Cultural and technological change in the future information environment

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Executive summary

Research context, objectives and scope

The information environment is an increasingly central element of UK Defence activity,[1] anticipated to undergo significant changes that present multiple Defence opportunities and challenges. These trends include technological change and sociocultural developments that shape how current and emerging technologies are developed, adopted and used in society.

To support UK Defence in contextualising the future impact of new and emerging technologies, RAND Europe and Frazer Nash Consulting conducted a study examining how technological developments in the information environment may shape culture in the Generation After Next (GAN) timeframe, i.e. 2035–2050.[2] Rather than precisely forecasting technological trajectories and their cultural impacts, the study aimed to characterise the landscape of technological change in the GAN information environment, develop a conceptual framework for understanding the links between technological change and culture, and apply this framework to an initial assessment of the cultural implications of selected technological developments.

Key findings

Understanding technological change in the GAN information environment

First, the research team examined existing literature and insights from emerging science and technology (S&T) horizon-scanning to capture the technological developments anticipated to shape the GAN information environment and assess which will likely have the most significant impact.

Impactful change is likely in ten technological areas: artificial intelligence (AI), biotechnology, extended reality, human-machine interfaces, information and communication technologies (ICTs), advanced materials, sensors, space technology, quantum technology and encryption, and security, validation and privacy-enhancing technologies. Incremental advances in these areas will likely continue impacting the information environment alongside emerging new technologies not yet in use (e.g. quantum computing).

This study identified six technological systems worthy of further analysis to help understand the dynamic and interaction between technologies in different aspects of the information environment. These systems

1 The information environment was defined as 'all informational processes, services, and entities, thus including informational agents [comprising individuals and organisations] as well as their properties, interactions, and mutual relations' (Floridi, 2005).

2 Culture was defined as a 'shared set of (implicit and explicit) values, ideas, concepts, and rules of behaviour that allow a social group to function and perpetuate itself. Rather than simply the presence or absence of a particular attribute, culture is understood as the dynamic and evolving socially constructed reality that exists in the minds of social group members.' (Hudelson, 2004).

capture six areas of significant technological change in the GAN information environment: **automated information systems, virtual metaverses, augmented and mixed reality, advanced connectivity, human augmentation and information security**.

Conceptualising the impact of technology on culture

The study's second phase focused on conceptualising technology's impact on culture by reviewing existing cultural anthropology and Science and Technology Studies (STS). This phase drew on existing work in Actor-Network Theory (ANT), determining technology as an 'actant' in cultural change and recognising that characterising this role depends on understanding a technology's intended use, the intentions behind its development and its user applications and regulatory frameworks. The study conceptualised cultural change as changes in shared societal ideas, values and behaviours that shape people's ways of being in the world,[3] including cultural identities, behavioural norms and values and perceptual lenses through which people and communities determine facts about themselves, others and their culture. We identified four interaction levels between these cultural and technological elements, ranging from an individual's understanding of 'self' to societal institutions and domains: individual, micro, meso and macro.

To capture these interactions as a coherent narrative, we developed a framework for understanding future technologies' impact on culture. This comprises four stages (Figure 0.1), each addressing a different component for comprehensively understanding future technologies' impact on culture. We applied the framework to an initial exploration of the cultural impacts of the six technological systems identified in the study's first phase.

Assessing the cultural impacts of technological developments on the future information environment

In the study's third phase, we conducted deep dives to characterise future trends in the development and use of the six technological systems, and interviewed relevant experts to understand these trends' cultural implications. The results showed that each technological system had distinct cultural implications, with several **cross-cutting themes** emerging in the analysis:

- Technological developments are expected to drive a changing landscape of cultural identities, potentially diminishing the significance of demographic and geographic delineations and elevating transnational and subnational cultural identities formed through virtual interactions. Technology may also increasingly integrate into cultural identities, e.g. hybridising human identity through technological enablement and the increased importance of how cultures define norms and values relating to technology use.
- Technological change is associated with shifts in defining and understanding three cultural concepts: privacy, equity and accountability. These factors will likely come under increasing pressure in the future information environment due to increasing data exploitation for technological applications, new inequities in accessing technological tools and obfuscating end-user identity, and thus responsibility for risks and harms emerging from technology use. However, some developments, such as privacy-enhancing

3 Aranzadi (2018).

Figure 0.1 A framework for understanding future technologies' impact on culture

Technology as actant	• Assessment of technology to interrogate its role as an **actant** in the future information environment; • Identify the origins of technology (e.g. who develops the technology), the impact of its use (e.g. who uses the technology) and the scope of its use (e.g. when and where is the technology used).
Cultural topology	• Cultural topography as understanding the cultural landscape of the population of interest; • To identify and explore the cultural influences which impact the thinking and behaviour of the population of interest.
Ecological interaction	• Ecological interactions as the loci of interaction between the environment and the technology; • Identification of points of interaction at the individual, micro, meso and macro-social levels.
Influence or integration	• Amalgamation of all the outputs of the previous stage to consider whether the technologies in question are likely to be integrated into culture, or mediate cultural change.

Source: Frazer Nash Consulting.

technologies, also provide opportunities for more effective safeguarding of such norms and values.

- New technologies will likely continue amplifying cognitive biases, affecting how individuals engage with information and exacerbating people's difficulties in identifying and understanding facts. In particular, personalisation of information-related services and content may significantly challenge communities' ability to establish common cultural touchpoints and develop and reproduce them into collective cultural identities.

Finally, across these interactions, new and emerging technologies will likely continue empowering and constraining social movements contributing to sociocultural change (e.g. through advocacy). While social movements might leverage new technologies to engender sociocultural transformation (e.g. through digitally-enabled activism), political regimes or other actors might weaponise other technologies against social movements, constraining their facilitation of cultural change.

As significant uncertainty surrounds the nature and adoption of new and emerging technologies in the 2035–2050 timeframe, it is challenging to determine whether advances in the six technological systems will engender cultural change or whether new technological realities will integrate into existing cultural frameworks. However, several **potential areas of considerable cultural change** are evident at different levels of ecological interaction between culture and technological systems:

- At the **personal level** (i.e. the 'self'), technological advances (such as human augmentation) may raise questions about human identity and how we understand the biological foundations of human experience.

- At the **micro level** (e.g. interpersonal and human-machine sociality), tensions between personalising human experiences or information flows and defining common cultural touchpoints may yield substantial cultural change. While these will likely benefit human prosperity, they may also challenge people's ability to collectively identify and agree on the nature of physical, societal, political and economic realities and, thus, culture.
- At the **meso level** (e.g. urban areas, humans and the state), technologies are likely to transfer more interpersonal interaction from the physical to the virtual environment, mediating individuals' interactions with physical spaces and infrastructure. This shift may challenge the perceived cultural value of physical artefacts (e.g. architecture) while also changing the culture of physical environments such as cities through technological integration.
- At the **macro level** (e.g. societal domains such as education and healthcare), substantial cultural effects will more likely be due to the rapid innovative pace than specific technological developments. Cultural integration of technology may become more difficult because of societal and institutional limits to absorbing and adapting to technological change, thereby yielding technology-mediated cultural change instead.

Implications for UK Defence

Inherent uncertainty about cultural and technological developments in the 2035–2050 information environment means UK Defence will require a more refined understanding of the relevant dynamics to navigate them effectively.

To achieve this, UK Defence should build on this study's outputs via:

- Holistic application of the study's conceptual framework through a more in-depth examination of selected technologies;
- Recurrent application of the framework to build a coherent research base on the cultural impact of new and emerging technologies; and
- Framework testing and iteration, incorporating lessons from multiple studies.

Additionally, UK Defence should:

- Deepen understanding of the cultural impact of emerging technologies by developing cultural topographies, advancing application- or capability-centred analysis, and examining historical examples of the cultural impact of technological change.
- Stay abreast of emerging research on technology-enabled social manipulation threats and audiences' (diminishing) ability to identify and understand facts, enabling UK Defence to operate effectively in a changing information environment. UK Defence should also track the impact of technological change on the formation of cultural identities, particularly in public associations with a national cultural identity.
- Continue exploring and monitoring cultural norms and values around using key emerging technologies and how these may impact perceptions of acceptable use within Defence. UK Defence may also benefit from a greater understanding of the future dynamics of technology access and potential inequities and patterns of digital exclusion.

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Abbreviations & Definitions

AI	Artificial Intelligence
ANT	Actor-Network Theory
AR	Augmented Reality
ASTRID	Analysis for Science and Technology Research in Defence
DSTL	Defence Science And Technology Laboratory
GAN	Generation After Next
ICT	Information and Communication Technology
IoT	Internet of Things
MR	Mixed Reality
NLP	Natural Language Processing
RQ	Research Question
S&T	Science and Technology
SME	Subject matter expert
STS	Science and Technology Studies
UK	United Kingdom
US	United States
VR	Virtual Reality
WP	Work Package

Chapter 1. **Introduction**

1.1. Context

Navigating the information environment is an increasingly central element of Defence activity. For example, a recent iteration of Global Strategic Trends highlights that 'information will become ever more central to humanity, and conflict', making information-related activity critical for Defence's ability to achieve its strategic and operational objectives.[4] The information environment will likely change significantly between now and 2050, presenting multiple opportunities and challenges for Defence. Such changes include an anticipated transformation of the media landscape with the greater role of social media, the diminishing importance of facts in public discourse, the development of immersive virtual spaces, increasing digital communication and interaction, and increasing connectivity between devices, objects and human beings.[5]

Technological innovation plays a critical role in this changing context. Digital technologies have already significantly impacted how people consume and engage with information and how communication occurs at interpersonal and broader societal levels.[6] Future technological advances will likely continue this trend, with potential shifts in societal engagement with communication devices and virtual environments and changes in information threats and other developments.

However, understanding the future information environment requires more than examining technology's advancing capabilities in isolation. Understanding how individuals, communities and societies are likely to use and apply future technologies and how this may impact the cultural factors shaping human behaviour and broader societal dynamics is critical. Thus, Defence must understand how technological and cultural developments interact to navigate the future information environment effectively.

1.2. Research objectives and scope

In this context, RAND Europe and Frazer Nash Consulting conducted a study investigating how technological developments in the information environment might shape culture in the Generation-After-Next (GAN) timeframe, i.e. 2035–2050. Table 1.1 outlines the study's research questions (RQs).

4 UK Ministry of Defence (2018).

5 OPEN Publications (2023), Kavanagh & Rich (2018).

6 For example, see Rottger & Vedres (2020).

Table 1.1 Study research questions

Work package	RQs
WP1	RQ1: Which technological developments will likely shape the GAN information environment? RQ2: Which technological developments will likely have the most significant impact on the GAN information environment?
WP2	RQ3: How is culture shaped through the information environment?
WP3	RQ4: How might the identified technological developments shape culture through the information environment? RQ5: What overarching implications, threats and opportunities does the analysis suggest for UK Defence?

Several key definitions shaped this study's research scope:

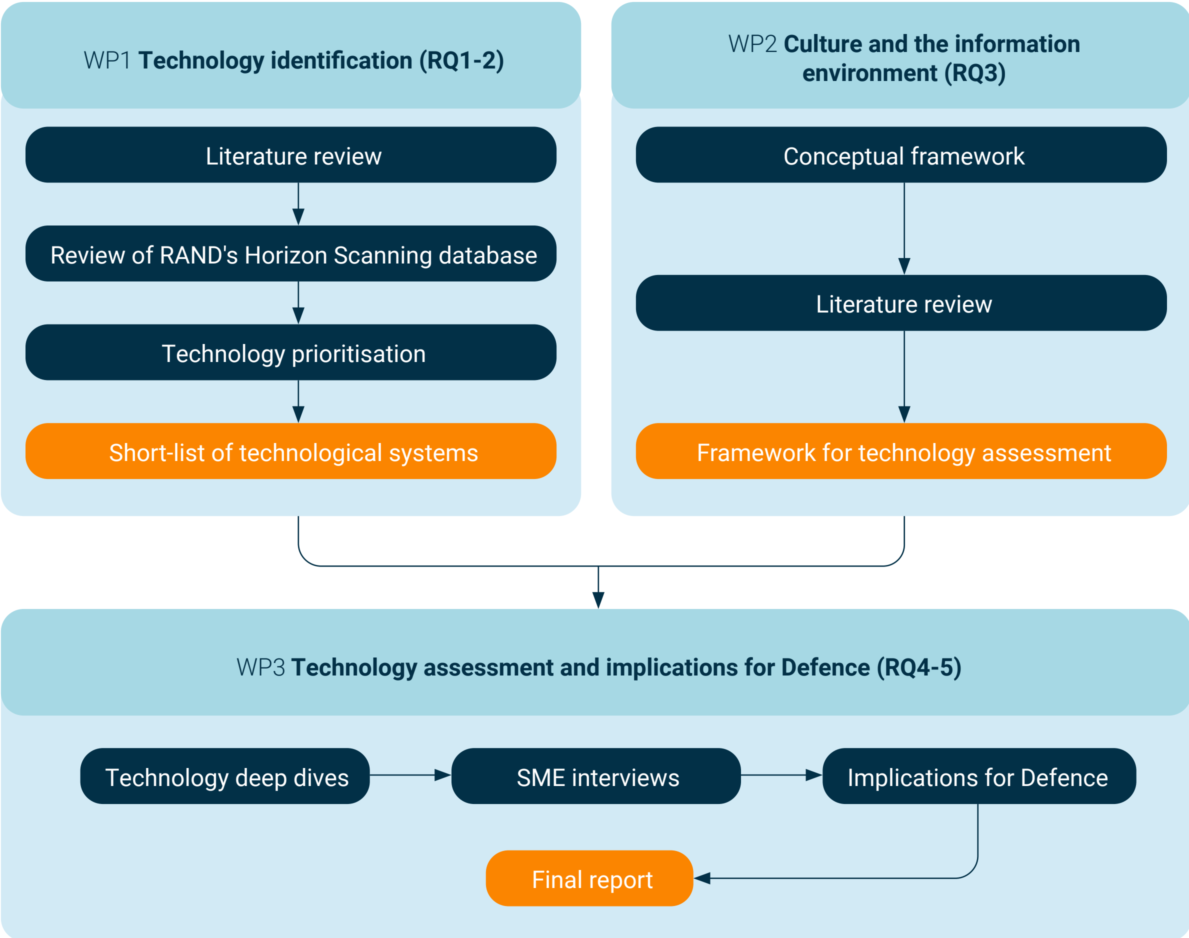
- **'Information environment'**: Based on existing political and communication-science literature, we defined this as 'all informational processes, services, and entities, thus including informational agents [comprising individuals and organisations] as well as their properties, interactions, and mutual relations'[7]; thus, the 'information environment' refers to the processes through which individuals are exposed to and engage/interact with information[8];
- **'Technological development'**: We defined this as technological advances relating to the information environment, i.e. developments in how individuals and organisations produce, access or consume information;
- **'Culture'**: Based on anthropological research, we defined culture as the dynamic and evolving socially constructed reality shared across social group members and mirrored in artefacts in the physical environment.[9]

1.3. Research approach

We used a structured multi-method research approach to answer the above RQs, using the three work packages (WPs) shown in Figure 1.1.

7 Floridi (2005).
8 Rottger & Vedres (2020).
9 Hudelson (2004).

Figure 1.1 Overview of the research approach



Source: RAND Europe.

1.3.1. WP1 – technology identification

We orientated the study's first phase towards identifying the technological developments most likely to shape the GAN information environment. This phase comprised two research activities:

1. **Literature review:** We reviewed publicly available open-source academic and non-academic literature to a) characterise trends and developments associated with the GAN information environment and b) identify the emerging technologies likely to shape it. We identified relevant literature via Google Scholar searches using Boolean search strings (based on keywords linked to the RQs) and snowball searching (i.e. identifying sources through the selected sources' references). We applied inclusion and exclusion criteria to all search results to identify the most relevant studies based on the source's relevance, literature type, source language and publication date. We excluded those with limited relevance to the RQs, published in languages other than English or before 2012. We reviewed included sources using a structured Excel-based data-extraction matrix.

2. **Horizon-scanning:** We also reviewed the RAND Europe Centre for Futures and Foresight Studies (CFFS)[10] science and technology (S&T) horizon-scanning database to identify additional emerging technological developments. This horizon-scanning database comprises the ongoing collection and analysis of multifarious sources tracking advances in S&T disciplines. To identify developments relevant to the information environment, we reviewed the horizon scanning database for the 2020–2023 timeframe and filtered data by each technological development's relevance to the information environment. We extracted 258 items and clustered them according to technology type.

We synthesised data from the literature review and horizon-scanning results, developing a longlist of 53 technological developments within ten technology categories (described in Chapter 2). To identify developments with the most significant potential impact on the GAN information environment, research team members and two RAND experts scored each technological development on the following parameters: a) its likely impact level on the information environment and b) the likelihood its impact materialises within the GAN timeframe (2035–2050). This assessment also helped refine the longlist of technological developments and identify the best options for analysing cultural impacts on the GAN information environment.

Based on the scoring results, we identified six technological systems for further analysis:

1. Automated information systems
2. Virtual metaverses
3. Mixed and augmented reality
4. Advanced connectivity
5. Human augmentation
6. Information security.

These systems captured interactions between the most potentially impactful technological developments for the GAN information environment. We conceptualised them as clusters of interconnected technologies relevant to various aspects of the information environment (e.g. information access, interpersonal communication and information security).

We selected technological systems rather than individual technological developments as the unit of analysis for subsequent research phases for several reasons:

1. Analysing technology interactions relative to particular aspects of the information environment supported a more precise analysis of likely cultural impacts.
2. Focusing on technological systems allowed us to consider the emergence of new technologies alongside advances in each system's existing technologies.
3. Using technological systems allowed us to capture specific aspects of the information environment, enabling the identification of different technologies' potential future uses and applications (and thus their potential impact).

1.3.2. WP2 - culture and the information environment

The study's second phase aimed to develop a conceptual framework for assessing the cultural implications of emerging technologies. This phase was underpinned by a stock-take of relevant cultural and societal components and their interactions

10 See https://www.rand.org/randeurope/research/futures-and-foresight-studies.html (as of 6 March 2024)

with a future information environment, thus addressing RQ3. We developed the conceptual framework in two parts:

- First, we reviewed academic literature on interactions between the information environment and culture, undertaking a non-systematic review of literature from social anthropology and Science and Technology Studies (STS). The review focused on literature, theories and ethnographies predicated on the interaction between technology development, knowledge production and sociocultural context. We also examined the directionality of relationships between technology and culture based on Actor-Network Theory (ANT).[11] The ANT approach considers knowledge and technology as actants in knowledge production, helping conceptualise the relationship between information environments and culture as symbiotic and bidirectional.
- Second, based on the literature review, we identified cultural aspects at different societal levels (e.g. macro, meso, and micro). This process included disaggregating cultural elements associated with a) macro-level institutions, such as global systems, knowledge assemblages and nation-states, b) meso-level institutions, such as local authorities, workplaces and residences, and c) micro-level institutions, such as family, social networks and individuals. By utilising several focus levels, our conceptual framework development drew out cultural phenomena operating within and between each level. This multi-level approach also helped examine additional intersections of interest, such as gender, race and class-based experiences, through concepts such as habitus, critical race theory and intersectionality. The final conceptual framework (presented in Chapter 3) captured key interactional loci and points of influence between technological change and culture.

1.3.3. WP3 - technology assessment

The study's third phase aimed to understand the potential cultural impacts of technological changes in the GAN information environment (RQ4), applying the assessment framework developed in WP2 to the six selected technological systems identified in WP1.

We first undertook deep dives for each of the six technological systems using targeted desk research to review existing research and information on each system's key characteristics. Guided by the assessment framework, the deep dives examined the following for each technological system:

- Its component technologies and their characteristics;
- Its likely development trends, including future priorities and key developers;
- Its key end users, applications and information-environment impacts;
- Its regulation landscape, including existing regulations, future regulatory directions and potential barriers.

To better characterise relevant technological trends and selected technology clusters' impact, we conducted ten subject-matter-expert (SME) interviews to validate and refine the deep-dive insights. We identified interviewees using purposive sampling based on their expertise and its alignment with the study topic. Interviews lasted 60–90 minutes

11 Lezaun (2017) and Sayes (2014).

and followed a semi-structured format based on an interview protocol structured according to the assessment framework. Interviewees included two experts from non-governmental and international organisations, five from academia, and three from non-academic research institutes. We analysed interviews using an inductive thematic approach.

We conducted a final internal analysis to identify and structure the study's conclusions and implications for UK Defence. This analysis informed this final technical report, subject to technical Quality Assurance from RAND, Frazer Nash and the ASTRID Technical Lead.

1.3.4. Caveats and limitations

This study's activities and findings are subject to several caveats, limitations and assumptions:

- **Future uncertainty:** This study aimed to identify potential developments in technological innovation and their impacts on the information environment and culture up to 2050. Given the pace of technological change and the inherent uncertainty surrounding new technologies' future use and performance, this study's findings are not specific predictions of future technology advances and scenarios. Instead, they offer insights into key trends and potential futures associated with the cultural impacts of technological change.
- **Literature review and interview constraints:** This study predominantly relied on consolidating insights from existing literature and SMEs' informed opinions. However, the study's budgetary and timeline constraints limited the scope of these activities; we could only review a limited amount of literature and interview a limited number of SMEs. To expand the potential future trends and scenarios we could explore, we included peer-reviewed studies and non-academic sources in our literature review, e.g. expert opinion, government reports and news articles. Readers should consider these methodological limitations when interpreting the study's findings. Chapter 5 discusses research avenues for building on, refining and validating this report's findings.
- **A focus on conceptual insights relating to the cultural impact of emerging technologies:** We undertook this study as a preliminary exploration of the potential cultural implications of technological change in the information environment. We maintained a conceptual approach to analysing the cultural implications of different technological systems to enable a broad overview of potential impacts. Thus, our analysis focused on the conceptual elements of culture (e.g. norms and values) rather than technological systems' impact on a *specific* culture (e.g. the UK's culture). While this approach provides a preliminary insight into the relationship between technological change in the information environment and culture, future research might benefit from a targeted approach to specific cultures informed by developing cultural topographies. Chapter 5 discusses this recommendation for further research in more detail.

