitations of detection tools in identifying and verifying AI-generated content. UK Defence should therefore identify pathways to access reliable detection and verification tools, which may include collaboration with other government departments, allies, and relevant commercial partners.
- **Ensuring resilience against disruptions to data and information flows**: As technological advances offer more persistent access to data and information, it is pivotal for organisations to balance the ability to maximise utilisation of this access with preparedness for its loss. In other words, organisations, including UK Defence, need to retain the ability to operate without access to extensive and diverse data, particularly in crisis situations. Conducting exercises may help UK Defence develop adequate processes and technical safeguards for these scenarios, and may also support all decision-makers' individual preparedness for the loss of information access.

Previous research has also recommended several measures to reduce the risk of accidents and inadvertent escalation, as well as encourage sound nuclear decision-making more broadly, by **strengthening institutional information management safeguards and decision-making cultures**. This includes adjusting relevant procedures and protocols

199 Arnold et al. (2023).

200 Johnson (2022a).

to 'buy time' for senior decision-makers in emergent crises and involving a wider set of stakeholders in nuclear decision-making.[201] Such measures can help organisations future-proof their information management culture, while ensuring that good practices for robust decision-making (e.g. encouraging open and rigorous deliberation and challenge, and ensuring transparency about uncertainty in intelligence assessments) remain embedded within the organisation. These recommendations warrant renewed consideration, as organisations ought to be able to effectively support decision-makers' ability to navigate a more complex, pressurised and high-risk information environment.

Though this research chiefly concerns the dynamics of decision-making in the nuclear deterrence context, there are also several broader strategic considerations:

- The UK's nuclear deterrence strategy should remain mindful of the changing role that information manipulation plays in key adversaries' strategic cultures and how this manifests in their nuclear deterrence strategies. Although there is growing evidence of some actors' (particularly Russia's) information manipulation tactics and their strategic use, understanding of other adversarial actors is significantly poorer and may consequently be overlooked in strategic discussions. Additionally, information manipulation tactics and strategies can be expected to change as the technological and non-technological aspects of information ecosystems evolve. The UK and its Allies should be mindful of this dynamism and incorporate alternative information manipulation tactics into exercises testing potential escalation pathways.
- Relatedly, the UK's strategy needs to be cognisant of the potential impacts of the future information environment on alliance dynamics within NATO, particularly ensuring and maximising the political credibility of extended nuclear deterrence. Existing recommendations for this include bolstering transparency within NATO around nuclear matters, fostering closer coordination of messaging and communication strategies across the Alliance, and identifying opportunities for NATO Allies to more proactively shape debates and narratives around nuclear deterrence in a more contested information environment.[202]
- Lastly, the complexity and dynamism of the future information environment increase the challenge of effective signalling and messaging, particularly in the context of unfolding crises. In such a context, cross-government dialogue and coordination are essential both as part of crisis management (e.g. to maximise coherence and coordination of messaging) and, more broadly, to facilitate the sharing of insights, lessons and best practices related to audience engagement and strategic communication.[203]

5.2. Future research agenda

Despite significant policy attention to trends in the information environment and their significance to defence policy and strategy, systematic, evidence-based research on the

201 Lewis et al. (2014).

202 Wilton Park (2026); Williams & Drew (2020).

203 Williams & Drew (2020).

information environment and its impacts remains limited. This research attempted to provide a better conceptual footing for future research in this area, particularly by identifying 1) the mechanisms through which the changing information environment affects nuclear deterrence outcomes, and 2) factors which mediate these effects. We also attempted to link emerging work on information ecology with scholarship on nuclear deterrence and decision-making to facilitate more systematic assessments of future effects of changes in the information environment.

We see several priorities for future research to further advance understanding of the questions raised in this report and guide decision-makers across the chain of command in their ability to effectively capitalise or build resilience against potential disruptions in the information environment:

- Firstly, there remains a dearth of empirical research in this field. While conceptual and analytical literature provides useful frameworks and hypotheses around the effects of the information environment, generating empirical evidence is needed to understand 1) decision-maker perceptions of those effects and the accompanying risks and opportunities, and 2) potential audience behaviours, particularly in contexts of informational complexity and risk. Future research should thus aim to address these gaps by engaging more closely with decision-makers (both at high- and low levels) and audiences.
- Secondly, there are ample opportunities for experimental research to examine how decision-makers and publics may react to and navigate developments in specific crisis scenarios. Such experimental research could be survey-based or take the form of more elaborate table-top exercises or wargames, testing actor reactions and behaviours in the context of different crisis dynamics. This would help improve understanding of the variation in actor responses and, therefore, the important mediating situational factors that affect risks and opportunities stemming from the information environment. Such exercises could also help strengthen the UK's preparedness and emergency response in the event of a risk of nuclear escalation.
- Thirdly, as discussed throughout this report, future scholarship should explore the effects of potential changes in individual information ecosystems rather than the information environment at large. Providing a systematic assessment of the evolving nature of national information ecosystems among the UK, its allies, and its adversaries may help highlight specific areas of risk for potential escalatory dynamics, as well as advance the UK's understanding of how allies and adversaries formulate deterrence-related policy and make decisions in crisis contexts. The information ecology framework can therefore facilitate a more data-driven assessment of trends in individual national information ecosystems, thereby improving the accuracy of anticipated trends and effects for nuclear deterrence and decision-making. This assessment could be historical, i.e. examining the nature of information ecosystems around nuclear crises to understand their effects using historical data.

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