1.4. Report structure

Beyond this introductory chapter, this report comprises four additional chapters:

- **Chapter 2** discusses findings relating to RQs 1 and 2, beginning with a contextual description of the current information environment and trends and then outlining the technological change areas expected to shape it from 2035 to 2050;

- **Chapter 3** presents findings relating to RQ3, discussing the relationship between technological change and culture and outlining the framework for assessing the cultural impact of technological developments in the GAN information environment;
- **Chapter 4** focuses on RQ4, describing the likely implications of the six technological systems for the GAN information environment and culture;
- **Chapter 5** concludes the report by summarising the research findings and outlining the key implications for UK Defence (RQ5).

Chapter 2. Technological change and the information environment

This chapter gives an overview of the broader ecosystem of technological change in the GAN information environment, presenting the research findings relating to RQ1 and RQ2:

- **RQ1:** Which technological developments will likely shape the GAN information environment?
- **RQ2:** Which technological developments will likely impact the GAN information environment the most?

The chapter begins with a contextual discussion of the different elements and dynamics of the information environment. It then presents the project's findings on the areas of technological change most likely to shape this in the future. Finally, the chapter reflects on the cross-cutting dynamics of technological change in the GAN information environment, drawing chiefly on the literature review and horizon scanning conducted in WP1.

2.1. Evolving nature of the information environment

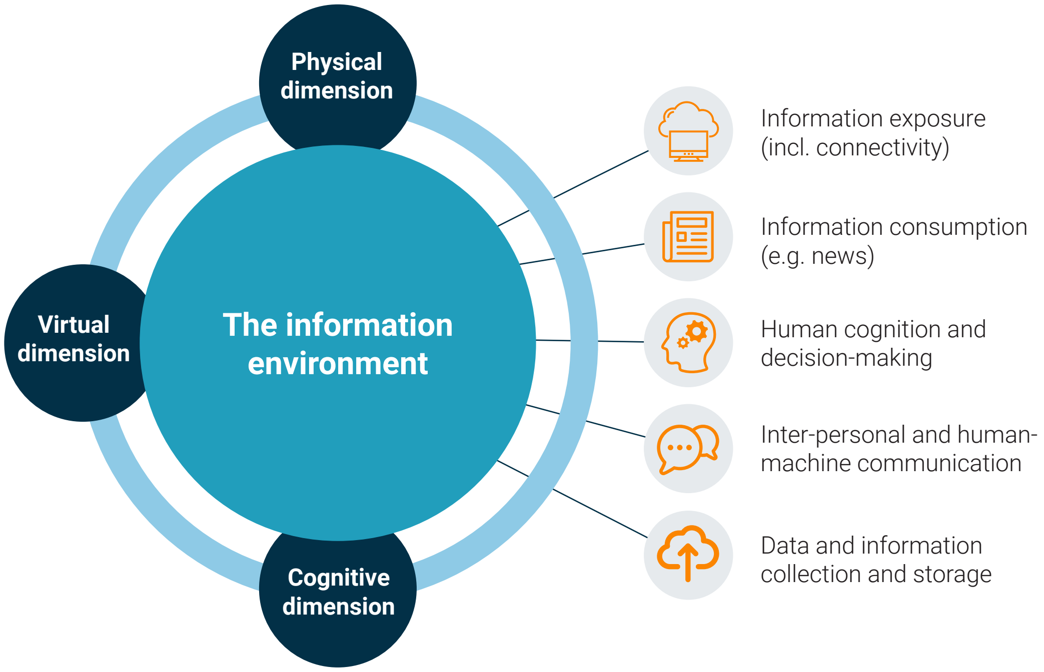
The information environment consists of the processes through which individuals, groups and society are exposed to, store and consume information and use it for decision-making and communication. These processes yield physical and virtual manifestations shaped by human cognitive abilities.[12] Research typically conceptualises the information environment according to three dimensions:

- The **physical dimension** refers to the information environment's material characteristics, e.g. the infrastructure facilitating connectivity and information processing and the technological tools/machines facilitating communication;
- The **virtual dimension** encompasses how information is communicated virtually and exchanged interpersonally or across society;
- The **cognitive dimension** refers to human cognitive abilities and factors that impact how humans perceive information and translate it into behaviour, including social, cultural, linguistic and psychological elements of human cognition and behaviour.

These dimensions influence five critical processes in the information environment (see Figure 2.1 below): a) how individuals, groups and broader society are exposed to information (including via the internet), b) how they consume it, c) how they process and use it for decision-making, d) how they communicate it with others and d) how they collect and store it.

12 Government Accountability Office (2023), OPEN Publications (2023).

Figure 2.1 Conceptual overview of the information environment



Source: RAND Europe literature analysis.

Various trends define the present-day information environment across these dimensions, summarised in Table 2.1 and described below.

Table 2.1 Summary of current trends characterising the information environment

Dimension	Key trends
Physical	• Increased numbers of interconnected devices, driven by growing demand for connectivity, data and related services; • A shift in the device types used for communication and information consumption from fixed devices (e.g. desktop computers) to highly mobile sensors and devices (e.g. smartphones); • The increasing importance of space technology, space-based and space-enabled services in the information environment; • Increasing geographic and demographic divides in information exposure and consumption patterns via access to connectivity and other services.
Virtual	• Increases in the scale, speed and access of information diffusion via internet-enabled platforms and services; • The expansion of the information environment's virtual dimension as augmented, mixed and virtual reality (AR, MR and VR) technologies mature; • Increasing primacy of social media over traditional news as the leading news and information source; • Amplification of 'truth decay', i.e. the declining role of facts and systematic analysis in public discourse.

Dimension	Key trends
Cognitive	• Exacerbation of the cognitive biases shaping people's interpretation of information, e.g. technological characteristics that amplify echo chambers and information-filter bubbles; • Increasing informational accessibility through digital and social media – raising the risk of information overload; • Increasing polarisation in public discourse, particularly about political issues.

2.1.1. Physical dimension

Technological innovation has significantly evolved the information environment's physical dimension in recent decades. One key trend is the **increasing number of interconnected devices, driven by a growing demand for connectivity, data and related services**.[13] The rising number of devices embedded with sensing capabilities and connected with other devices via the internet is commonly known as the Internet of Things (IoT), whose exponential growth was described as 'potentially amongst the most significant disruptive technologies of the 21st century'.[14] Object connectivity will likely continue increasing exponentially, alongside IoT's pervasiveness in home, work and social environments and the rapid expansion of internet traffic.[15]

The device types used for communication are also changing, moving **away from fixed devices (e.g. desktop computers) to highly mobile sensors and devices such as smartphones**.[16] With an increasing proportion of internet users exclusively accessing the internet via a mobile phone, smartphones are also becoming the primary avenue for reading news.[17] This trend correlates with a global trend towards social media and messaging applications as the preferred source of news and information, which is expected to continue growing.[18]

Moreover, technological innovation has **extended the information infrastructure into the space domain**, increasing the role of space-based or space-enabled services in the information environment.[19] Satellite systems now play a critical role in enabling global telecommunications via satellite communications, positioning-navigation-timing and other services.[20] This infrastructure complements other connectivity technologies, including undersea infrastructure, mobile telephony and land-based copper and fibre cabling. As Section 2.2 explores, the space domain's future importance for providing services such as connectivity will likely increase, facilitated by growing demand and supply-side enablers. These include particularly the decreasing cost of access to space, which

13 Alavi et al. (2018), Chin et al. (2019).
14 Chin et al. (2019:46).
15 OPEN Publications (2023).
16 Rottger & Vedres (2020).
17 Newman et al. (2019), GSMA (2019).
18 Newman et al. (2019), Rottger & Vedres (2020).
19 Black et al. (2022).
20 Black et al. (2022).

has reduced cost-related barriers to access for many space-enabled services.

Alongside these cross-cutting trends are several **emerging divides in how populations engage with such physical infrastructure and associated information exposure**. Firstly, research suggests increasing **geographic divides** in global information exposure and consumption patterns. These divides are chiefly significant differences in internet access between the Global North and Global South, but also cultural differences in patterns of media consumption (e.g. observable differences in what media consumers most rely on in different countries).[21] Secondly, differences in digital technology engagement have also driven **demographic divides**, particularly **intergenerational differences** in how people access and consume information. Younger generations rely more on digital and social media for news consumption, while older generations rely on TV, radio and print.[22] Moreover, research suggests that younger people are less identified with and loyal to news brands than older generations.[23]

2.1.2. Virtual dimension

The information infrastructure's evolving nature has yielded several trends in the information environment's virtual dimension, primarily affecting information diffusion and consumption patterns through virtual communication channels. By enabling multiple virtual communication types, **improved and expanded internet coverage has facilitated information diffusion 'at an unprecedented scale',** broadening any single person's information dissemination reach and drastically increasing the speed of information exchange across geographic boundaries.[24] The proliferation of mobile communication devices has subsequently facilitated the rapid growth of online social platforms such as Facebook and Twitter, generating a social media landscape that continues rapidly evolving and developing, e.g. with the recent rise of TikTok.[25]

In tandem, **social media has steadily replaced traditional news media as the primary source of news and information,** changing how individuals engage with print, digital and social media.[26] This development is strongly linked to greater reliance on digital technologies, as discussed above, but also reflects the media ecosystem's shift towards a 24-hour news cycle and the increased number and diversity of news organisations competing for consumers' attention.[27] The emergence of new social media platforms (e.g. TikTok), the changing role of established ones (e.g. Facebook), and the rapid evolution of the overall social media landscape have also shaped information consumption and communication behaviours.[28]

Increasing reliance on social media for news consumption and changes in the role of traditional media have also driven changes in public discourse and the information types individuals consume. Previous RAND research

21 Rottger & Vedres (2020).
22 Newman et al. (2019), Newman et al. (2022).
23 Newman et al. (2019).
24 Rottger & Vedres (2020, p. 21).
25 Rottger & Vedres (2020), Ofcom (2023).
26 Newman et al. (2022).
27 Kavanagh & Rich (2018).
28 Newman et al. (2022).

highlighted how the changing commercial pressures on news organisations led to prioritising commentary over investigative journalism, contributing to a trend known as **'truth decay'**, a term describing the rising disagreement about facts and data analysis, an increasingly blurred line between opinion and fact in public discourse, the growing volume and influence of opinion over facts, and declining trust in traditional media and information sources.[29]

The evolving nature of public discourse is closely linked with **changes in information threats, particularly mis-and-disinformation**. Research has drawn mixed conclusions on how significantly mis-and-disinformation threats have grown and impacted public attitudes and behaviours in recent years, particularly with the rise of social media.[30] Though some researchers suggest concerns about the scale and impact of misinformation have been overstated,[31] others have documented mis-and-disinformation's growing threats, particularly on social media. Examples include:

- The amplifying effect of social media channels and social media platforms' algorithmic design on the diffusion of false information[32];
- The significant discourse generated by social media bots around significant political events, such as the 2016 US Presidential Elections[33]; and
- Growing difficulties in identifying disinformation as actors utilise difficult-to-verify content blurring the line between truth and fiction.[34]

Alongside the proliferation and sophistication of information and communication technologies (ICTs), the information environment's virtual dimension is rapidly evolving as **augmented, mixed and virtual reality (AR, MR and VR) technologies mature**. The advent of AR, MR and VR communication is typically discussed relative to the emergence of what is referred to as the 'metaverse': virtual realities facilitating real-time interaction in a fully immersive virtual world. Though the development of a fully-fledged metaverse is nascent, immersive games and platforms facilitating social interaction within a virtual setting have already begun entering the market.[35] The trend towards using AR, MR and VR technologies to augment and enhance social interaction is expected to continue, with the technology growing in variety and importance across sectors.[36] Chapter 4 explores this trend further.

2.1.3. Cognitive dimension

In addition to the changing media landscape, broader sociocultural developments have **exacerbated the cognitive biases shaping people's interpretations of information**. Such biases relate to cognitive processes known as motivated reasoning, whereby a person's desire for a particular conclusion affects how they

29 Kavanagh & Rich (2018).
30 Rottger & Vedres (2020).
31 Rottger & Vedres (2020).
32 Vosoughi et al. (2018), Garcia-Camargo & Bradshaw (2021).
33 Bessi and Ferrara (2016).
34 Garcia-Camargo & Bradshaw (2021).
35 Dwivedi et al. (2022).
36 NATO Science and Technology Organization (2023).

process information. Examples of motivated reasoning include people avoiding or engaging in a biased manner with information likely to challenge them or selectively engaging with information to enable a (perceived) normatively correct conclusion or satisfy social goals.[37] For example, individuals may interpret information to match their beliefs by seeking information conforming to their attitudes, beliefs and behaviours. Based on the media landscape's changing, selective exposure suggests that individuals' information environments are inherently biased towards information consistent with their existing opinions and beliefs.[38] Two concepts frequently associated with these biases and the current information environment include a) **echo chambers**, i.e. the tendency in social media networks for people to expose one another to information reinforcing the networks' prevailing attitudes, and b) **filter bubbles**, i.e. selective informational exposure based on social media algorithms.

From a technological viewpoint, the increasing number of interconnected data-generating devices and greater informational accessibility via digital and social media also drive a **greater risk of information overload**, potentially increasing the effect of cognitive biases shaping how individuals access and process information.[39] Social and political polarisation and increased competing demands on the education system – which is consequently struggling to train individuals in understanding and evaluating the quality of the information they interact with – also exacerbates the information environment's cognitive dimension.[40]

At the interpersonal and societal level, increasing cognitive biases and technologically-driven changes in digital and social media (particularly social media algorithms) generate **increasing polarisation and social discord**, potentially raising the potency of mis-and-disinformation. For example, research on the dynamics of online discourse around the 2016 US Presidential Election showed that information is primarily exchanged online between individuals already sharing similar political beliefs, tending to polarise political discourse.[41] While this does not necessarily extend to other areas of discourse, it reflects concerns about how cognitive biases enable mis-and-disinformation. The behavioural impacts of mis-and-disinformation are understudied, but there are indications that disinformation is 'alarmingly more likely to be noticed and shared' in today's information environment.[42]

2.2. Technological developments in the GAN information environment

Emerging technologies can impact information access, consumption, storage, communication and other information-related processes. Those of particular concern in the current context include ICTs, technologies facilitating connectivity between and among objects and humans, Artificial Intelligence (AI) and space technology. Incremental advances in these

37 Rottger & Vedres (2020).
38 Rottger & Vedres (2020).
39 OPEN Publications (2023).
40 Kavanagh & Rich (2018).
41 Barbera et al. (2015).
42 Vosoughi et al (2018) and White (2018) in OPEN Publications (2023:20).

technologies will likely continue impacting the information environment alongside emergent technologies not yet in use.

Characterising the technological features of the GAN information environment, the research team identified ten categories of technological advances, each comprising an array of new and maturing technological developments. These ten categories are:

- **AI:** AI technologies already provide significant risks and opportunities in the current information environment,[43] featuring several future high-impact development areas. AI development will likely progress from narrow to broad capabilities, e.g. expansive AI knowledge and the ability to navigate diverse scenarios in uncertain conditions.[44] This trajectory mirrors the development of Artificial General Intelligence from current technologies considered Artificial Narrow Intelligence, though this is unlikely to occur in the GAN timeframe.[45] More incremental, continuous advances are likely in AI techniques such as artificial neural networks, natural language processing, computer vision, unsupervised machine learning and deep reinforcement learning.[46] Advances in generative AI (i.e. AI technologies able to generate text, images and other media content) are particularly relevant to the information environment, alongside applications such as autonomous cyber defence.[47]
- **Biotechnology:** Though less often associated with the future information environment, several anticipated biotechnology advances relate to how individuals store, process and analyse information. Applying biotechnology to data storage raises the possibility of data stored as DNA sequences, facilitating the high-density storage of large quantities of information and removing the need for physically large and costly data-storage facilities in the future.[48] There has also been a growing interest in cognitive biotechnology, i.e. technology aiming to enhance human physiology through biophysical, biochemical or bioengineered means, optimising human abilities to think, sense, coordinate and act upon external stimuli.[49] Biotechnology also intersects with advances in human-machine teaming, discussed further below.
- **Extended reality:** As noted earlier, AR, MR and VR technologies will likely significantly extend the information environment's virtual dimension by facilitating more immersive digital interactions, conceptualised as 'extended reality'; this encompasses a spectrum of digitally-augmented AR experiences that blend digital content with physical realities to create fully immersive virtual environments. Critical future extended-reality technological advances include real-time holography (i.e. digital representations of humans or physical objects in a virtual

43 Rottger & Vedres (2020), OPEN Publications (2023), GAO (2023).

44 Martinez-Plumed et al. (2021).

45 McLean et al. (2023).

46 Martinez-Plumed et al. (2021).

47 Marr (2023a), Lohn et al. (2023).

48 Trafton (2021).

49 Johns Hopkins University & Imperial College London (2021).

environment)[50] and neural rendering (i.e. realistic digital rendering of humans in place of computer-generated avatars),[51] interactive AR applications (e.g. AR embedded into wearable devices such as contact lenses, mirrors and windshields),[52] and fully-immersive environments facilitating real-time virtual interaction.

- **Human-machine interfaces:** As AI advances expand and increase autonomy levels, developments in human-machine interfaces are expected to facilitate communication and information transfer between humans and machines. The latter includes brain-machine interfaces, wearable devices facilitating machine interaction through movement or virtual assistance to the user, and haptic and social-touch technology (i.e. social touch between humans and artificial technology-mediated social agents).[53] Research suggests that advances in human-machine teaming may translate to technologies facilitating new modes of technology-assisted interpersonal communication and interaction, such as brain-to-brain communication.[54]
- **ICTs:** Future advances in ICTs include progress in contemporary technologies facilitating connectivity and more disruptive novel ICT concepts. The former includes advanced wireless networks (e.g. future iterations of 5G and 6G), cloud computing, antennae technologies, IoT expansion, next-generation semiconductors and blockchain application for information processing systems.[55] Advances in neuromorphic computing intersect ICTs and AI, i.e. computers with brain-like architectures and advanced properties compared to von Neumann computers, thus more suitable for AI and machine learning applications.[56] Among more disruptive concepts, experts suggest the potential for developing a human application programming interface (API), i.e. a programme to 'store and enforce the rules people set about what is allowed to come into their awareness, what takes up their time and what information is shared about their activities.'[57] In addition, new data-storage concepts will likely materialise from exploring new materials and techniques to enhance data-storage capacity and density, e.g. nanophotonics and 5D optics.[58]
- **Advanced materials:** Like biotechnology, advanced materials have few but relevant applications in the future information environment. Anticipated GAN developments include next-generation electronics that leverage materials like silicon and graphene to provide high-performance, high-speed and higher-capacity data storage and information

50 Andrews (2020).
51 World Economic Forum (2022).
52 Future Business Tech (2023).
53 Ofcom (2021), Day (2021).
54 Binnendijk et al. (2020).
55 McKinsey & Company (2022), Duncan (2022).
56 Schuman et al. (2022).
57 Pew Research Center (2022a).
58 See, for example, Stokel-Walker (2021), Gu et al. (2014).

processing.[59] There is also growing interest in stretchable electronics and smart fabrics, i.e. materials enabling advanced wearable technologies facilitating data collection, particularly about human behaviour and physiology.[60]

- **Sensors:** Advances in sensor technologies are a vital area enabling innovation in a broad range of technological capabilities. For example, advances in sensor technologies enable innovation in mobile devices and AR technologies and the IoT's anticipated expansion. Such innovation includes advances in Light Detection and Ranging (LiDAR) technologies that improve object recognition by enhancing the quality and range of sensor-captured data for devices such as augmented reality headsets.[61] The potential proliferation of advanced sensors also links to the emergence of persistent sensing through wireless sensor networks, i.e. the continuous surveillance and monitoring of defined geographic areas.[62]
- **Space technology:** Products and services provided through space technology (particularly satellites) already play an essential role in connectivity and communication. Space-enabled services are likely to significantly expand during the GAN timeframe due to increasing demand for high-bandwidth, low-latency persistent connectivity, decreasing space-access costs, and the increasing technological sophistication of satellite technologies.[63] Future advances may include the sophistication of small satellite technologies, mega-constellations (large constellations of small satellites facilitating global connectivity), and deep-space communication technologies.[64] These and other space technologies will likely support global connectivity provision, including rural and remote locations, and provide high-quality data to multiple data-driven sectors (e.g. transport) through Earth Observation.[65]
- **Quantum technology and encryption:** There is considerable debate about the future impact of quantum computing, quantum communication and other quantum technologies, despite the uncertain development timeline surrounding quantum technology applications. Quantum technology applications promise significant potential impacts on the information environment, including novel communication infrastructures (i.e. a quantum internet), advanced data storage capabilities (i.e. a quantum memory), and quantum computers' possible disruption of current encryption systems.[66]
- **Security, validation and privacy-enhancing technologies:** The future information environment is associated with increased concern about privacy risks and security threats, i.e. due to the

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59 See, for example, University of Cambridge (2021a), Mircea (2021).

60 See, for example, Ecole Polytechnique Fédérale De Lausanne (2020), Loke et al. (2021).

61 See, for example, Pohang University of Science & Technology (2022), University of Cambridge (2021b).

62 Matin & Islam (2012).

63 Ofcom (2021).

64 Ofcom (2021), Black et al. (2022), Macquarie University (2020).

65 Ofcom (2021), Black et al. (2022).

66 Beshaj et al. (2022).

increased numbers of and connectivity between devices with limited cybersecurity safeguards.[67] These concerns are expected to drive technological innovation towards improved information security, end-user privacy and communication validation, e.g. data-removal devices and advanced encryption methods such as post-quantum encryption.[68] In addition, cybersecurity AI applications might include reliable methods for detecting AI-manipulated content in the future (e.g. 'deep fake' images and videos).[69]

Our analysis of the above technological developments indicates several cross-cutting trends in technological change dynamics in the GAN information environment:

- First, future change will likely include a combination of incremental advances in key technological areas already shaping today's information environment (e.g. AI techniques) alongside novel and potentially more disruptive concepts (e.g. quantum computing). Therefore, understanding the information environment's future evolution depends on considering broader trends in continuous technology development rather than focusing on new technological developments in isolation.
- Second, it is likely that some technologies relevant to the information environment will enable advances across multiple areas. For example, AI advances will likely enable the development of advanced information security solutions and drive progress in extended reality in conjunction with other enabling technologies. Understanding these technologies' applications and interactions with other technologies is therefore critical, as their impacts may vary across different dimensions of the information environment.

Based on these considerations, the research team identified six technological systems to explore the cultural impacts of technological innovation further, as summarised in Table 2.2 and detailed in Chapter 4.

67 OPEN Publications (2023).

68 See, for example, Hemsworth (2020), Choi (2021).

69 See, for example, Ruhr-University Bochum (2020).

Table 2.2 Summary of the selected technological systems

Technological system	Description
Automated information systems	Automated information systems refer to the automation of information-related processes, particularly content-generation and decision-making. They are chiefly enabled by advanced AI technologies, e.g. generative AI.
Virtual metaverses	A virtual metaverse comprises digital environments and applications that provide end users with a fully-immersive or simulated reality. This includes, for example, applications facilitating immersive digital interpersonal communication through digital twins (e.g. virtual models that accurately reflect physical objects or individuals).
Mixed and augmented reality	Mixed and augmented realities are technology-enabled experiences that blend physical and digital realities by imposing computer-generated elements onto end users' physical experiences. They include advanced AR and MR software and new hardware applications, such as AR/MR-enabled glasses, contact lenses or windshields.
Advanced connectivity	Advanced connectivity encompasses developments facilitating the internet's continued expansion as a 'global connector' and growing human and object connectivity, creating an increasingly interconnected communication network embedded into the physical world. Advanced connectivity includes, for example, developing low-power/wide-area networks, next-generation WiFi and next-generation cellular protocols.
Human augmentation	Human augmentation refers to technologically-enabled improvements in humans' physical, mental and cognitive capabilities, particularly capabilities impacting how individuals perceive, access and process information. This involves technologies such as wearables devices and stretchable electronics, allowing people to access, process or interpret larger quantities of information more quickly and effectively.
Information security	Information security encompasses technological applications to protect and safeguard information, including encrypting communications and detecting harmful or malign information. Information security includes new technological solutions for detecting advanced information threats, encryption and privacy safeguards.

Chapter 3. Understanding the cultural impacts of technological change

This chapter presents a framework for understanding future technologies' cultural impacts, drawing on existing literature on the relationship between technology and culture (RQ3). We developed the framework to facilitate an analysis of potential impacts of technological systems (see Chapter 2) on culture, and to support future UK Defence work on understanding the cultural implications of technological developments. The first section introduces the framework's underpinning concepts, while the second section details the framework and its constituent elements.

3.1. Conceptual outline

Several concepts must be defined to generate a framework for understanding the impact of future technologies on culture. First, we establish what culture means, how it shapes human behaviours, and how humans and technologies shape it. Secondly, we consider the concept of technology relative to human culture.

3.1.1. Culture

Culture comprises a shared set of ideas, values and behaviours that shape people's ways of being,[70] defining how humans interpret and organise the living world in a way common to fellow members of the same population.[71] Therefore, culture guides an individual through the vast breadth of the living world so that their experience of its social and natural particularities is similar to others sharing the same culture.[72] This shared experience promotes congruence between people's lived experiences. However, culture is not just reproduced socially but embedded in larger population-based institutions, which owe their creation to the shared ideas, values and behaviours that led to their development.[73] Importantly, culture does not just exist homogeneously at the nation-state and population level. Instead, cultures exist across all types of human groupings.[74] Therefore, approaches to understanding culture must consider the vast spectrum and variation in beliefs, practices and identities across human populations.[75]

3.1.2. Technology

From an anthropological perspective, technology can be understood as the tool society uses to support a particular functional role.[76] Anthropological approaches to technology range from investigations into the role of tools during hominin evolution to social anthropological studies of technology's

70 Aranzadi (2018).
71 Aranzadi (2018).
72 Banwell et al. (2013), Vanderburg (1985).
73 Vanderburg (1985).
74 Aranzadi (2018).
75 Aranzadi (2018).
76 Vanderburg (1985).

impact on lived experiences. However, all such approaches understand technologies through their role of supporting the practices underpinning society's functioning.[77] Technology includes hardware (e.g. tools, machines and infrastructure) and software (e.g. concepts, theories and models)[78] and performs the actions human societies depend on to function. Thus, development of a technology is inextricably bound to its intended role. Since technologies mediate the relationships between humans and their societal characteristics, their existence depends on their intended function as an intermediary.[79]

Recognition of this role underpins the theoretical approaches to technology that Science and Technology Studies (STS) pursue, in which Actor-Network Theory (ANT) is a dominant theory for understanding the societal role of technology.[80] ANT holds that non-human elements (including technologies) are required for human society's formation and functioning, working alongside culture to stabilise the collective human experience.[81] ANT refers to such non-human entities as 'actants'. Since technologies are designed to perform functions deemed valuable by those who develop them,[82] they always exist to serve a purpose, one that is repeated with each use of the technology. As such, technologies can be understood as the locus of all decisions about their creation and intended use.[83]

Regarding technology change, ANT posits that technological developments result from humans' changing value judgements about what each society considers necessary for its continued functioning.[84] For example, the telephone's development fulfilled a need for verbal communication across large distances in a society where writing was the only long-distance communication available.[85] Given the telephone's functional importance to human societies, it can also be understood as a vital societal *technique*, becoming a fundamental component of human social ecology. Thus, telephones became a technological cornerstone for subsequent developments (e.g. smartphones, video conferencing and social media). All such developments and their current use depend on telephones facilitating long-distance verbal communication.

3.2. The framework

We integrated the above concepts into a framework to guide our exploration of culture and technology's roles in the future information environment (Figure 3.1). This framework comprises four stages, each representing a different component necessary for comprehensively understanding the impact of future technologies on culture. We outline the rationale for each stage and describe its practical application.

77 Lezaun (2017).
78 Vanderburg (1985).
79 Vanderburg (1985).
80 Lezaun (2017), Sayes (2014).
81 Sayes (2014).
82 Sayes (2014).
83 Sayes (2014).
84 Sayes (2014).
85 Vanderburg (1985).

Figure 3.1 A framework for understanding the impact of future technologies on culture

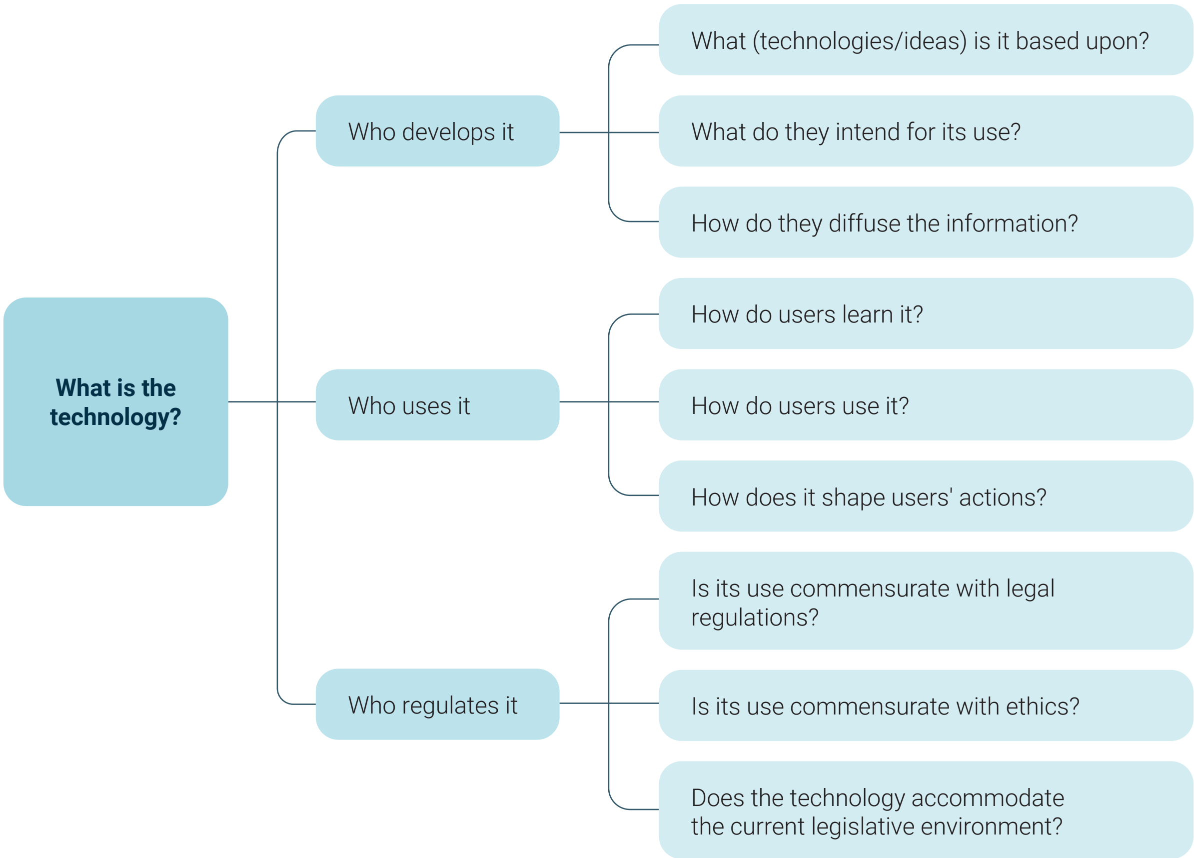
Technology as actant	• Assessment of technology to interrogate its role as an **actant** in the future information environment; • Identify the origins of technology (e.g. who develops the technology), the impact of its use (e.g. who uses the technology) and the scope of its use (e.g. when and where is the technology used).
Cultural topology	• Cultural topography as understanding the cultural landscape of the population of interest; • To identify and explore the cultural influences which impact the thinking and behaviour of the population of interest.
Ecological interaction	• Ecological interactions as the loci of interaction between the environment and the technology; • Identification of points of interaction at the individual, micro, meso and macro-social levels.
Influence or integration	• Amalgamation of all the outputs of the previous stage to consider whether the technologies in question are likely to be integrated into culture, or mediate cultural change.

Source: Frazer Nash Consulting.

3.2.1. Stage 1: Understanding technology as an actant

The first stage of this framework seeks to understand a particular technology by contextualising its origins, scope and potential impact, enabling a better inference of the technology's intended use. ANT asserts the need to explore the technological components most salient to understanding a technology's role as an actant. We can broadly divide these components into who developed it, who uses it and who regulates it (see Figure 3.2 below).

Figure 3.2 Technology as an actant



Source: Frazer Nash Consulting.

ANT's principle that actants fulfil the role of 'gathering actors from other times and spaces' helps us understand a technology's development,[86] viewing it as a product of the developers' past actions and decision-making. Thus, understanding a technology's intended use depends on identifying the intentions behind its development. However, decisions and value judgements made during development are not always explicit and conscious. Indeed, the social construction of technological development and knowledge production significantly shapes the development process, with the physical tools and technical theories utilised essentially co-producing technological development.[87] Therefore, we should consider the following questions to understand developers' roles in shaping technology:

- What technologies/ideas is the technology based on?
- What is the developer's intended use for the technology?
- How do the developers diffuse information for its use?

86 Sayes (2014).

87 Sovacool and Hess (2017).

The second component to understanding technology as an actant concerns how a person uses it. Understanding technology use can help better understand how technologies mediate relationships between humans and other social or structural societal components.[88] Even when developers intend particular uses for technology, the realities may vary considerably.[89] As such, the following questions are posed to generate a more comprehensive understanding of technology's use in action:

- How do users learn to use the technology?
- How do users use the technology?
- In what ways does the technology shape the users' actions?

The final component to consider when exploring technology as an actant is how it and its use are regulated, i.e. its legitimisation at the macro-social level. Regulations and standards around a technology's use also influence its development.[90] Most development occurs per these standards, but there is no guarantee. We asked the following questions to understand how technologies fit into the regulatory landscape:

- Is the technology's use commensurate with legal recommendations?
- Is the technology's use commensurate with ethical usage?
- Does the technology accommodate the current legislative environment?

Notably, the above questions take a high-level approach to defining a user versus a developer. For many contemporary technologies, their proprietary nature may confuse understanding of who the developers are and their agency to control their technology's distribution and use. Thus, it is best to understand *developers* as the individuals who created the technology. Indeed, the nuances around privatised technological development pose interesting ecological questions relevant to the future information environment.

A comprehensive evaluation of likely technologies in the future information environment offers a deeper understanding of the theories and practices they derive from, how they translate into everyday use, and how they fit into a nation-state's broader regulatory landscape.

3.2.2. Stage 2: Generating a cultural topography

The second stage of this framework focused on understanding the culture of interest. While cultures tend to be considered at the nation-state level, culture can be present at any level of human interaction. Therefore, it is essential that any studies into cultural impact precisely define the culture of focus.[91] This stage is informed by the Cultural Topography Analytical Framework, developed to assess the sociocultural influences that shape policy decision-making, informs this stage.[92] The stage aims to identify and explore the cultural influences impacting the population of interest's thinking and behaviour, focusing specifically on the role of identity, norms, values and perceptual lens[93] (Figure 3.3).

88 Vanderburg (1985).

89 Maxigas (2017).

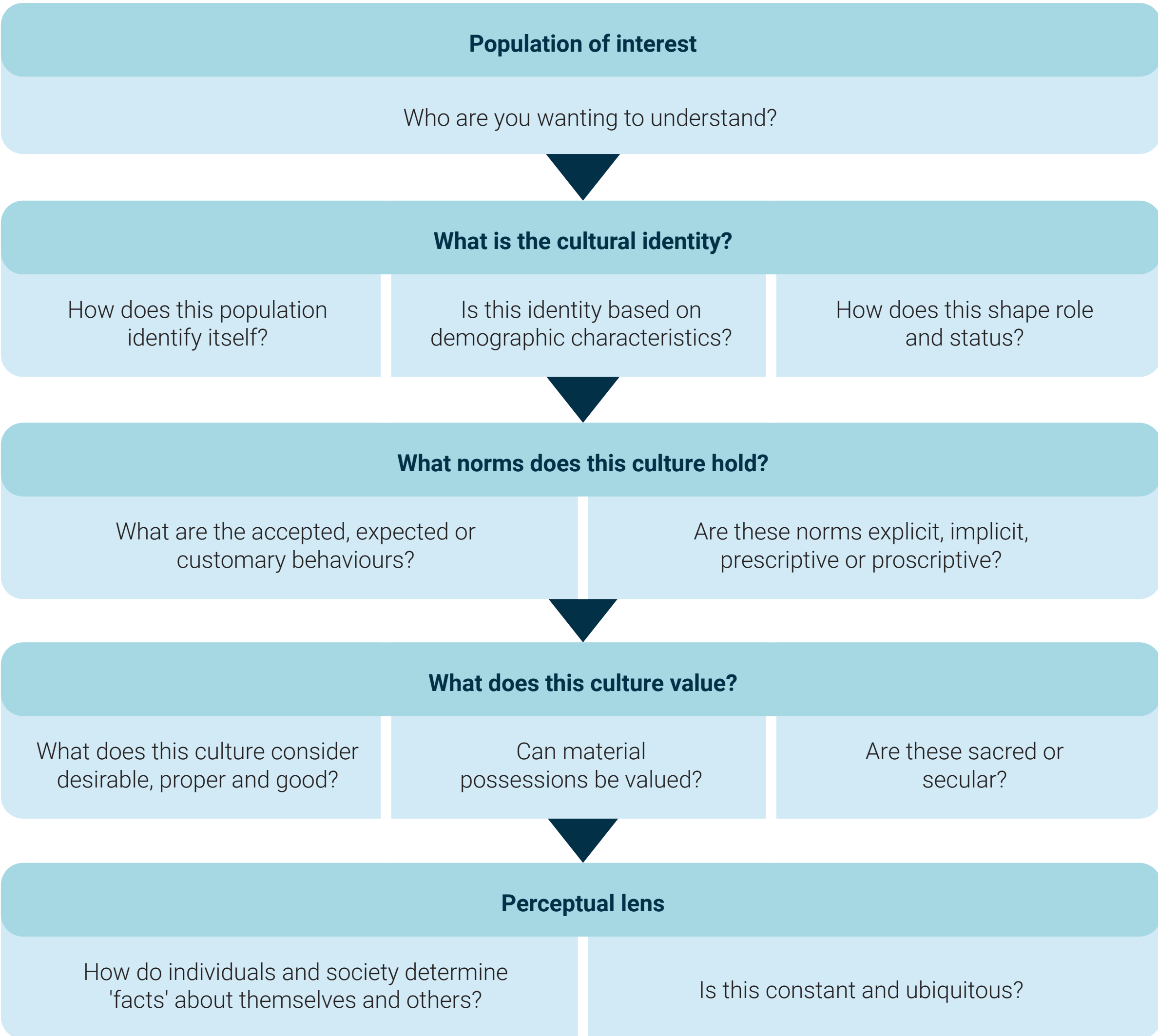
90 Sovacool and Hess (2017).

91 Crossley (2015).

92 Johnson and Maines (2018).

93 Johnson and Maines (2018).

Figure 3.3 A framework for generating a cultural topography



Source: Frazer Nash Consulting.

'Cultural identity' refers to how a population determines the character traits distinguishing its members from those outside the population. These identities can derive from the population's demographic characteristics or other experiential facets it considers valuable for self-identification.[94] Identity metrics can also operate hierarchically, with some more valued than others.

'Norms' refer to a group's accepted, expected or customary behaviours[95] and can influence behaviours within a population. Non-adherence to norms often results in negative

94 Johnson and Maines (2018).

95 Johnson and Maines (2018).

social consequences, supporting their importance in mediating behaviours. Thus, it is vital to understand culturally mediated behaviours for which non-adherence may be socially sanctioned.

'Values' are culturally transmitted beliefs about what a population considers desirable, proper and good.[96] Adhering to values can yield individuals positive social consequences. What is considered valuable can include the material and immaterial, e.g. ranging from an individual's possessions or capital to their behaviours, morals or ethics.

The final cultural topography metric refers to a culture's 'perceptual lens', describing how a population establishes facts about itself and others,[97] determining what it knows and guiding its members' understanding of the nature of their collective reality.

Considering the role of identity, norms, values and perceptual lenses present within cultures will help identify specific loci where technology use might be consistent or inconsistent with culture. Mapping a population's cultural topography will also help establish a bound context.

3.2.3. Stage 3: Understanding ecological interactions

The framework's third stage focuses on generating a roadmap outlining a technology's specific contexts of use and its potential interactions with culture. 'Ecological interactions' refer to people's interaction with their lived environment. Applied to technology, it means an individual's specific interactions with technology, when they occur and how they might impact the individual. The framework proposes four interaction levels for identifying these parameters: self, micro, meso and macro (see Figure 3.4 below). The ecological framework outlines these interactive possibilities. However, it is not exhaustive, and not all levels require consideration if not relevant to the technology in question.

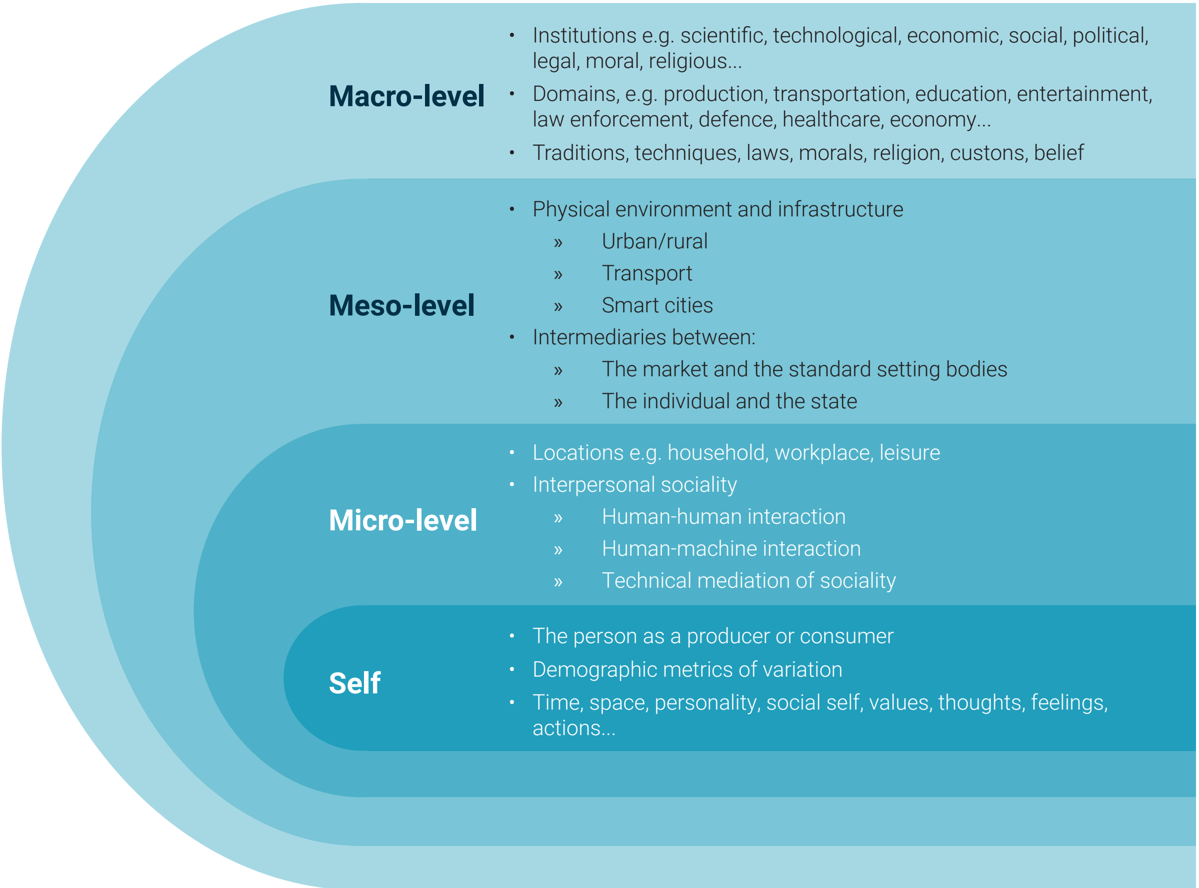
The level of the self refers to the specific interaction between the user and the technology. Most anthropological literature on individual-level technology use concerns its potential reconfiguration of an individual's sense of self,[98] including how technologies might shape their identity or alter how they determine facts about themselves.

Micro-level ecological interactions refer to an individual's direct interactions, such as daily household, workplace or social ones, primarily informed by anthropological literature on technology's role in mediating sociality between individuals, i.e. how technologies shape interpersonal interactions that might not otherwise be possible.[99]

In contrast, meso and macro-level ecological interactions between individuals and technology are often less tangible. However, they can still shape people's lived experiences of technology use and generate continued cultural impact. Meso-level structures include technological interactions within local infrastructure or intermediaries between individuals and higher organisational levels like the state or global markets.[100] The macro level focuses more on the technology's impact

96 Johnson and Maines (2018).
97 Johnson and Maines (2018).
98 Boellstorff (2015).
99 Crossley (2015).
100 Crossley (2015).

Figure 3.4 A framework for identifying ecological interactions



Source: Frazer Nash Consulting.

on social and state institutions and broader cultural phenomena such as traditions, laws and beliefs.[101]

A more comprehensive understanding of the presence of technologies is possible by covering the different analysis levels presented here. This approach optimises the identification of the interactional loci between humans and technology to increase the specificity of insights into the likely future information environment.

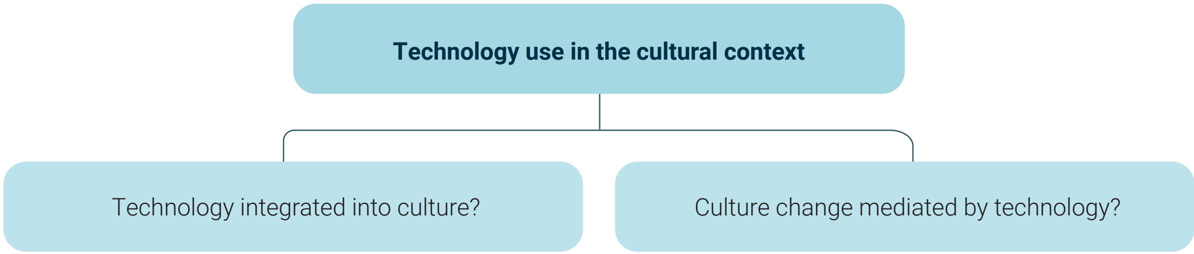
3.2.4. Stage 4: Influence or integration of technologies

Stage 4 amalgamates all the outputs of the previous stages to consider whether the technologies in question will likely integrate into culture or mediate cultural change (see Figure 3.5). As a blueprint for how people operate in the world, culture is not a fixed entity; instead, it constantly evolves in response to novel contexts.[102] While culture can guide humans' behaviour and actions, it may not

101 Vanderburg (1985).

102 Aranzadi (2018).

Figure 3.5 Determining the influence or integration of technology into culture



Source: Frazer Nash Consulting.

offer appropriate guidance when confronted with novel technology; this is where cultural transformation can occur.

This framework stage aims to assess all previously generated outputs to assess whether a particular population's use of a new technology and its pre-existing cultural topography are aligned. If congruent, the new technology may integrate into the population's culture without prompting major changes. However, if it clashes with elements of the cultural topography, then it may be abandoned. Alternatively, a technology incompatible with the population's pre-existing culture may stimulate cultural changes to accommodate it – the scenario by which future environments may undergo cultural change.

For example, the development of the telephone necessitated culturally mediated behaviour around when to use it (e.g. time of day and discussion types) and how (e.g. phone location and answering etiquette). Therefore, the telephone's development required the cultural adoption of ideas, values and behaviours around its use alongside structural and institutional changes facilitating its spread (e.g. the establishment of telecom companies, regulations and legislation). However, subsequent telephone-based technological developments – such as mobile phones, video calling and smartphones – required less cultural adaptation due to pre-established norms and expectations. Such technologies could also rely upon the pre-established institutions supporting telecommunications, illustrating cases where cultures can more readily accept technological development.

Chapter 4. Assessing the cultural impacts of technological developments on the future information environment

This chapter presents study findings relating to RQ4: How might the identified technological developments shape culture through the information environment?

This chapter's insights stem from a targeted analysis of six technological systems identified to capture areas of significant technological impact in the GAN information environment (see Section 2.2). The conceptual framework presented in the previous chapter informed this analysis, conducted after reviewing existing literature and interviewing SMEs.

Due to the study's resource and timeline constraints, we applied the framework as an analytical tool guiding the research process and narrative. However, it was impossible to comprehensively answer all framework questions for all systems. For each technological system, we report the research findings in four parts:

1. Its key characteristics and future trends as an actant (Framework Step 1).
2. Its key applications, relevant technological developments and regulatory dynamics (Framework Step 1).
3. Its implications for cultural identities, norms, values and idea generation through perceptual lenses (Framework Step 2).
4. Its primary ecological interactions with culture (Framework Step 3) and whether the technology might become culturally integrated or contribute to cultural change (Framework Step 4).

4.1. Automated information systems

4.1.1. Key characteristics and future trends

Automated information systems are computer-based systems that collect, process, store, distribute and/or produce information autonomously. These systems are designed to streamline data management, enhance efficiency and support decision-making processes. However, they also autonomously generate information and content, which may feed into autonomous behaviours such as negotiation and communication with humans or other machines.[103] The latter typically relies on specialised AI-enabled software applications supporting data processing, storage, retrieval and production.

Automated information systems comprise a wide range of capabilities. This study focused particularly on **systems facilitating automated decision-making and information generation**. Therefore, from a technological point of view, advances in generative AI and specific AI techniques, such as natural language processing (NLP), are of particular interest. Generative AI refers to systems that generate new content, such as text, images or

103 Avignone (2021).

videos, based on patterns and training data.[104] Such systems are typically based on deep-learning architectures, such as recurrent neural networks, convolutional neural networks or transformer models.

The current AI-development landscape is characterised by rapid advances in several key areas, including NLP.[105] Based on advances in deep-learning techniques, relevant computer hardware, large natural-language models and Generative Adversarial Networks, generative AI has rapidly developed into complex and sophisticated generative models in recent years.[106] As a result, generative systems can produce increasingly human-like output levels in terms of the quality and authenticity of information. Building on these recent advances, automated information systems will likely evolve significantly in the period 2035 to 2050, particularly in the following areas:

- **The ability of systems to deal with uncertainty and partial knowledge and performance in complex human-machine environments**: Despite significant progress, current systems' capabilities for dealing with uncertainty, partial knowledge or incomplete data remain limited. The development of many AI techniques is thus concerned with improving these capabilities.[107] For example, future research towards virtual assistants will likely aim to develop proactive rather than reactive systems that can perform a more diverse range of tasks, generate information across various domains and deal with different (and changing) interaction and query types.[108] Models must also perform equally well with large datasets and small, personalised ones.[109]
- **Reasoning capabilities and temporal sensitivity**: Research to augment AI models with better reasoning capabilities is ongoing. Such research has, for example, incentivised logical AI reasoning by verifying the entire reasoning chain models go through when making deductions rather than focusing solely on their output.[110] Research has also been concerned with AI models' temporal reasoning and sensitivity, ensuring they can be more easily updated for better temporal awareness.[111]
- **AI models' transparency and explainability**: Many AI models, including large generative AI and natural language models, are characterised as a 'black box', whereby it is difficult to distil what logic models adopt between receiving a data input and providing an output.[112] Enhancing transparency and explainability is a significant step for addressing two corresponding challenges. First, there are known bias challenges in AI models, particularly regarding the reproduction and amplification of data biases. Second, explainability links to addressing the 'hallucination' challenge in current natural

104 McKinsey & Company (2023).
105 Research interview, 3 July 2023a.
106 Retinraj (2023).
107 Martinez-Plumed et al. (2021).
108 Martinez-Plumed et al. (2021).
109 Research interview, 3 July 2023a.
110 Lightman et al. (2023).
111 Research interview, 3 July 2023a.
112 Research interview, 3 July 2023a.

language models, whereby models generate false information with an unclear reasoning chain.[113]

4.1.2. Applications and implications for the information environment

Applications of automated information systems are numerous and diverse in type and autonomy level. While some applications in the GAN information environment may be oriented towards full automation of information-related tasks, others may provide lower levels of autonomy by providing recommendations, automating routine tasks, and thus enabling humans to focus on higher-level decision-making and problem-solving. As mentioned above, there are two application areas of particular concern for the future information environment and culture:

- **Automated decision-making**, i.e. delegating decision-making to autonomous agents. Examples range from using AI models to assess and make decisions about the quality of argumentative essays and debates to AI-enabled detection and evaluation of crime 'hot spots' for policing and using autonomous systems to provide decisions in legal contexts.[114]
- **Automated content generation**, i.e. using generative language models to produce written or audio-visual content. Such content can range from news articles to essays, letters, contracts, computer code and cultural artefacts such as poetry, screenplays and visual art.[115]

Adoption of automated systems such as the virtual assistant ChatGPT is already growing fast, with the ChatGPT system recorded as 'the fastest growing consumer application in history'.[116] While the system's rapid adoption stems partly from the significant public interest shown by individual end users, many businesses and industries have begun exploring more systematic ChatGPT adoption due to perceived productivity-enhancing opportunities in sectors such as banking, hospitality and tourism.[117]

Future applications of automated information systems will likely cross multiple economic sectors, including infrastructure and transport management, education, healthcare and defence. Due to the low end-user costs and minimal technological know-how required for many models, such as ChatGPT, the technology will likely be available to a wide range of end users, including non-technically-minded individuals and organisations–thus democratising access to artificial decision-making and content generation. Existing technology adoption patterns suggest many businesses may adopt technologies such as ChatGPT due to cost-saving incentives despite its uncertain limitations and risks.[118]

The implications of technology development and adoption for the future information environment depend significantly on the application type and sector. However, they may include the following:

113 Lightman et al. (2023).

114 Green (2013), Chohlas-Wood (2020).

115 Metz (2022).

116 Hu (2023).

117 Dwivedi et al. (2023).

118 Research interview, 3 July 2023a.

- **Autonomous information agents' increasing agency in the information environment and larger information yields from generative models**: Language models' ability to generate natural language may increase the proportion of artificially generated versus human-generated content in a person's information environment. This may include malign information, such as propaganda, with generative models enabling actors to generate larger quantities at lower costs.[119] Therefore, autonomous agents' increasing role in information generation has implications for the environment's overall nature and dynamics while raising questions about the role of technology in information and knowledge production. For example, debates are already emerging in scientific contexts about whether technological systems can or should be recognised as co-authors if their role in producing scientific knowledge continues to increase.[120]
- **Difficulties detecting artificially generated content and false information**: There have been significant efforts towards developing evaluation frameworks and detection methods to identify artificially generated and/or false information. However, concerns remain about the challenges of detecting mis- and disinformation generated by language models, potentially making malign information campaigns (e.g. propaganda) less discoverable.[121] From an end-user perspective, the challenge extends to difficulties distinguishing artificially generated versus human-generated content, potentially increasing distrust in information sources and amplifying cognitive biases such as motivated reasoning (see Section 2.1.3). Moreover, this issue has raised concerns about recognising content authorship in academic research and education.[122]
- **Increasing privacy and cybersecurity concerns**: Adopting natural language models like ChatGPT has raised significant concerns about privacy and data-protection challenges. Such concerns stem from the considerable data end users enter into a system with high data-leakage risks and without sufficiently robust privacy and data protection safeguards. From a cybersecurity perspective, the technology also raises concerns about end users' increased exposure to social engineering attacks, malware threats, phishing attacks and identity theft.[123]

The regulatory landscape is under significant pressure due to the rapid evolution of automated information systems. As AI and similar technologies can be used for various benign and harmful purposes, existing developments highlight the challenge of AI regulation from a technology-driven approach. Regulating AI, including automated information systems, would likely require an application-driven approach focused on AI applications presenting a risk of harm to individuals or contravening existing legal safeguards (e.g. AI used for criminal purposes).[124]

119 Goldstein et al. (2023).
120 Dwivedi et al. (2023).
121 Goldstein et al. (2023).
122 Dwivedi et al. (2023).
123 Sebastian (2023).
124 Research interview, 30 June 2023.

In the future, AI system regulation will likely involve national regulatory bodies and international or supranational organisations, such as the European Union. In the UK, the use of automated information systems is governed by the Data Protection Act (DPA) of 2018 and the Copyright, Designs and Patents Act of 1988 which governs intellectual property rights. The latter grants legal protection to creators and owners of original works, including software and databases. It is unclear how these regulatory frameworks might be impacted by the expanded use of automated systems independently generating original content (albeit based on existing open-source data).

Future regulatory action faces additional challenges, particularly given the slow pace of policy and regulation compared to the technology's rapid development and adoption (driven by the demand for productivity and other perceived benefits).[125] Technology governance is also likely to face barriers at the international level due to national technology-development interests. For example, countries with developing technology markets are unlikely to support governance arrangements and regulatory action that may constrain their technological development efforts.[126]

4.1.3. Cultural implications

The cultural impacts of automated information systems depend heavily on the level of autonomy that a technological system is enabled to have as well as the context in which it is being applied, and for what purpose.

Regarding a society or community's cultural identity, automated information systems' increasing sophistication and adoption raise questions about **what we understand as human versus artificial intelligence, identity and personhood**. While traits such as creativity and logical reasoning may commonly be associated with human intelligence, advances in generative models' reasoning capabilities may challenge these notions while also posing questions about the defining features of 'artificial' intelligence. Scholarly debate has already considered whether (and to what extent) artificial intelligence truly represents 'intelligence' and the hierarchy of human versus artificial intelligence.[127]

As cultural identities are reproduced, in part, through cultural artefacts,[128] adopting generative models in sectors such as creative writing and visual arts also raises questions about **the role autonomous information systems may play in reproducing culture**. For example, societies will likely need to consider whether to embed artificially-generated art and creative writing in cultural reproduction or safeguard human-generated historical artefacts as centrepieces of cultural identity, potentially challenging established assumptions that culture is an inherently human artefact.

The proliferation of artificially generated content in the information environment may also affect how knowledge about cultural artefacts is reproduced and its role in forming cultural identity. On the one hand, increasing artificially-generated content may mean that human-generated cultural artefacts become less visible, limiting their participation in processes reproducing cultural identities. On the other, automating processes such as

125 Research interview, 3 July 2023a.

126 Research interview, 23 June 2023.

127 Research interview, 23 June 2023.

128 Heersmink (2021).

archiving and documenting cultural artefacts may help preserve and transmit cultural heritage, potentially making cultural content more accessible to different audiences.[129]

Like human augmentation technologies (see Section 4.5), automated information systems raise questions about **the nature of human agency versus machine agency**. Existing research reports that the increasing adoption of AI-enabled tools supporting human activity presents 'a turning point that will determine a great deal about the authority, autonomy and agency of humans', requiring debate around the desired and necessary boundaries.[130]

This question also relates to the normative aspects of culture. **Debates about acceptable levels of automation and appropriate normative reference points to balance the societal costs and benefits of adopting automated systems** will likely accompany future technological developments in this area.[131] New behavioural norms will likely emerge within societies and communities to guide such systems' development and use in different contexts. For example, new norms may emerge about the automation level acceptable in educational or creative workplace settings, reflecting a society's value of creativity and critical thinking. New normative taboos may also emerge regarding automation use in specific contexts, such as automated decision-making in military and national security environments. This issue concerns the current debate over the ethical and normative boundaries of using AI in military operations.[132]

Design advances also raise **ethical, moral and legal questions in designing autonomous models**, including which moral and ethical codes should be embedded in informational agents' designs and the circumstances under which one may ascribe moral agency to computational agents. From a legal perspective, adopting automated information agents will also impact how existing legal frameworks and norms apply to autonomous technologies.[133] A more general question is how future technology development can or should align with social norms and human goals and how technology can embody human social realities and experiences.[134] This question also relates to the cultural values a society might wish to embed in technological design.

In the context of generative models, diversity and inclusion are the values of greatest concern. As previously mentioned, generative models face challenges reproducing and amplifying the **biases embedded in data** on which models are trained. Such biases include racial or gendered biases that have individual and societal costs if subsequently reproduced.[135] As this reflects the tendency of generative models to amplify the majority opinion, improvements in model design would be needed to ensure that models can recognise societal norms and values such as protection of minority characteristics, social

129 Caramiaux (2020).

130 Pew Research Center (2023).

131 Research interview, 30 June 2023.

132 Depp (2023).

133 Hales & Gayle (2013).

134 Research interview, 3 July 2023a.

135 Research interview, 3 July 2023a.

justice and multi-culturalism.[136] Conversely, adopting autonomous information systems that reproduce biases may pressure existing cultural norms and values relating to diversity and inclusion by influencing public debate with biased, misaligned perspectives.

The value of human labour and the right to work may also come under pressure from automating decision-making and information generation. Adopting generative models has already raised **concerns about automation's potential to cause rapid, widespread displacement of human labour**.[137] For example, the United States has seen a series of labour strikes in creative industries based on fears that generative AI adoption will threaten actors', writers' and other professionals' roles, job security and compensation.[138]

Since automating decision-making and generative processes is primarily motivated by economic factors (i.e. productivity gains and cost-efficiencies), automating processes that currently rely on human labour will likely have significant social and cultural impacts. Historical automation cases offer parallels with current and future automation-triggered changes to peoples' work. However, the pace of AI innovation is significantly faster, challenging society's ability to develop normative, ethical and governance frameworks for responsible and beneficial exploitation of the technology.[139]

Lastly, as mentioned in the previous section, artificial information generation is expected to **challenge the processes by which people determine facts and derive ideas about themselves, others and their environments**. In combination with the pace at which information can be produced by artificial models, and the authenticity of artificial information and challenges in distinguishing it from content developed by humans, end-users may experience increasing difficulties recognising false information.[140] Audio-visual information is seen to carry particular risks; as humans tend to place significant trust in audio-visual formats, difficulties distinguishing artificial from human-generated content may substantially increase the former's influence on people's attitudes and behaviours.[141]

Without reliable and effective detection and evaluation frameworks to help people distinguish artificial from human-generated information or disinformation, some experts anticipate a 'truth crisis'. In this scenario, the inability to distinguish between true and false information **radically decreases the perceived value of objective facts,** such that individuals only engage with and absorb information aligned with their existing attitudes and beliefs.[142] The declining trust in institutions such as the government amplifies this challenge. For this reason, there is increasing emphasis on developing explainable evaluation frameworks to help individuals identify information as true or false, thereby building critical thinking skills and trust in reliable information sources.[143]

136 Research interview, 3 July 2023a.

137 Research interview, 3 July 2023a.

138 Sankaran (2023).

139 Research interview, 3 July 2023b.

140 Research interview, 30 June 2023, 3 July 2023a. Goldstein et al. (2023).

141 Helmus (2022).

142 Research interview, 3 July 2023a.

143 Research interview, 3 July 2023b.

4.1.4. Summary and ecological interactions

Table 4.1 below summarises the potential interactions between technology and culture across four ecological loci.

As society has already begun adapting to AI adoption across various industries and areas of everyday life, most applications of automated information systems will likely integrate into existing cultural frameworks. However, two particular interactions may engender more significant sociocultural changes:

- Firstly, rapid and large-scale automation of decision-making and information-generation functions might cause sociocultural disruption as human roles alter substantially within short periods. Norms and values may thus come under pressure, particularly as communities explore assumptions about the value of human labour and the nature of human versus artificial intelligence.
- Secondly, artificially generated content is associated with significant changes in how individuals and communities generate ideas and determine facts about each other and the environment. Although developing detection, verification and content moderation frameworks may mitigate the scale of this impact, social structures will come under significant pressure as artificial content generation challenges people's ability to distinguish facts and make sense of their information environment.

Table 4.1 Ecological interactions in automated information systems

Level	Key interactions
Macro	• Increasing role of AI in producing cultural artefacts and reproducing culture; • Sociocultural disruption due to the potentially rapid, widespread automation and displacement of human labour, including changes in professional cultures and domains (e.g. education); • Increasing cultural debate about acceptable automation levels and the ethical and moral norms guiding automation in different domains.
Meso	• Increased difficulty distinguishing artificial and human-produced content and establishing facts about one's physical, socioeconomic and political environment; • Potential constraints on self-representation and equity due to bias reproduction in autonomous models.
Micro	• Increasing interaction and knowledge exchange between autonomous systems, humans and machines, including in the workplace.
Self	• Changes in people's sense of self and perception of personhood and agency due to increasing automation of decision-making and content-production.

4.2. A virtual metaverse

4.2.1. Key characteristics and future trends

Various definitions of the term 'metaverse' associate it with different capabilities and characteristics.[144] However, it is typically understood as **a persistent and virtual environment comprising applications that allow end users to have agency in real-time and fully immersive or simulated realities**,[145] including facilitating immersive digital interpersonal communication through digital twins (virtual models representing a physical object, updated using real-time data). Though entirely virtual, metaverses are informed by real-world data, using sensors to capture real-world information about end users and their environments. This information enables individuals to 'enter, assume a persona (or multiple personas), interact with others, have affordances and agency, perhaps modify the environment itself, and then leave'.[146] Such experiences are possible in an open-access metaverse environment or a closed commercial enterprise.[147]

The term 'metaverse' first appeared in a 1992 science-fiction novel by Neal Stephenson, describing a persistent virtual world accessed through wearable goggles that 'reached, interacted with and affected nearly every part of human existence'.[148] Though less extensive, the development of immersive environments progressed significantly in the 2000s and 2010s, particularly in gaming and entertainment contexts.[149] Recent technological advances and socioeconomic developments (e.g. increased remote working during the COVID-19 pandemic) prompted significant investment in developing more extensive and immersive virtual environments beyond gaming to various socially interactive elements.[150] Commercial enterprises from companies such as Meta, Apple, Google and Microsoft have spearheaded this effort, with Meta alone investing around £7.9bn in researching and developing its metaverse.[151]

The metaverse's considerable commercial potential will likely continue driving technological advancements,[152] with Meta aiming for the metaverse to reach a billion people globally by 2035.[153] However, virtual metaverses' future evolution and adoption rely on technological advances in several areas, including advanced connectivity to address limited bandwidth, latency and data-transfer limitations currently restricting metaverse applications.[154] Advances in virtual reality hardware (e.g. headsets, gloves, glasses and contact lenses) and AI techniques for creating immersive and responsive environments are

144 Chowdhury & Marler (2022).
145 Chowdhury & Marler (2022).
146 Marler et al. (2023).
147 McKinsey & Company (2022).
148 Ball (2022, 3).
149 Ball (2022).
150 Moynihan et al. (2022).
151 Moynihan et al. (2022).
152 Pew Research Center (2022b).
153 Meta (2023).
154 McKinsey & Company (2022).

also required, including developing digital twins and technologies to facilitate interactions between people, objects and their digital counterparts and environments.[155]

4.2.2. Applications and implications for the information environment

It is unlikely that there will be one metaverse. Instead, experts predict that **multiple, parallel and interrelated virtual environments will exist that end users can utilise for different purposes**.[156] Each virtual environment may have specific characteristics, varying end-user autonomy/agency levels and focusing on different services (e.g. entertainment, commerce and education). While the potential applications are wide-ranging, key uses include:

- Immersive gaming and entertainment – extending to immersive cultural experiences such as film screenings and gallery viewings[157];
- Social networking and interpersonal communication, with interactions in immersive virtual environments replacing or extending current social media platforms[158];
- Novel forms of business and commerce, e.g. immersive virtual commerce[159];
- Preventative healthcare and advanced therapeutic methods, e.g. for patients with impaired motor functions or psychological conditions[160];
- Personalised learning and training in simulated environments.[161]

Predictions about the scale of future metaverse activity vary. Some experts forecast extensive metaverse use for all aspects of human activity and a revolutionary change in how societies and businesses function.[162] Others predict more targeted metaverse use, limiting applications to key sectors such as entertainment, healthcare and education.[163] According to recent expert surveys conducted by the Pew Research Center and Elon University's Imagining the Internet Center, 54% of 624 expert participants predicted the metaverse to be a refined, fully immersive, well-functioning aspect of daily life for over half a billion people globally by 2040.[164] In contrast, 46% of experts held that the metaverse would *not* be a well-functioning aspect of daily life in 2040 due to the technology's perceived limited benefits and potential harms.[165]

The cost of the interfaces end users use to engage with virtual environments is a crucial factor expected to shape the scope and scale of virtual environments' adoption. Alongside increasing cross-sector interest in virtual environments, significantly decreased costs may prompt a rapid proliferation of metaverse

155 AWS (2023).

156 Chowdhury & Marler (2022), Research interview, 3 July 2023b.

157 Sohail (2023).

158 Sohail (2023).

159 McKinsey & Company (2022).

160 Pew Research Center (2022b).

161 McKinsey & Company (2022).

162 See, for example, Ball (2022), Marr (2023b).

163 Pew Research Center (2022b), Research interview, 3 July 2023b.

164 Pew Research Center (2022b).

165 Pew Research Center (2022b).

technology – even among end users with no personal interest in the technology's benefits – due to the increasing number of services a metaverse may be able to provide, thus necessitating people to use it to access services they need.

The impacts of metaverse technologies on the information environment will depend on the scale of their adoption and the diversity and prevalence of their applications. If adoption continues increasing without particular use restrictions, metaverse applications may impact the information environment in the following ways:

- **Expansion of virtual communication and engagement**: Metaverse adoption may significantly expand virtual forms of communication and engagement. Regarding the information environment's physical dimension, metaverse development and adoption are likely to drive changes in the information infrastructure due to the significant connectivity requirements associated with virtual environments and pervasive sensing required to capture data about end users and their physical environments. Additionally, a proliferation of new devices (e.g. VR goggles) will accompany metaverse adoption, replacing existing technological interfaces such as smartphones. For end users, increasing proportions of daily social interaction, information consumption and service access (e.g. commerce) may operate within a metaverse.
- **Changed or amplified patterns of digital exclusion**: Some experts anticipate that virtual environments will only reinforce existing intergenerational digital divides.[166] Others suggest that metaverse-application uptake may differ across communities, dividing communities that access and utilise immersive virtual environments from those that do not.[167] Connectivity access is thus a critical factor in potential digital divides, as virtual environments depend on significantly more advanced connectivity than current technologies such as smartphone-based internet browsers and social media.[168]
- **Exacerbation of cognitive biases through echo chambers and filter bubbles**: Current expert opinion suggests that virtual environments may amplify current challenges via echo chambers, filter bubbles, and algorithm-driven polarisation.[169] A metaverse enabling greater personalisation of user experiences may yield more fractured views of reality, potentially exacerbating existing echo-chamber/filter-bubble effects by amplifying the cognitive biases discussed in Section 2.1.3. This dynamic might involve communities and societies experiencing parallel realities, exacerbating societal polarisation and distrust in established information sources.[170]
- **Amplification of information threats and digital harms**: The emergence of more potent forms of social manipulation and threats such as mis- and disinformation is a significant concern about virtual

166 Research interview, 30 June 2023.

167 Pew Research Center (2022b).

168 Research interview, 3 July 2023b.

169 Moynihan et al. (2022).

170 Canales (2021).

environments,[171] reflecting the suggestion that immersive virtual environments are more influential than less immersive communication forms (e.g. current social media). Virtual reality can also be continuously and dynamically manipulated, potentially amplifying manipulation risks, increasing distrust and blurring the lines between virtual and physical realities and truth and fiction in either environment.[172]

- **Increasing privacy and data-security challenges**: Like automated information systems, virtual reality technologies are associated with significant privacy and data-security challenges.[173] Driven by the emphasis on personalising virtual experiences, virtual environments will likely require considerable personal (e.g. biometric) data from end users and continuous updates of such data to mirror end users' physical movements in a virtual space.[174] If developers aim to facilitate seamless end-user transitions between virtual environments, transferring personal data between metaverses will present additional challenges.[175]

Experts anticipate significant challenges in developing governance mechanisms for virtual environments, particularly from a regulatory perspective. As regulation already lags behind technological advances in areas such as AI, regulatory and policy-making bodies are expected to be under additional pressure from developments in augmented and virtual reality technologies, with insufficient government expertise available to ensure timely, effective and efficient regulatory provision.[176] As well as addressing potential societal risks and harms within a metaverse, regulatory action will also need to address accountability issues: adopting virtual identities may obfuscate end users' real identities, complicating the identification of perpetrators of harm in virtual environments.

Some experts have argued for formatively managing VR technologies as an alternative to reactively regulating immersive environments to limit their exploitation. Formative management would limit applications to specific sectors, such as training, education or healthcare support in treating people with disabilities.[177] This argument is motivated by the perceived risk that the widespread application of immersive environments to day-to-day communication and social interactions would yield significant social challenges and risks (e.g. declining social cohesion and growing disconnect between physical and virtual experiences) too challenging to manage retrospectively.[178]

However, any potential metaverse governance frameworks would likely be shaped by private-sector actors with significant commercial interests in an unlimited application range.[179] The development of virtual environments and enabling technologies is already dominated by a relatively small number of private-sector

171 Waltzman (2022).

172 Research interview, 30 June 2023.

173 Moynihan et al. (2022).

174 Research interview, 30 June 2023.

175 Pew Research Center (2022b).

176 Research interviews, 30 June 2023, 3 July 2023a.

177 Research interview, 3 July 2023a.

178 Research interview, 3 July 2023a.

179 Moynihan et al. (2022).

actors driven by profit maximisation and the technology's commercial potential rather than end-user demand.[180] This dynamic may increase the future concentration of wealth and power in the 'metaverse economy' and technology industry.[181]

4.2.3. Cultural implications

The development and adoption of virtual environments will likely have widespread societal and cultural impacts across cultural identities, norms, values and individuals' and wider communities' perceptual lenses.

Regarding the formation of cultural identities at a societal level, the emergence of elaborate virtual environments may change existing cultural identities' importance while enabling new ones to emerge at the sub-national, national or trans-national level. Expert opinion indicates that future metaverses may reach such a sophistication level that they 'come to function almost like new countries in our society, countries that exist in cyberspace rather than physical locations but have complex economic and political systems that interact with the physical world'.[182] The emergence of these new virtual environments may correspond with new cultural configurations that complement or diminish existing cultural delineations. Some experts who anticipate a more interconnected global society emerging via virtual reality suggest that such a development may **reduce the importance of national and individual identities and change how societies define and shape their cultural identities**.[183]

At an individual level, interactions in virtual environments will likely impact an individual's on-and-offline identity in various ways. Existing research on the effect of virtual engagements on individuals' self-perceptions highlights the so-called Proteus effect, whereby '**an individual's avatar or digital representation [influences] an individual's sense of self**'.[184] Translated effects from digital environments to physical experiences can have powerful therapeutic effects, driving interest in virtual reality in the medical sector. However, studies have already shown digital immersions' broader impacts on end-user attitudes and behaviours, such as gender and racial bias, empathy, negotiation confidence, financial planning and commitment to physical exercise.[185] Such findings indicate that virtual experiences may spark changes or long-term transformations in self-perception and identity, including personal and societal roles.

A related perspective relates to human agency and the conceptualisation of digital human rights, i.e. how human rights paradigms might evolve in a virtual environment. Some experts warn of significant threats to human agency via the **increased risk of malign actors, such as authoritarian regimes, exploiting virtual environments for surveillance and societal manipulation**.[186] In scenarios where virtual environments lack privacy safeguards, selected private sector or governmental actors could use direct control to limit an individual's

180 Pew Research Center (2022b).
181 Moynihan et al. (2022).
182 Coehn-Peckham (2020).
183 Moynihan et al. (2022).
184 Jerome & Greenberg (2021).
185 Jerome & Greenberg (2021).
186 Pew Research Center (2022b).

agency in digital interactions. The changing relationships between individual end users and those controlling virtual environments have led some to argue that 'our sense of physical identity, time and agency will become subject to entirely new paradigms where the gateways to these experiences might be controlled by interests other than citizens'.[187]

Such possibilities contradict the expectation of decentralised and democratised digital governance and conflict with the expectation that blockchain technologies, considered by many to be a prerequisite for a metaverse's architecture,[188] will facilitate such decentralisation.[189] While blockchain's commercial and technological value and effectiveness are contested, its adoption is commonly associated with a 'cultural change around user and developer rights, interoperability in virtual worlds, and compensation for those who support open-source software'.[190] Thus, current predictions and assessments of virtual environments' governance dynamics indicate that metaverse applications may amplify end-user agency in digital spaces through decentralised and democratised control while also risking the fundamental diminishment of this agency if the actors developing and operating virtual environments exploit the associated data collection for malicious purposes.

The emergence of virtual environments may also **change current behavioural norms around digital interactions**. One key characteristic of a metaverse is that it is 'defined by people involved in its development and use',[191] potentially enabling a dynamic whereby digital-space governance is fully democratised regarding the underpinning behavioural norms. Like existing norms relating to political participation, virtual environments may incentivise the emergence of norms around participation in the governance of virtual spaces. Since multiple metaverses may co-exist, each virtual environment might have specific characteristics, including cultural identities and behavioural norms. Thus, conflicting and polarised virtual worlds could emerge, each shaping identities and cultural norms differently.[192]

Self-representation and privacy might evolve alongside pervasive virtual environments. Given privacy-protection concerns in virtual environments, metaverses will likely feature 'realistic, life-like avatars or entirely novel forms of self-representation'.[193] As well as providing extra privacy, adopting these technologies may be motivated by a desire to achieve 'more nuanced self-representation [that is] better mapped to user identity, attributes and preferences', increasing the quality of one's experience in a metaverse.[194] However, such self-representation may also challenge end users' trust in others they encounter in an immersive space or virtual environment. For example, involuntary changes to one's avatar

187 Pew Research Center (2022b).
188 Ball (2022).
189 Marr (2023b).
190 Ball (2022, 231).
191 Marler et al. (2023).
192 Pew Research Center (2022b).
193 Jerome & Greenberg (2021).
194 Jerome & Greenberg (2021).

might undermine trust, presenting a new form of online harm.[195]

Such new self-representation and interpersonal communication methods also have **broader implications for interpersonal trust and the importance of honesty in a society's cultural identity**. As some cultures place significant value on honesty and trust, such values could be undermined by technologies such as virtual avatars which may be exploited or manipulated.[196] Expert opinion suggests that the expanding forms of self-representation and virtual connection will necessitate a wholesale reconfiguration of how individuals establish and maintain trust in themselves, others and information sources (e.g. institutions).[197]

Freedom of expression is another value that may be affected by adopting immersive environments. Immersive environments could enable new forms of self-expression, potentially facilitating new types of democratic participation and reinforcing the importance different cultures currently place on creativity and individual expression.[198] However, freedom of expression in virtual environments must also be balanced against the need to maintain inclusive and safe virtual environments.[199]

Some commentators are concerned about the lack of diversity in virtual reality technology development and **how virtual environments might diminish societal values of diversity and inclusivity**.[200] While new forms of self-representation (e.g. avatars) could support inclusivity, concerns have also been raised about how easily virtual environments might facilitate harassment and other harmful behaviours towards those with different characteristics.[201] Consequently, there is a risk that virtual environments embed and promote behaviours discouraging end users from expressing their identity.[202]

Finally, as discussed in the previous section, virtual environments are associated with significant changes in people's physical and virtual perceptual lenses and their ability to recognise and understand facts. Two dynamics are at play in this context:

- Firstly, due to the Proteus effect and other cognitive processes, **virtual environments may change end users' abilities to distinguish physical from virtual realities**, affecting their perception of physical reality through virtual interactions and experiences. Some commentators see the potential of increasingly blurred lines between physical and virtual realities as a challenge, stressing that manipulating virtual realities may negatively affect individual psychology in the virtual and physical space. Therefore, manipulations experienced in a digital environment may influence an individual's physical or 'real-world' behaviours, potentially challenging established sociocultural institutions such as democratic political systems.[203] Others

195 Jerome & Greenberg (2021).
196 Research interview, 3 July 2023b.
197 Pew Research Center (2022b).
198 Research interview, 3 July 2023b,
199 Jerome & Greenberg (2021).
200 Veloz (2022).
201 Veloz (2022), Lu (2022).
202 Lu (2022).
203 Research interview, 30 June 2023, Waltzman (2022).

suggest that, though possible, increasingly blurred perceptions of physical and virtual realities do not present an immediate societal risk.[204]

- Secondly, **several virtual reality characteristics challenge people's ability to distinguish fact from fiction**.[205] The potential for virtual environments to be dynamically manipulated risks people increasingly struggling to distinguish reality from fictional or manipulated experiences. At a societal level, virtual environments' potential for generating more pervasive echo chambers also presents a risk that communities struggle to achieve factual consensus.

4.2.4. Summary and ecological interactions

Expanding virtual communication and engagement through interoperable metaverses may significantly affect culture. However, the extent of this impact depends on whether metaverse applications remain limited to sectors such as entertainment and gaming or emerge as the next iteration of the internet (an 'internet in 3D'), as some experts predict.

Discussions with experts indicated that shifting significant parts of human activity and interaction into metaverse environments may amplify existing cultural norms and values (e.g. honesty in interpersonal communication, privacy, inclusivity and equity). However, the increased risk of social manipulation inherent in virtual environments may generate cultural disruptions, particularly without robust content moderation and governance mechanisms. Other significant impacts may stem from extending self-representation to virtual identities and the need to consider the risks (e.g. difficulties establishing accountability) and benefits (e.g. safeguarding privacy) of anonymity that virtual environments offer.

Table 4.2 below summarises the key ecological interactions between metaverse technologies and culture.

Table 4.2 Ecological interactions in virtual metaverses

Level	Key interactions
Macro	• Changing delineations of cultural identities, potentially decreasing the importance of geographically and nationally defined identities and the emergence of new ones through virtual sociality; • The changing importance of cultural norms and values such as honesty, creativity, inclusivity and privacy through immersive virtual environments.
Meso	• A re-definition of the relationship between individuals, private-sector actors and the state due to the potential exploitation of immersive environments for persistent surveillance and societal manipulation; • The emergence of new modes of political and democratic participation through virtual environments; • Increasingly blurred lines between virtual and physical realities and individuals' changing relationship with their physical environment.

204 Research interview, 3 July 2023b.

205 Research interview, 3 July 2023a.

Level	Key interactions
Micro	• The potential amplification of harms and distrust in interpersonal sociality due to challenges enforcing accountability in virtual environments; • Extension of the virtual dimension of interpersonal sociality and its potential for diminishing the value of physical sociality.
Self	• Extending self-representation to virtual identities and increasing the importance placed on digital self-representation; • A changing understanding of physical identity, time and agency in one's physical environment; • Increased agency and self-expression through anonymisation and decentralised governance of virtual environments.

4.3. Augmented and mixed reality

4.3.1. Key characteristics and future trends

Augmented Reality (AR) describes technology-enabled experiences that blend physical and digital realities by imposing computer-generated elements onto end users' physical experiences. Unlike purely virtual experiences, AR experiences feature computer-generated content interdependent and integrated with the real world, facilitating augmented perceptions of one's real-world environment.[206] While some researchers defined AR as relying on head-mounted displays, others conceptualise it more broadly based on three characteristics:

1. It combines virtual content with real-world characteristics.
2. It generates real-time interactive experiences.
3. It renders systems in 3D.[207]

AR systems' overarching objective has been described as **supplementing and improving a user's view of a real environment.** As such, AR systems are not limited to augmenting a user's visual perception of the world but can also augment their hearing, smell and touch.[208] AR applications link closely with mixed-reality (MR) systems that provide more interactive experiences for end users, enabling digital content to interact with and respond to non-digital objects/content in real time rather than overlaid on a physical environment.[209]

The future development of AR applications links closely with the advances in VR technologies discussed in the previous section. They are embedded in AI technique development (particularly computer vision) and other technologies (e.g. sensors) that facilitate recognition and mapping of a user's physical environment and telecommunication and connectivity technologies providing the baseline computing infrastructure for AR and MR experiences.[210] However, a key objective in AR/

206 Mekni & Lemieux (2014).
207 Ismail & Noh (2013).
208 Ismail & Noh (2013).
209 Jerome & Greenberg (2021).
210 Jerome & Greenberg (2021).

MR innovation is developing interfaces such as 'smart glasses' and digital eyewear that facilitate the overlay of digital content onto end users' perceptions of their physical environment.[211] AR/MR interfaces' cost and accessibility will likely be critical in shaping their scope and uptake among the general public.

4.3.2. Applications and implications for the information environment

Like VR, AR system applications will likely focus on gaming and entertainment, though educational and training applications have received increasing attention.[212] While AR and MR gaming and entertainment applications are largely driven by the appetite for more immersive (and thus richer) end-user experiences, the education sector has attracted more interest due to AR and MR's reported benefits in understanding and retaining educational content, motivation and collaboration in educational settings.[213] Other domains where AR applications will likely proliferate include cultural heritage and tourism,[214] manufacturing, healthcare, visualisation and engineering (e.g. robotic design and development).[215]

Across these domains, AR and MR use presents several implications for the information environment:

- **Qualitative and quantitative changes in information processing**: AR use will likely affect how individuals interact with information about their environment qualitatively and quantitatively. A physical environment augmented with computer-generated content will expose end users to more information about their physical surroundings, potentially increasing cognitive loads.[216] From a qualitative perspective, AR is understood to produce a qualitative shift in information representation, enabling individuals to build knowledge about their physical environments via directly superimposed digital content. While the quantity of AR-generated information might increase end users' cognitive loads, the interpretation of information in AR may be facilitated through detailed guides provided by AR systems on how to apply pieces of information without extensive critical thinking needed from the end-user.[217]
- **Amplification of cognitive information-processing biases**: Like VR, AR and MR will likely amplify key cognitive biases shaping how individuals engage with their information environment. AR-and-MR-enabled services predominantly provide highly personalised content, reinforcing selective information consumption and amplifying information filter bubbles.[218]
- **Amplification of malign information threats**: The relationship between augmented experiences and end users' perceptions of physical reality presents social-manipulation risks for targeted end

211 Jerome & Greenberg (2021).
212 Savela et al. (2020).
213 Thomas et al. (2019).
214 Jung et al. (2018).
215 Mekni & Lemieux (2014).
216 Buchner et al. (2021).
217 Ariso (2017).
218 Ariso (2017).

user AR and MR experiences. For example, end users exposed to manipulated AR and MR content might experience distrust or other emotional reactions likely to have broader effects on their behaviour in their physical environment. At a societal level, this raises the risk of broader societal manipulation. Additionally, research suggests that AR and MR technologies may challenge end users' abilities to distinguish fact from fiction in both an 'augmented' environment and a physical one, presenting another risk factor for malign exploitation.[219]

- **Changing media landscape**: AR will likely become increasingly bound up with social media as immersive 3D content increasingly replaces 2D media while affecting how the broader media ecosystem produces and distributes information.[220] Thus, expanded AR use by social media platforms might amplify social media's increasing domination of the media landscape over traditional editorial media while simultaneously enabling news organisations to reach a wider readership through more immersive journalism.[221] AR may also change how individuals consume and interact with news due to AR's potential to trigger more emotional reactions than traditional news formats. For example, the media might exploit AR's enhanced potential for eliciting emotional effects to reach larger audiences and influence public opinion, potentially fragmenting the media landscape and reinforcing social echo chambers.[222]

4.3.3. Cultural implications

While many VR-associated cultural considerations may also apply to AR and MR, unique dynamics are at play for AR and MR. These dynamics result from end users' different engagement levels in a virtual metaverse versus an AR/MR application: while virtual environments immerse individuals in a fully-virtual environment distinct from physical reality, AR/MR applications overlay and thus integrate digital information into an individual's actual physical environment. Research suggests this difference may significantly impact social networking and interpersonal connectedness, both positively and negatively:

- On the one hand, emerging research indicates that **AR applications can enhance social communication and interaction**, positively affecting socialisation and collaborative behaviour.[223] For example, research into AR games and entertainment reports that AR games can incorporate social and collaborative aspects that incentivise sociability.[224] These positive effects relate particularly to the interconnectedness between end users of the same AR and MR application, such as AR game players.
- On the other hand, experimental research has indicated that **using AR applications can detrimentally impact social connectedness,** with AR users reporting

219 Ariso (2017).
220 Bullock (2018).
221 European Commission (2016).
222 Department of Homeland Security (2022).
223 Savela et al. (2020).
224 Serino et al. (2016).

less social connection when interacting with others.[225] These effects are particularly evident in the physical (dis)connectedness of AR or MR application users: for example, because AR and MR applications allow users to interact with virtual content only visible to them and not others, those in an end users' immediate physical environment may feel uncomfortable and disconnected from an end user engaging with AR and MR content. Similarly, future AR and MR applications may display virtual content relating to individuals in an end user's environment, potentially violating social norms such as privacy or engendering distrust between individuals.[226]

In summary, research indicates that while AR and MR use may foster social connectedness between end users of the same applications, negative implications are also possible due to the disconnect between an end user's 'augmented' experiences and their physical environment. This dynamic may affect the formation of cultural identities, as new cultural communities could form around specific AR and MR application use (e.g. within the gaming community). Conversely, immersion in AR and MR experiences may amplify the disconnect between end users and their existing cultural environment by reducing physical interconnectedness.

AR and MR applications have also been associated with **changes in people's relationships with physical spaces**. Recent social experiments indicated that AR experiences might change how end users feel and interact with physical spaces outside augmented simulations, i.e. that feelings and attitudes formed in 'augmented' situations carry over to non-augmented ones.[227] As with the Proteus effect, AR use may significantly affect individuals' connections and understanding of physical spaces based on AR experiences. Thus, it may affect how individuals navigate their physical environment, with various implications for individuals' cultural identity. Thus, AR-enabled experiences will likely shape interpersonal connections or cultural identities inside and outside an 'augmented' environment.

Though presenting a risk of malign social manipulation, such dynamics also offer opportunities for cultural change through advocacy. Recent work documented an **increasing interest in AR-enabled activism**, underpinned by the activist community's perspective of AR as a technology with the 'potential for contributing to broad cultural shifts'.[228] The underlying belief is that the immersive quality of AR experiences may enable activists to 'tell stories in more expressive ways, transporting audiences into a new reality defined by the creator'.[229] In essence, AR and MR present an opportunity to connect audiences more closely with the phenomena activism is concerned with (e.g. climate change) by incorporating it into an audience's real-life physical environment. As well as enabling positive cultural change, this opportunity could facilitate malign purposes, such as regimes and non-state actors intimidating individuals or communities.

Like VR applications, **AR and MR may significantly affect privacy and**

225 Miller et al. (2019).
226 Miller et al. (2019).
227 Oulette (2019).
228 Silva et al. (2022, 3).
229 Silva et al. (2022, 3).

data-protection norms and social values. At a societal level, AR applications will likely continue the trend by which the IoT has challenged traditional 'data minimisation' norms, presenting 'an even more visible and potentially sensitive confluence of sensors and connectivity'.[230] This likelihood stems from how much data progressively advanced iterations of AR applications will need to collect on their users and their users' physical environments and its necessary persistence to seamlessly embed digital content into a user's physical environment. Large-scale uptake of AR and MR applications, particularly for day-to-day activities such as social networking, may thus engender significant changes in social norms and attitudes towards privacy and data protection.

At a personal level, adopting AR and MR technologies may also **challenge attitudes and behaviours linked to protecting privacy and personal data**, potentially affecting interpersonal connections and the importance of social values such as honesty. As noted above, AR and MR applications may enable the overlay of digital information onto an end user's perception of other individuals in their physical environment in the future. If used without the consent of individuals in an end user's environment, such applications may significantly challenge social norms around privacy and honest communication or generate new rules and behavioural norms. This effect may be particularly strong in communities where honesty and privacy are important aspects of the cultural topography.

4.3.4. Summary and ecological interactions

While some AR and MR effects on the information environment and culture mirror those of VR technology, several unique dynamics are summarised relative to the ecological loci in Table 4.3 below. The critical aspect differentiating AR/MR's impact from other technologies is the merging of virtual and physical reality and the implications of this for:

- An individual's perception of their physical environment through qualitative and quantitative shifts in the presentation of information about physical spaces;
- Amplifying cognitive biases, such as selected reasoning through content personalisation, with potentially greater effects on individuals' abilities to establish and maintain a factual understanding of their physical environment.

Across the four cultural elements, AR and MR may thus present the most significant impacts on perceptual lenses, i.e. processes through which cultures generate collective ideas.

230 Jerome & Greenberg (2021).

Table 4.3 Ecological interactions in augmented and mixed reality

Level	Key interactions
Macro	• Development of new cultural norms for augmented interactions, e.g. acceptable AR/MR use in interpersonal interaction.
Meso	• People's changing relationship with their physical environment through augmented perceptions of physical spaces; • New forms of AR/MR-enabled activism and technology-enabled amplification of social movements facilitating cultural change.
Micro	• Potential challenges in maintaining honesty in interpersonal interactions as individuals adopt AR/MR lenses in engaging with others without their consent; • Increases in virtual connectedness and collaboration within communities connected through AR/MR applications, alongside corresponding decreases in physical social connectedness.
Self	• A disconnect between individuals' physical and AR/MR-facilitated experiences, changing their respective importance for personal enjoyment, self-expression and everyday activity.

4.4. Advanced connectivity

4.4.1. Key characteristics and future trends

The future information environment will likely include **continued expansion of the internet as a 'global connector' and increasing human and object connectivity levels**, creating an increasingly interconnected communication network embedded into the physical world.[231] In this context, advanced connectivity comprises technological concepts aiming to enhance human-object connection and interconnectedness in the information environment. Examples of the numerous technological enablers of advanced connectivity include:

- **5G/6G cellular networks**: Currently, 5G networks are being globally deployed to improve speed and reduce latency in cellular network technology. These networks will continue evolving, with the next generation of wireless cellular connectivity (i.e. 6G) aiming to enhance connectivity speed, reduce latency and enable more reliable, cost-and-energy-efficient connectivity solutions.[232] 6G is expected to be introduced in 2030 and is considered a requirement for various consumer applications, including AR, MR, VR, holographic communication, terahertz frequencies and advanced AI-driven applications.[233] Moreover, 6G networks will enable connectivity to progress from personalised communication to more seamless real-time connections

231 European Commission (2016).

232 Johnson (2020).

233 Sinha & Sengupta (2023).

between devices, sensors and computing systems.[234]

- **Space-enabled connectivity**: Space technologies have attracted increasing interest as enablers for advanced connectivity, potentially providing global signal coverage, extended broadband access, connectivity for mobile communications and the IoT and broadcasting and other telecommunication services.[235] Future space-based technologies used for connectivity will likely include low-earth orbit satellites and mega-constellations (i.e. sizeable constellations of small satellites facilitating persistent global internet coverage). Increasing utilisation of space-based technologies for connectivity is largely driven by decreasing space-access costs and space markets' commercialisation, positively influencing technological innovation in the space economy.[236]
- **Mesh networking and edge computing**: Technological advances in connectivity also aim to provide more decentralised network architectures, e.g. through mesh networking and edge computing. The former refers to decentralised network architectures in which interconnections between multiple devices (known as 'nodes') create a mesh-like structure. Each node in this network can communicate directly with neighbouring nodes, forming multiple paths for data transmission to facilitate more seamless and resilient connectivity.[237] Conversely, edge computing is a distributed computing paradigm that positions data processing and storage closer to the network's edge, near the data-generation source. Edge computing aims to overcome the limitations of traditional centralised cloud computing by locating data processing and analysis closer to data production rather than relying solely on remote cloud servers.[238]

These technological advances are expected to increase the geographic scope of connectivity, facilitating more persistent and resilient internet access and internet-enabled applications. Other objectives driving connectivity innovation include reducing latency and associated energy consumption and increasing data throughput and spectrum efficiency.[239]

4.4.2. Applications and implications for the information environment

Advanced connectivity may take different forms due to the increasing interconnectedness of the information environment's various elements. Examples include:

- **Improved connectivity and personalisation of end-user services and industrial applications**: The IoT ecosystem will continue growing, seeing a proliferation of connected devices across different industries and sectors that will likely generate more sophisticated IoT applications, greater device interoperability

234 Sinha & Sengupta (2023), Giordani (2020).

235 Black et al. (2022).

236 Black et al. (2022).

237 Science Direct (2023).

238 Gold & Shaw (2022).

239 McKinsey & Company (2022).

and more personalised services for end users. An example of the latter is the development of 'smart homes' facilitated via increased object connectivity in a person's home environment.[240]

- **New industrial products and services and the continued development of 'smart' cities and infrastructures**: Enhanced connectivity – particularly an expanded IoT – also has varied applications at the industrial or sectoral level. Like the emergence of 'smart homes', advanced connectivity is expected to progress 'smart city' initiatives, leveraging advanced connectivity to improve urban infrastructure, sustainability and quality of life, particularly for people in urban areas. Examples include advancements in 'smart' transportation, energy management, waste management and preventive infrastructure maintenance.[241]
- **The emergence of an 'internet of bodies':** Advances in object connectivity may eventually extend to human bodies. Researchers refer to the potential development of an internet-linked network of human-connected devices collecting end users' biometric data as an 'internet of bodies'.[242] While mainly discussed in the context of advanced, personalised medicine, the concept may expand to other personalised services, such as home management.[243] An 'internet of bodies' may also ultimately lead to an 'internet of brains', i.e. human brains connected to the internet to facilitate direct brain-to-brain communication and enable access to online data networks.[244] Section 4.5 on human augmentation discusses this development in more detail.

These developments' implications for the information environment vary. First and foremost, **connectivity is a critical enabler for other applications expected to shape the information environment in 2035-2050,** including automated information systems, AR, MR and VR applications and wearable technologies discussed in other parts of this chapter. Therefore, the impact of advanced connectivity on the information environment will primarily be through access to and availability of these advanced technologies, which will likely require higher bandwidths and low latency.

By itself, advanced connectivity promises better and more reliable access to data, information and digital communication channels for end users, organisations and broader sectors. This promise implies **expanding the information environment's virtual dimension** for interpersonal communication in domestic, social or professional environments. For example, advanced connectivity has been linked to the growth of remote working, particularly following the COVID-19 pandemic. Building on this, organisations and employers may transfer more activities and services to the digital domain for the enabling effects of advanced connectivity, including telemedicine and tele-education.[245] However, increased connectivity also expands the scope of information individual end users receive from

240 Austin (2019).

241 McKinsey & Company (2022).

242 Lee et al. (2020).

243 Lee et al. (2020).

244 Boran (2019).

245 Hamingson (2023), Deloitte (2023), ITU & UNICEF (2021).

various devices, sometimes in real-time. This development may increase end users' cognitive load and raise the importance of critical thinking skills and information literacy to ensure they can effectively navigate and leverage the benefits of advanced connectivity.[246]

The key challenges stemming from advanced connectivity in the information environment relate primarily to **data protection, privacy and security in cyberspace**:

- Regarding **data protection and privacy**, increased connectivity between objects, devices and human bodies presents cybersecurity risks due to the increased quantity and diversity of the data collected and shared across devices.[247] Significant privacy and data safety concerns have already been raised in light of the IoT's expansion due to end users' limited control over the collection, retention and distribution of their data.[248] An added privacy challenge is the potential to triangulate an individual's data from multiple sources that might otherwise only capture it anonymously.
- Poor **cybersecurity** standards also increase the risk of data leakages from interconnected devices, amplifying data protection and privacy challenges associated with connectivity. Given the increase in internet-connected devices, networks such as the IoT also increase the information environment's vulnerability by broadening its attack surface, i.e. increasing the number and ubiquity of interacting devices and inter-device connections that may be compromised.[249]

4.4.3. Cultural implications

Advanced connectivity will likely raise questions about the value and importance of connectivity itself, and the norms and values embedded in the governance of a more thoroughly and persistently interconnected world.

Existing work on future trends in the internet's design and governance already frames **connectivity as a fundamental norm and value in a world where society increasingly relies on digital spaces**. According to one expert surveyed by the Pew Research Center on future internet visions, 'the fundamental norms and values of a data-driven global network society [are] connectivity, the free flow of information, communication, participation, flexibility and transparency. These values are the norms guiding digital life and practice as they underlie the construction of networks in business, education, health care, science and politics'.[250] This sentiment is reflected in recent moves to recognise connectivity and internet access as a fundamental human right, e.g. the United Nations officially recognised it as one in 2016.[251] Such developments embed the idea that a lack of connectivity may inhibit a person's access to services reflecting other fundamental human rights, such as education, healthcare and safety information.[252]

246 ITU (2021).
247 Maras (2015).
248 Maras (2015).
249 OPEN Publications (2023).
250 Pew Research Center (2022a, 46).
251 OHCHR (2023).
252 OHCHR (2023).

A human rights perspective on connectivity and its future sociocultural value is reinforced by the **challenges that denied connectivity presents from a human rights perspective**. For example, internet shutdowns are already highlighted as human rights challenges in the digital age, as they infringe on the right to freedom of opinion, expression, association, peaceful assembly, and participation in public and political life.[253] As connectivity becomes more persistent and ubiquitous, its absence (e.g. via internet shutdowns) may affect people more significantly, gaining greater importance as a human rights violation.

Regarding cultural identities and their formation, connectivity has implications at individual and societal levels:

- At the individual level, research suggests that increasing connectivity between humans, including the potential emergence of an 'internet of brains', **may produce conflicting dynamics for human interaction and agency in the information environment**. While it may '[open] the doors to extraordinary new means of human collaboration', it may also '[blur] fundamental notions about individual identity and autonomy in disconcerting ways'.[254] The latter relates particularly to concerns that a future network of direct brain-to-brain connectivity may reduce the barriers limiting one individual from coercing another or extracting their thoughts or data without consent, thus compromising their agency and personhood.[255]
- At the societal level, experts consider **connectivity an enabler for new modes of learning, self-discovery and mobility that may impact identity formation**. As connectivity enables access to new data and services that deepen insights into human life, society and the physical environment, it may embed in the processes through which societies formulate common cultural touchpoints.[256] Like the impact of virtual environments and augmented realities, connectivity may challenge existing cultural delineations while enabling new cultures and sub-cultures to form through digital interactions or connectivity-enabled physical mobility. For example, experts suggest that the enabling effect of connectivity on remote working may make isolated, sparsely populated areas more attractive places to live.[257] The changing demographic makeup of urban and rural areas may translate into local communities' cultural identities.

Regarding cultural norms and values, technological advances in connectivity require considering how connectivity supports diversity and inclusivity, particularly **how connectivity may amplify or reduce existing societal inequities**. Increasing connectivity levels may help narrow access gaps, addressing current digital divides. For example, developing space-enabled telecommunications connectivity promises a space-based infrastructure for global internet coverage that offers persistent, ubiquitous and high-quality

253 Bellasio et al. (2021).

254 Martone (2019).

255 Martone (2019).

256 Research interview, 5 July 2023.

257 Pew Research Center (2022a, 75).

connectivity (including remote rural areas where connectivity is currently poor).[258]

While advances such as space-based telecommunications infrastructure may address current connectivity shortfalls, there is also **a risk that future advances amplify existing digital-access divides and engender new patterns of digital exclusion**.[259] For example, connectivity divides might emerge between the Global North and Global South if the uptake of advanced connectivity technologies is uneven across countries and regions with differing technological and economic development.[260] An estimated one-third of the global population currently lacks access to high-speed broadband, reinforcing the economic, political and social disadvantages of limited technology access and use.[261] Greater disparities in connectivity service costs or infrastructure costs may amplify such divides in the future, leading to increasingly severe consequences as more services and day-to-day interactions depend on connectivity. Such discrepancies may reinforce or result in new social hierarchies with sociocultural implications.

Connectivity advances also link to societal norms and values around democratic participation, stemming from its significance to human rights such as freedom of expression and peaceful assembly. Research on the future dynamics of online spaces suggests that **connectivity advances may increase reliance on technology for political participation**. Since some communities may remain or become digitally excluded, democratic institutions must consider how to enable their political participation via alternative means.[262] There is a risk that certain communities' digital exclusion could be exploited to reinforce their marginalisation in political life. Thus, discrepancies in access to advanced connectivity technologies might challenge democratic norms and values, particularly concerning individuals' abilities to participate in democratic processes.

Among less technologically and economically developed countries, the cultural implications of advanced connectivity may be associated with increasing environmental value attachments. In many ways, advanced connectivity involves environmental issues such as energy consumption, e-waste management, and the carbon footprint[263] –particularly in societies more affected by changes in the global climate or where environmental degradation and energy consumption are particularly challenging.[264] As these and other societies navigate potential future energy crises, the evolving cultural positions on environmental issues may affect societal perceptions of advanced connectivity technologies and their socioeconomic value.

Lastly, adopting advanced connectivity technologies may **challenge privacy norms that feature strongly in many cultures**.[265] While the challenges to individual privacy are already debated today, advanced connectivity

258 Black et al. (2022).
259 Research interview, 5 July 2023.
260 Rottger & Vedres (2020).
261 Signe (2023).
262 Pew Research Center (2022c).
263 Malmodin & Lunden (2018).
264 Research interview, 23 July 2023a.
265 Research interview, 5 July 2023.

and increased cross-device user-data collection will likely amplify these challenges. Indeed, the potential triangulation of data across devices and datasets may make it increasingly difficult for individuals to maintain anonymity and fully protect their data. From a cultural perspective, this may trigger debates about the normative importance of privacy relative to personalisation of services and other benefits that stem from connectivity. Traditionally marginalised communities for whom privacy has added significance as a safeguard against harassment and discrimination may be particularly affected by privacy-related concerns. Therefore, challenges may also arise for related dimensions of culture, such as equity and non-discrimination, if advanced connectivity challenges current privacy norms.[266]

4.4.4. Summary and ecological interactions

Advanced connectivity encompasses a range of different concepts that, together, present a more interconnected future network of physical spaces, objects and human bodies. While device-related connectivity may extend rather than shift current sociocultural debates, more substantial cultural shifts might emerge in applying connectivity to human bodies. Therefore, emerging forms of connectivity, including an 'Internet of Bodies' or 'Internet of Brains', may be more likely to mediate cultural change, particularly concerning individuals' sense of agency, personhood and values such as anonymity. Table 4.4 summarises these and other ecological interactions between advanced connectivity and culture.

Table 4.4 Ecological interactions in advanced connectivity

Level	Key interactions
Macro	• Reinforcing connectivity as a cultural value and fundamental human right; • Reducing or amplifying existing societal connectivity inequities; • Potential clashes between the cultural importance and value of connectivity versus privacy.
Meso	• Increasing interconnectivity between humans and their physical environment; • Expanding opportunities and challenges for democratic participation, i.e. the potential for digital citizenry on the one hand versus connectivity weaponisation on the other (e.g. internet shutdowns).
Micro	• Enabling human-to-human collaboration through direct and more persistent connectivity; • Personalising home and workplace services by integrating devices and personal physiological data.

266 Research interview, 5 July 2023.

Level	Key interactions
Self	• Potentially compromised agency and personhood via privacy infringements, particularly in the event of data triangulation between interconnected devices; • New connectivity-enabled modes of learning, self-discovery and mobility, providing new opportunities for self-development and self-actualisation.

4.5. Human augmentation

4.5.1. Key characteristics and future trends

Human augmentation technologies refer to **technologies that enhance human capabilities, either physically or cognitively**. The human augmentation field is interdisciplinary, relying on advances in various technological areas, including sensing, actuation, neuroscience and AI techniques.[267] The technological applications most associated with human augmentation include:

- Wearable devices and implants for tracking and analysing physiological and environmental data (e.g. biochips and implantable sensors). These technologies aim to achieve real-time continuous monitoring of physiological data to understand human health conditions and performance.[268]
- Sensory augmentation technologies such as hearing and retinal implants designed to improve or augment sensory activities, particularly vision and hearing.[269] Smart prosthetics are a related category, including exoskeletons, i.e. whole-body robotic suits that enhance end users' physical capabilities and improve their mobility, strength, endurance and other abilities.[270]
- Brain-computer or brain-brain interfaces that establish direct communications between human brains and/or computer devices.[271]

While the technological systems discussed earlier in this chapter relate to human augmentation, this section discusses technologies that go beyond improving human *experiences* (e.g. through automation and immersion), focusing instead on directly improving human cognitive or physical *functions*.

Significant advancements are likely in human augmentation technologies in the 2035–2050 timeframe. Examples include developing more sophisticated but less invasive technologies, such as brain-computer interfaces enabling seamless human-machine interaction, cognitive teaming and communication.[272] Current technological development priorities

267 Raisamo et al. (2019).
268 Perkovic (2022).
269 Sienko et al. (2018).
270 Paturel (2014).
271 Chandler et al. (2022).
272 Binnendijk et al. (2020).

include developing safeguards to reduce associated risks (and perceptions thereof), particularly in invasive technologies; ensuring the long-term stability and resilience of technology performance; and developing a more holistic understanding of human brain activity to advance neurotechnology.[273]

Assessments of the extent and scope of technological applications for enhancing human cognitive and physical capabilities in the GAN timeframe vary significantly. While some experts predict the tactical improvement of human capabilities, others have explored the **potential emergence of 'trans-humanism'** within the 2050 timeframe. This concept describes 'a new form of human (a trans-human) […] where information and communication technologies and biomedicine will fundamentally improve the human condition and greatly enhance human intellectual, physical and psychological capacities'.[274] Trans-humanism implies the adoption of considerably advanced technologies by 2050, including brain-to-brain communication and genetic enhancement, and thus depends on resolving the various scientific and engineering barriers currently characterising the field.[275]

Unlike other technological areas, adopting human augmentation technologies will likely depend more heavily on **societal understanding of risk, safety and the comparative benefits of these technologies**. The invasive nature of some human augmentation technologies challenges public trust in them, meaning future technology development will need extensive testing to demonstrate their safety and low risk across a large heterogeneous population of end users. Achieving this will require significant public involvement in technology development, particularly as testing will require extensive and diverse end-user samples to test technologies over increasing periods to collect sufficiently rich technology-performance data.[276]

Such considerations may be reflected in future regulatory frameworks. Regulations will likely evolve at the national level in line with ethical and legal norms and standards, including those relating to privacy and data protection, consumer safety and related issues such as labour rights. **A critical regulatory consideration is ensuring the safety of human augmentation technologies** while balancing robust safety mechanisms with sufficient regulatory flexibility and agility to enable responsible innovation.[277] There are also concerns about the **impact of human augmentation technologies on legal and moral responsibility and accountability**. People may perceive human augmentation as constraining human control over cognitive and physical functions via embedded technology, thus posing questions about accountability for detrimental consequences resulting from 'augmented' human actions.[278]

Due to the highly interdisciplinary nature of human augmentation, expertise across multiple related fields will be needed in relevant legislative and regulatory bodies to ensure regulation remains fully up-to-date with

273 Research interview, 23 June 2023b.

274 European Commission (2016).

275 Research interview, 23 June 2023b.

276 Research interview, 23 June 2023b.

277 European Commission (2016).

278 Burwell et al. (2017).

technological development while facilitating continued innovation.[279]

4.5.2. Applications and implications for the information environment

The technological advances described above translate into three categories of human augmentation applications:

1. Augmented senses, i.e. augmenting human sensory capabilities such as vision and hearing.
2. Augmented action, i.e. improving the physical aspects of human activity.
3. Augmented cognition, i.e. monitoring and analysing human cognition and developing corresponding technological enablement.[280]

These categories map onto several broad types of use:

- **Improving physical and psychological attributes to optimise performance and quality of life**: Existing research on societal perceptions of human augmentation technologies indicates that most individuals associate their benefits with physical health improvements (e.g. general health and strength) and sensory capabilities (e.g. eyesight).[281] Though less commonly associated with human augmentation, applying the above-described technologies may also augment psychological and mental functions such as brainpower, memory and information capacity.
- **Improving the quality and accessibility of services**: Many human augmentation technologies connect to work-related applications to enhance workplace productivity or educational inclusivity via assistive technologies.[282] From an inclusivity perspective, similar use cases may emerge to improve the accessibility of public infrastructure.[283]
- **Improvements in human-machine connectivity** via brain-computer interfaces – particularly in increasing the amount and quality of data transfer – may provide benefits such as enhanced prosthetic-limb control and improved neurorehabilitation techniques. A related application is understanding human physical and psychological processes to improve human-machine connectivity applications and facilitate AI system training.[284]

Human augmentation raises three main implications for the information environment: a) improving human capabilities in absorbing, processing and analysing information, b) mitigating barriers to and introducing new modes of interpersonal communication, and c) generating new forms of social manipulation. First, human augmentation may **improve human capabilities in absorbing, processing and analysing information**. For example, brain-computer interfaces are anticipated to assist in decision-making and problem-solving, enabling the human mind to consume and process greater quantities and varieties of information more efficiently and effectively. Embedded computing through

279 Research interview, 23 June 2023b.

280 Raisamo et al. (2019).

281 Kaspersky (2020).

282 Pataranutaporn (2020), Frackiewicz (2023), Binnendijk et al. (2020).

283 Frackiewicz (2023).

284 Binnendijk et al. (2020).

brain-computer interface technology may also support learning activities, enabling technology-assisted accelerated learning.[285]

Second, human augmentation may **mitigate barriers to and introduce new modes of interpersonal communication**. Regarding communication inclusivity, assistive human augmentation technologies may facilitate communication for individuals with hearing or speech impediments.[286] At the higher end of the technology development spectrum, advances in brain-computer interfaces may translate into developing brain-to-brain communication technologies, leading to entirely new modes of interpersonal communication.[287]

A third implication is the potential for **new forms of social manipulation** in the information environment. Sensing technologies (e.g. hearing implants), in particular, carry a risk of interference, whereby devices could be manipulated to provide erroneous information to the end user.[288] Such manipulation of sensory inputs would substantially amplify current threats from artificially creating or manipulating visual and auditory information (e.g. images and videos).[289] Therefore, human augmentation could undermine end users' cognitive safety and influence their ability to assess the credibility of information they receive while using human augmentation technologies.

4.5.3. Cultural implications

Though ethical, technological and regulatory barriers may constrain the degree of human augmentation achievable in the future, significant levels of human augmentation may raise questions about underlying notions of personhood and culture as a human or interpersonal construct. This stems from the challenge human augmentation presents to **understanding human identity and personhood in a world of increasingly technology-enabled human functioning**.[290] Given the direct embedding of technology into human cognitive, physical and psychological functions, substantial levels of human augmentation may '[blur] the notions of identity and of what it means to be human', introducing new normative lenses on humanity and producing new stigma for those not seen as attaining those norms.[291] Discussions of how human identity may evolve have, for example, posited that technology-enablement enables a 'hybridisation of human identity', extending human personhood via artificial elements.[292] For example:

- At an individual level, human augmentation technologies such as brain-computer interfaces may **provide opportunities for individuals with pre-existing communication impairments to gain or re-gain modes of self-expression**.[293] This development may provide opportunities for individuals' abilities to express their

285 European Commission (2016).

286 Cinel et al. (2019).

287 Binnendijk et al. (2020).

288 Raisamo et al. (2019).

289 Maras & Alexandrou (2018).

290 Research interview, 23 June 2023a.

291 European Commission (2016).

292 Babushkina & Votsis (2021).

293 Sample et al. (2019).

identity through un-inhibited expression and interactions. However, researchers have raised concerns about the same technologies' potential effects on a user's sense of self, particularly if the technology becomes deeply embedded into an individual's bodily schema and affects their self-understanding and perceived bodily autonomy.[294]

- At a broader societal level, existing literature reflects on whether **technological augmentation fundamentally changes the contemporary understanding of 'humanity'** and whether society will evolve into 'Homo sapiens technologicus' through technological enhancement.[295] If human augmentation levels vary across different communities, this question may increase cultural polarisation between 'augmented' and 'non-augmented' communities.

In addition, human augmentation raises various issues for existing human rights paradigms. Augmentation as an increasingly accepted and inherent part of human identity and personhood raises the question of **whether to recognise human augmentation should as a human right emerges,**[296] extending current debates about recognising connectivity and internet access as a fundamental human right and the nature of the human condition. Such debates may vary across national and regional contexts in line with existing cultural and ethical perspectives on issues such as human advancement, the importance of technological innovation versus privacy, and innovation's role in national socioeconomic development.

Societal divides in human augmentation levels may also emerge from **divergent ethical and cultural views on and, thus, acceptance of human augmentation technologies**. For example, some communities may plausibly have ethical and cultural reservations against human augmentation,[297] potentially extending cultural divides between communities due to the differential uptake of human augmentation technologies. Technological enablement that changes society's understanding of human personhood and identity raises the question of whether the concept of 'universal human rights' could remain valid or whether human rights paradigms will inherently become divided between 'augmented' and 'non-augmented' communities.

Adopting human augmentation presents various issues for social norms and equity values:

- Firstly, the social dynamics of human augmentation adoption may include **disparities in access to relevant technologies**, thus introducing new forms of digital exclusion whereby the economically disadvantaged cannot access the same enhancement level as other societal segments.[298] Although decreased disparities in health outcomes are a perceived benefit of human augmentation technologies and related developments such as the 'Internet of Bodies', it is unclear whether such benefits would materialise. Indeed, historical examples of healthcare innovations show that technological advances may increase healthcare costs and exacerbate

294 Burwell et al. (2017).

295 Burwell et al. (2017).

296 European Commission (2016).

297 European Commission (2016).

298 European Commission (2016).

disparities due to pre-existing access barriers.[299] The socioeconomic and cultural impacts of increased disparities stemming from human augmentation may extend inequalities, with 'augmented' humans enjoying greater prosperity, social status and access to services than 'non-augmented' humans.[300]

- Secondly, existing research draws attention to human augmentation technologies' impact on **disability-related perceptions, social stigmas** and, perhaps, 'non-augmentation'.[301] The increasing availability of assistive technology and applications that can restore cognitive and physical capabilities may amplify the stigma attached to disability as societal expectations of what constitutes 'normal' human capabilities will rise.[302] This may undermine norms and values related to equity and non-discrimination while challenging existing commitments to inclusivity in different cultures. More widely, however, if human augmentation technologies become more ubiquitous, sociocultural attitudes towards them may result in societal, physical or psychological pressures on people to use them. As such, individuals with personal reservations about technological augmentation may experience new forms of social stigma.[303]

Adopting human augmentation technologies also raises issues about **social values linked to labour protection and the nature of work**. This mirrors the automation issues discussed in Section 4.1, whereby human augmentation risks rapid and widespread displacement of human labour if 'augmented humans' can increasingly perform essential functions and professions more efficiently than 'non-augmented' humans.

Regarding perceptual lenses, human augmentation may introduce two contradictory dynamics in people's ability to determine facts. By enhancing people's cognitive capabilities, **human augmentation technologies may improve their capacity to absorb more information and evaluate its quality better**, limiting the scope and impact of cognitive biases (e.g. confirmation biases and echo chambers). This effect may apply to absorbing cultural knowledge and information relevant to reproducing cultural identities (e.g. cultural history). However, as already noted, this opportunity must be balanced against the risks of malign manipulation that directly challenges people's ability to assess the information they receive.[304]

4.5.4. Summary and ecological interactions

Human augmentation technologies may significantly alter people's future ability to navigate and engage with information, shifting many process dynamics in the information environment. Across the ecological interactions captured in Table 4.5 below, two factors emerge as potential enablers of technology-mediated cultural change:

- Firstly, substantial human augmentation levels (e.g. capabilities approaching

299 Lee et al. (2020).

300 European Commission (2016).

301 Burwell et al. (2017).

302 Burwell et al. (2017).

303 Lee et al. (2020).

304 Raisamo et al. (2019).

trans-humanism) may be socioculturally disruptive by changing notions of personhood and human identity. A more intrinsic association of technological enablement with human personhood may challenge the assumptions underpinning the current understanding of cultural norms and paradigms, such as universal human rights.

- Secondly, advanced human augmentation may challenge existing interpersonal sociality forms and yield new social hierarchies and divisions between the 'haves' and the 'have nots'. Such hierarchies may exert extensive sociocultural effects, particularly if technology generates substantial differences between 'augmented' and 'non-augmented' humans.

However, these scenarios are highly uncertain and may not materialise in the GAN timeframe. Alongside possible technological limits, ethical and normative considerations may constrain the human augmentation levels available to society in the GAN information environment.

Table 4.5 Ecological interactions in human augmentation

Level	Key interactions
Macro	• A changing cultural understanding of labour protection and work resulting from the rapid displacement of labour generated by human augmentation; • Societal polarisation stemming from divergent ethical and cultural acceptance of human augmentation.
Meso	• The emergence of new social hierarchies and disparities in technology access, with implications for societal structures and relationships between communities and the state as a technology regulator; • The potential amplification of disability-related social stigma.
Micro	• The emergence of new forms of interpersonal sociality through human augmentation, including direct brain-to-brain communication; • The potential breakdown of sociality between 'augmented' and 'non-augmented' humans.
Self	• The potential hybridisation of human identity, with people's sense of self increasingly connected with technological enablement; • Reduced barriers to self-expression among those with communication impairments and other conditions.

4.6. Information security

4.6.1. Key characteristics and future trends

While emerging technologies are frequently considered enablers of disorder or risk in the information environment (e.g. via technological exploration to facilitate more authentic mis- and disinformation), the GAN information environment will likely be shaped by technologies providing information security. This technological system is concerned with technologically safeguarding three principles of information security[305] across all processes in the information environment:

1. Confidentiality: ensuring information is only accessible to authorised users.
2. Integrity: ensuring information is accurate, complete, trustworthy and only alterable by authorised users.
3. Availability: ensuring information remains accessible to authorised users and protected from intentional denial or disruption.

Several technological advances play a role in this technological system, including:

- **Applying AI techniques to information security**: Advances in AI capabilities have driven increasing interest in its application for information security, including detecting malign information and other cyber threats. In the future, AI techniques such as machine learning and computer vision may provide reliable detection of malign information, including artificially-manipulated, highly authentic audio-visual content (known as 'deep-fakes').[306] The development of such methods has already begun, although there are persistent challenges with the robustness, reliability across different data environments, scalability and portability of existing detection models.[307] Similarly, research has already begun to explore applying AI to cyber defence to provide solutions towards autonomous, real-time identification and mitigation of the expanding array of cyber threats. This promises to help address the continuing sophistication of cyber threats, e.g. intelligent malware, automated cyber-attack operations, phishing attacks and social engineering underpinned by malign AI exploitation.[308]
- **Technological advances in cryptography**: Civilian and military sectors widely use encryption mechanisms to protect information transfer. Future encryption will likely involve sophisticated cryptographic techniques and mathematical algorithms that provide high data storage and communications security. Such encryption methods go beyond conventional techniques to protect against increasingly advanced information threats. Of particular interest is the development of encryption based on the principles of quantum mechanics (i.e. quantum encryption) or securing communication networks against advances in quantum computing (i.e. post-quantum cryptography).[309]

305 Kim & Solomon (2013).

306 See, for example, Blue & Traynor (2022), U.S. Army DEVCOM Army Research Laboratory Public Affairs (2021), Ruhr-University Bochum (2020).

307 U.S. Army DEVCOM Army Research Laboratory Public Affairs (2021).

308 Burke (2020).

309 Princeton University CITP (2019).

- **Blockchain and distributed ledger applications**: Distributed ledger technology, including the blockchain, is commonly associated with decentralised data governance, as data is recorded and verified in a more transparent and distributed way via peer-to-peer mechanisms.[310] Since distributed ledger technologies are still developing, their future capabilities and applications remain uncertain. However, the potential for blockchain technology to improve information security is already being explored due to features that can help 'verify the legitimacy and provenance of digital content in a highly trusted, secured and decentralised manner'.[311] Among other uses, the technologies are thus associated with simplifying and increasing transparency in business interactions, improving privacy and security in big-data processing, disintermediating data management and record keeping (e.g. in governmental management of citizen records), and facilitating secure data exchange across the IoT.[312]

There are also developments aiming to **grant users of internet-enabled services greater control over their personal data**. For example, context-aware personal data management (PDM) or advances in personal information management systems (PIMS) could give people greater autonomy in determining, maintaining and developing their identity in online spaces in the future.[313] Similarly, a 'human API' (application programming interface) has been proposed to allow internet users to design and enforce their own rules about the information shared about their activities in digital spaces.[314]

These and other future advances in data protection and privacy safeguards are considered key features of a future web architecture known as **Web 3.0 (Web3),** i.e. the evolution of the World Wide Web. Though Web 3.0 is still being developed and has different technological features, one of its central elements is the expanded use of the blockchain for a more decentralised web architecture. Such decentralisation and development of a peer-to-peer network hope to grant individuals more control over data, activities and content interactions on the web, thus limiting the level of data collection and centralisation from large private sector actors who are the core providers of Web 2.0 services (e.g. Amazon, Google and Meta).[315]

4.6.2. Applications and implications for the information environment

As each security-focused information technology has a distinct objective and use, applications will also be varied in how individual end users utilise them and how they are incorporated into wider organisational and sectoral solutions (e.g. detecting and verifying information shared on social media). In the future, the technologies may be combined with or integrated into other solutions to provide improved, holistic solutions for information security:

310 Casino et al. (2019).
311 Rana et al. (2022).
312 Casino et al. (2019).
313 European Commission (2016).
314 Pew Research Center (2022b).
315 Digital Regulation Cooperation Forum (2023).

- From an end user's perspective, advanced information security may take on **new formats to help them understand their information environments and distinguish between real and manipulated content**. For example, researchers developing AI-enabled 'deep-fake' detection methods suggest the techniques could be embedded into vision-based devices (similar to AR interfaces such as goggles) to provide continuous end-user support in their specific environment.[316]
- At the sectoral level, experts have discussed the **potential development of advanced, consolidated warning systems** to help safeguard physical and digital communities by identifying emerging information risks and harms.[317] Such systems would see information security applications integrated with new models of citizen participation to provide decentralised, participatory community safeguarding approaches. Wider organisational and societal changes are associated with this new form of community governance in offline and online spaces, including the emergence of a 'new class of professionals – coders, information curators, literacy advisors – [to] help digital platforms encourage democratic behaviours [and] enable a culture of accountability in parts of the internet that is deeply trusted'.[318]

Two key implications of these applications and the technologies discussed above exist for the information environment. Firstly, they **mitigate the potential negative implications of other technological advances on the safety of the information environment for individual end users.** As this environment will likely feature a wider variety of more sophisticated mis-and-disinformation threats, solutions for their detection limit their negative effects on individuals and wider communities. Similarly, post-quantum cryptography will safeguard against the risks of developing quantum computing for communication and information-sharing processes. These scenarios see information security as a key intermediary factor in how the information environment may look in the 2035–2050 period.

Secondly, as mentioned regarding Web 3.0, developing information security, validation and privacy-enhancing technologies will likely **support the redistribution of power in internet governance and the information environment**. While the information-services market is currently heavily concentrated in a few online platforms, the development of Web 3.0 and related applications seeks to move away from market centralisation and redistribute power and data control to individual end users.[319] This shift could benefit information consumers while presenting potential challenges by removing trusted intermediaries in service provision (e.g. reducing service quality and increasing the complexity of accountability structures).[320] Moreover, technical decentralisation of the web architecture may not necessarily translate into the political redistribution of power to end users because implementing Web 3.0 may still centralise market power, e.g. due to the nature

316 U.S. Army DEVCOM Army Research Laboratory Public Affairs (2021).

317 Pew Research Center (2022b).

318 Pew Research Center (2022b, 6).

319 Digital Regulation Cooperation Forum (2023).

320 Digital Regulation Cooperation Forum (2023).

of consensus-based validation mechanisms embedded in Web 3.0 architecture.[321]

Emerging technologies offer potentially significant benefits for information security and information environment governance. However, several factors may hinder their impact or increase uncertainty about it:

- Firstly, there are **uncertainties about long lead times in developing solutions such as encryption algorithms** that can withstand emerging threats for rapidly advancing computing technologies. For example, existing work on the transition to post-quantum cryptography shows that phasing out and replacing compromised encryption methods can take 'a decade or more', suggesting that public and private-sector organisations will need to invest a significant amount of time and resources in protecting sensitive data.[322] Therefore, a critical consideration regarding the impact of information security solutions on the information environment is how quickly they can be developed and keep up with technological advances that may be exploited for malign purposes or undermine information security.
- Secondly, concerns have already been raised about the **unintended consequences of AI applications in areas such as mis- and disinformation detection**.[323] In particular, using AI models that lack explainability and risk reproducing gendered, racial or other biases may challenge detection by flagging false positives (i.e. situations when models mistakenly flag information as false). The greater risk of false positives and negatives means that using AI may have negative implications for the freedom of expression in digital spaces. For example, models may reproduce biases in understanding the language of minority cultural communities and be systematically more likely to detect and remove content produced by a specific community.
- Thirdly, applications aiming to improve information's confidentiality, integrity and availability **may not always effectively uphold all information security principles**. For example, while blockchain technologies are considered to benefit data integrity through decentralised information architectures, such benefits depend on how a blockchain solution is designed and implemented. As such, some blockchain solutions may suffer from 'poor use of cryptography, or poor implementation, [thus compromising] the security of a distributed ledger'.[324] Blockchain-based applications may also be susceptible to hacking and privacy risks, as data saved on a blockchain is visible to all that blockchain network's users.[325]

4.6.3. Cultural implications

The primary cultural implications of future information security systems relate to people's agency, their trust in the information environment and the evolution of data-privacy-and-protection norms.

321 Digital Regulation Cooperation Forum (2023).

322 Princeton University CITP (2019).

323 Woodley (2020).

324 National Security Cyber Centre (2021).

325 Digital Regulation Cooperation Forum (2023).

The implications for end-user agency feature heavily in debates about the future character of digital spaces.[326] In this context, advances in information security solutions, particularly encryption, potentially grant **individuals more agency and autonomy in the information environment**.[327] As emerging technologies such as AR, MR, VR and the IoT put increasing pressure on data protection and privacy safeguards, the development of Web 3.0 and associated tools (such as advanced encryption, mesh networks, digital passports and human APIs) will likely increase people's control over their data and digital identities.[328] Such developments may positively impact the cultural character of digital environments by translating end-user empowerment into democratised, participatory internet-governance structures.[329] They may also alter the balance of power in the information environment between individuals, private sector actors and governments – a dynamic closely linked to individualism in many national cultures.

However, several factors may mitigate these developments' impact. Firstly, the digital literacy people can develop to effectively use privacy-enhancing and data-protection tools and participate in effective internet governance is uncertain. While some anticipate that digital literacy will gradually improve, allowing individuals to navigate different technologies' risks and opportunities effectively, others expect end users to struggle to keep pace with technological innovation, undermining the utility of tools providing better security safeguards.[330] Secondly, there may be increasing pressures to limit encryption under the control of individual citizens, with state and private-sector actors constraining end users' access to advanced information security technologies.[331] As such, people's autonomy and agency in digital spaces may ultimately be constrained by commercial interests, sectoral competition or political/regulatory action. Lastly, as explained above, a technologically-enabled decentralisation of internet governance may not necessarily empower individuals because of the potentially contradictory dynamics in implementing Web 3.0.

Information security incidents and the availability or absence of technological tools to protect against them may also impact **how societies understand democratic norms and their manifestation in the virtual information environment**. While advances in some technological areas (such as AR, MR, VR and AI applications) are associated with digital spaces' increasing vulnerability to state-sponsored surveillance and other malign uses, the development and widespread adoption of information security tools may counterbalance such advances' effect to uphold democratic values in digital spaces.[332]

Advances in information security also have important implications for **how society understands and attaches normative importance to privacy and data protection**. The parallel development of technologies capable of threatening *and* safeguarding

326 Pew Research Center (2021).

327 Pew Research Center (2022b).

328 Digital Regulation Cooperation Forum (2023).

329 Pew Research Center (2021).

330 Pew Research Center (2021).

331 Pew Research Center (2021).

332 Pew Research Center (2022b).

information, communication and data will likely extend the current public debate on the value of privacy and data protection – particularly whether extensively collecting personal data without sufficient privacy safeguards outweighs the benefits end users gain from the providers and platforms collecting such data. Without advanced information security solutions, large-scale data and security breaches may significantly increase a culture's normative privacy and data-protection values. Related equity questions also stem from the importance of privacy for populations with protected characteristics, given potential equity implications for populations facing more significant barriers to accessing information-security solutions – further compromising already-vulnerable communities' privacy and data protection.

Regarding perceptual lenses, applications such as AI-enabled mis- and disinformation detection have clear **beneficial implications for end users' ability to understand and categorise facts –** particularly for their ability to identify manipulated content and distinguish facts from fiction in digital spaces. If technological solutions such as AI-enabled detection become sufficiently reliable and widely scaled across social media platforms, they could facilitate a broad cultural shift in the information environment's virtual dimension, significantly improving end users' trust in the online content they interact, helping establish credibility of trustworthy institutions while restricting the reach of malign actors.

However, several drawbacks of AI-enabled and other technological solutions may limit these benefits or have unintended sociocultural consequences:

- Firstly, as noted above, there are **concerns about the use of AI in the moderation of online discourse** due to AI-bias challenges and the opaque, black-box nature of many of the models online platforms leverage to detect and remove mis- and disinformation.[333] While advancing AI explainability and mitigating its biases will be vital in improving these applications' reliability, an inherent element of societal trust shapes how effective AI-enabled models are in increasing end users' trust in the online content they engage with. If perceptions of AI bias persist, using AI techniques to moderate digital content may have unintended consequences by undermining end users' trust in the information deemed factual by AI content-moderation models. It may also lead to perceived disadvantages or inequities by different communities, if they perceive AI models to reproduce bias against them through content moderation, potentially amplifying polarisation in digital spaces.
- Secondly, though many platforms may implement tools such as AI-enabled detection across their networks, detecting mis- and disinformation also relies on gatekeepers such as journalists and content creators. **Gatekeepers' lack of familiarity with advanced technological tools** may ultimately limit their benefits for those consuming information. It may also yield unintended consequences, such as if gatekeepers misuse technology-enabled tools and lose credibility among critical audiences.
- Thirdly, research on the implications of using AI in media and journalism indicates that adopting AI in these content-oriented professions may produce **significant structural shifts in media markets**, potentially introducing **disparities and**

333 Woodley (2020).

power shifts between different market actors depending on who has access to advanced technologies and who does not.[334] Notably, adopting more technologically advanced (and thus costly) solutions to enable functions such as information verification may create new market barriers for smaller market actors such as local news media. From a cultural perspective, this may limit such actors' role and influence in public debate while increasing that of large media organisations that may be inherently more disconnected from local communities. The second-order consequences of these dynamics may be increased competition between a few significant actors in the media landscape, already identified as a trend contributing to the so-called 'Truth Decay' effect (i.e. the decreasing role of facts and analysis in public life as media organisations focus more on opinionated content aligned with their audiences' existing attitudes and beliefs).[335]

The increasing use of AI and other technologies for detecting mis- and disinformation may also have implications for the character of content-oriented professions such as journalism. Existing work notes that adopting AI-driven tools in journalism may lead to 'potentially far-reaching structural changes in internal routines and divisions of responsibility between humans and machines'.[336] While these changes will likely be chiefly driven by advances in generative AI (see Section 4.1), the increasing use of and reliance on AI techniques in supporting functions such as detection and verification may also have a role in defining the division of human and machine labour across professions, thus shaping the public debate around the cultural appropriateness and acceptability of AI uses.

4.6.4. Summary and ecological interactions

Information security is a crucial dimension of the GAN information environment that may amplify or mitigate privacy, information integrity and reliability challenges from other technological advances. Current discourse suggests that with greater emphasis on individual data control and decentralised internet governance, developing Web 3.0 may significantly change online-space cultures. However, it is unclear whether Web 3.0's conceptual basis and other information security solutions could be effectively implemented or whether it may lead to unintended consequences.

While such impacts are uncertain, the speed of information security advances could be a key consideration regarding the cultural impact of emerging technologies as a whole. Notably, many technologies may have more disruptive effects if the development of information security solutions lags. Table 4.6 (below) summarises the remaining ecological interactions between information security and culture.

334 Helberger et al. (2019).

335 Kavanagh & Rich (2018).

336 Helberger et al. (2019).

Table 4.6 Ecological interactions in information security

Level	Key interactions
Macro	• Extending public debate over the value of privacy and data protection, potentially embedding privacy as a normative imperative in internet governance; • Developing ethical and regulatory safeguards to mitigate the negative implications of content moderation for freedom of expression.
Meso	• The changing cultural character of digital environments towards democratised and participatory modes of internet governance; • The changing power balance between individuals, private sector actors and governments in the information environment; • Potential structural shifts in media markets due to greater use of technology-enabled verification in the media.
Micro	• Increased trust in interpersonal sociality stemming from improved detection and verification tools.
Self	• Greater certainty in one's data and information integrity and a sense of safety in the information environment; • A greater sense of individual agency in the information environment due to personal control over one's data and digital identity.

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

This chapter discusses this study's conclusions, drawing on the evidence collection and analysis described in the report and our reflections on the major themes. The first section summarises and discusses the primary cross-cutting research findings, while the second discusses implications for UK Defence.

5.1. Summary and discussion of research findings

In the 2035–2050 period, the information environment will likely be shaped by multifarious technological advances across multiple S&T research disciplines, from developing new technologies to incrementally advancing existing ones. Technological advances in AI, VR, MR and AR technologies, bio- and neurotechnology, sensing and computing are expected to impact how we consume, share and interact with information, particularly through interactions with other technologies. This study aimed to explore the relationship between such changes in the information environments' technological landscape and potential future cultural change.

This study explored the potential cultural impacts of six technological systems capturing technological innovation in different aspects of the information environment: automated information systems (particularly decision-making and content-generation systems), virtual environments, augmented and mixed reality, advanced connectivity, human augmentation and information security. Each technological system presents multiple implications for cultural identities, norms, values and the perceptual lenses informing societal understanding of culture. While some impacts are unique to each technological system, several cross-cutting themes emerge:

- **Cultural identities**: Our results indicate that cultural changes may result from changing delineations of cultural identities, particularly those based on demographic and geographic characteristics. As technological change facilitates greater information consumption and interpersonal communication in the virtual world, experiences in those environments may acquire greater significance for an individual's perceived cultural identity than cultural elements bound to their immediate demographic environment (e.g. the local community or the nation-state). Cultural identities formed at the transnational or sub-national level around shared interests, attitudes and beliefs may become increasingly prominent. The increasing integration of technology *into* cultural identity may generate additional significant effects, including the potential hybridisation of human identity through technological enablement (discussed in Section 4.5) and the formation of cultural identities based on norms and values relating to technology use (e.g. some communities may become normatively opposed to certain technologies while others champion it).
- Assessing emerging technologies' impact on **cultural norms and values** consistently highlighted three issues:
    - **Privacy-associated norms and values:** Maintaining privacy was consistently reiterated as a challenge across most

technological systems discussed due to the quantity and diversity of data that advanced technology requires from end users. Advances in AI, AR, MR, VR, connectivity and human augmentation are all associated with increased pressures on the right to privacy, partly due to the increasingly seamless integration of physical and virtual reality that blurs the boundaries between physical and virtual personhood. However, advances in information security and web architecture decentralisation through concepts such as Web 3.0 also promise a fundamental shift in end users' data control, online activity and content interaction. These advances reflect the accumulation and decentralisation of information governance power between end users, public-sector organisations and private-sector actors, yielding contradictory enablers and barriers for privacy safeguards.

» **Equity-based norms and values:** Future technological advances frequently raise questions about access equality and technological adoption and enablement patterns and how they might vary across and within populations. Though some technologies are considered beneficial for reducing socioeconomic inequities, there are concerns they may exacerbate them or generate new patterns of technological exclusion. Further identified challenges include how diversity, equity and inclusion value are incorporated into technological development to mitigate the reproduction or amplification of existing gender, racial or other biases in technological solutions.

» Thirdly, anticipated regulatory challenges relating to many emerging technologies reflect **accountability** concerns and the general difficulty of establishing and maintaining democratic principles and positive behaviours in the information environment, particularly its virtual dimension. The potentially increased anonymisation of online interactions through virtual reality and increased automation of some information-related functions raise multiple challenges for establishing who is accountable for harmful outcomes in and outside virtual spaces. A related issue is the evolving role of commercial companies in governing the information environment, particularly online platforms such as social media, future virtual environments and other spaces. While some technological advances promise to elevate end users' agency and autonomy, others appear to constrain it, enabling leading commercial actors to consolidate greater control over information spaces and raising questions about keeping them accountable for future commercial strategies that may clash with cultural norms and principles, such as the right to privacy.

- Concerning **perceptual lenses**, our analysis of the six technological systems indicates that current trends in amplifying cognitive biases and exacerbating difficulties distinguishing facts from fiction will likely persist. The impact of greater personalisation of information-related services through technologies such as AR, MR, VR and human augmentation is a significant concern. While promising a better overall experience for end users, it may undermine the collective ability to identify common experiences based on objective facts and analysis. This possibility also applies to communities' ability to establish common cultural touchpoints and how they develop and reproduce collective cultural identities. Additional concerns stem from the possibility that personalisation and other technological features may amplify inherent cognitive biases in people's engagement with information and increase social manipulation risks by enabling access to more immersive and, thus, more believable and influential content.

It is also essential to consider **how new and emerging technologies may affect societal stakeholders' ability to navigate or engender cultural change**. The six technological systems discussed in this study illustrate, on the one hand, how social movements might leverage technologies to bring about sociocultural transformation (e.g. by using AR and MR in advocacy). On the other, they show how governments and political regimes might exploit such technologies for social manipulation (e.g. via internet shutdowns or persistent virtual-space surveillance). As social movements provide a crucial cultural change mechanism via advocacy and other means, cultural change dynamics may themselves become more closely interlinked with using new and emerging technologies.

Because of the significant uncertainties surrounding the nature and adoption of new and emerging technologies in the 2035–2050 period, it was challenging for this study to characterise whether advances in the six technological systems will lead to cultural change or whether new technological realities will integrate into existing cultural frameworks. However, several areas of possible cultural change were evident across technological systems at different ecological-framework levels:

- At the **personal level**, elements of anticipated technological change raise fundamental questions about human identity, particularly the implications of technologically-enabled human augmentation for what we understand as the biological foundations of human experiences. The technology-led hybridisation of human identity raises the possibility of a future scenario overhauling perceptions of the 'self' and increasingly embedding them within technological enablement, leading to disruptive sociocultural effects.
- At the **micro level**, tensions between personalised human experiences and the relationality by which communities and societies define common cultural touchpoints may generate substantial cultural change. Many technological advances this study considered aim to better support individuals in everyday life by tailoring services, augmenting an individual's capabilities and individualising information flows. While these seek to benefit human prosperity, they may challenge people's ability to collectively identify and agree on the nature of physical, societal, political and economic realities and, consequently, culture.
- At the **micro level**, many technologies associated with the GAN information environment shift interpersonal interaction from the physical to the virtual environment. In particular, the potential for widespread adoption of AR, MR and VR technologies indicates more significant technological mediation of many or all aspects of interpersonal sociality, affecting individuals' interactions and relationships, physical spaces and infrastructure. This increasing relocation of human activity into virtual spaces may erode the cultural value of physical artefacts (e.g. architecture) while also changing the make-up of physical environments such as cities

through technological integration and connectivity.

- At the **macro level**, substantial cultural effects are anticipated from the rapid innovative pace characterising many areas of S&T innovation. Discussions with SMEs in the study highlighted historical technological advancement examples with potential lessons for navigating societal and cultural adaptation to emerging technologies. However, the innovative pace will likely be far more rapid in the future technology landscape – a key difference from these past examples. As the rapid pace of technological advancement puts pressure on the societal and institutional ability to absorb and adapt to it, culturally integrating technology may become more challenging, yielding technology-mediated cultural change.

5.2. Implications for UK Defence

The future information environment is inherently uncertain, as are the associated cultural and technological developments likely shaping it in the 2035–2050 period. As the information landscape evolves, UK Defence will require a more refined understanding of these dynamics and their direct and indirect impacts.

This study identified three sets of implications for UK Defence. These concern UK Defence's ability to:

1. Understand future trends in the cultural impact of emerging technologies.
2. Effectively operate in a changing information environment.
3. Navigate a changing sociocultural context for the development and exploitation of emerging technologies.

These implications are summarised in Table 5.1 and described in the remainder of this section.

Table 5.1 Summary of implications of the study findings for UK Defence

Category	Implications and recommendations for Defence
Understanding the cultural impacts of emerging technologies	• UK Defence should invest in developing cultural topographies to ground future analyses of the sociocultural context of technological development in the UK and among key allies and adversaries. • Future analyses of the cultural implications of emerging technologies should focus on technological capabilities and applications as a starting point. • Defence may benefit from complementing future and foresight studies with historical research to understand recurrent dynamics and trends in the cultural impact of technological innovation.

Category	Implications and recommendations for Defence
Operating in a changing information environment	• Defence should continue monitoring emerging research on the implications of AR, MR and VR technologies, human augmentation on social manipulation, and relevant mitigations (e.g. detection and verification tools). • Defence will require a thorough understanding of the evolving nature of perceptual lenses and its audiences' and personnel's (diminishing) ability to identify and understand facts. It should also invest in understanding strategies and approaches for communicating with audiences in such an environment, such as emphasising the explainability of evidence in counter-misinformation efforts. • Defence should remain cognisant of the impact of technological change on the formation of cultural identities, particularly future trends in public associations with a national cultural identity.
Navigating a changing sociocultural context for developing and exploiting emerging technologies	• Defence should explore and monitor the cultural norms and values around using key emerging technologies and how these may impact perceptions of what constitutes 'acceptable use' in a Defence context. • Defence may benefit from a more in-depth understanding of the future dynamics of technology access, related inequities and digital exclusion patterns.

5.2.1. Understanding the cultural impacts of emerging technologies

This study's themes emphasise the inextricable connections between technological innovation and culture; future studies investigating technological advances and their implications for Defence should remain contextualised in sociocultural trends. While this study was premised on the theoretical assumption that technologies are actants in cultural change, it is evident that cultural and technological changes should be viewed through a co-productive lens rather than as linear and unidirectional impacts. Therefore, understanding the sociocultural context of technological innovation (e.g. societal perceptions of technology and the norms and values informing them) is necessary to understand whether and how technology may ultimately enact cultural change or become culturally embedded in its existing form.

This study provides an initial conceptual exploration of these dynamics. UK Defence should build on this baseline to understand the interactions between cultural and technological change at a more granular level and establish the likelihood of different scenarios and how these may affect Defence strategically, operationally and tactically. To support this, Defence should extend the study's conceptual framework for understanding the impact of future technologies on culture, including:

- Holistically applying the complete framework through more comprehensive studies, perhaps targeting fewer technologies in greater depth;
- Repeatedly applying the framework to build a comprehensive, coherent research base on the cultural impact of new and emerging technologies; and
- Testing and refining the framework, incorporating lessons from different studies.

We propose three related recommendations for this work:

- Firstly, we recommend that Defence invest in **developing cultural topographies** for understanding the most pertinent or important cultural environments. This is likely to include topographies of key national cultures, such as those of the UK, and critical allies and adversaries to enable Defence to understand the sociocultural context shaping technological impact in the UK and how this may differ between the UK and its allies and adversaries. Exploring these differences using a cultural topography would provide a more grounded perspective on how adopting and using emerging technologies may differ between the UK, its allies and adversaries in the future. Developing topographies for national or geographically-bounded cultures could be complemented by exploring transnational or subnational cultural formations, such as delineated online communities or ideological movements (e.g. conservative and liberal political communities).

- Secondly, we recommend that future analyses of the cultural implications of emerging technologies **focus more on technological capabilities and applications**. As many relevant technologies (e.g. AI) have a broad and diverse range of uses, understanding their cultural implications requires clarity about their possible use and application. As such, analysing capabilities or applications may better indicate the opportunities, risks and cultural implications associated with technological change. It may also help clarify a technology's precise role as an actant, as different developers and market dynamics may operate in different technological applications and end users' motivations, attitudes and behaviours may vary. Lastly, regulating emerging technologies may increasingly follow an application-oriented approach rather than a technology-driven perspective, better captured through an applications-focused lens.
- Lastly, Defence may benefit from complementing future and foresight-focused studies with **historical research to understand recurrent dynamics and trends in the cultural impact of technological innovation**. For example, this study highlighted recurring cases of 'technology hype' around emerging technologies and concerns about sociocultural impacts that sometimes do and sometimes do not materialise. Comparative analysis of these cases may help Defence clarify the conditions in which technologies may integrate into culture versus those where they become actants of cultural change. A second area of interest for Defence may be exploring historical case studies where war or armed conflict catalysed technological innovation.[337] These cases may provide valuable lessons in understanding the conditions in which organisations can rapidly adapt to new technologies and how they are socioculturally perceived.

5.2.2. Operating in a changing information environment

The technological and sociocultural trends described in this report have various implications for Defence's ability to navigate the information environment. Three implications Defence should explore further are as follows:

- Firstly, one of the most significant impacts of emerging technologies on

337 A selection of historical technological-change cases were recently examined for the Dstl High-Level Decision Support programme as part of research on new and emerging technologies' impact on operational and strategic advantage. This research could be built upon to identify the sociocultural aspects of high-impact technological innovations.

the information threat landscape will likely stem from manipulative uses of augmented and virtual reality spaces and human augmentation. As discussed in Chapter 4, these concerns stem from the combination of two factors, namely that a) emerging research indicates more immersive digital experiences may be more likely to influence an individual's attitudes, thoughts and feelings, and b) there is significant uncertainty about how to detect and mitigate manipulation, such as spreading of mis-and-disinformation, in an augmented or virtual reality setting. As malign actors may exploit these characteristics with direct implications for UK Defence, **Defence should continue monitoring emerging research on the implications of AR, MR and VR technologies and human augmentation on social manipulation and relevant mitigations** (e.g. detection and verification tools).

- Secondly, the evolving nature of perceptual lenses and the (diminishing) ability of Defence's audiences and personnel to identify and understand facts may directly impact UK Defence. Since some technological systems may increase people's difficulty distinguishing truth from fiction, **Defence will need to understand the implications of a future scenario where discourse and audience attitudes and opinions are less informed by objective facts and evidence or where audiences are less likely to agree on them**. Moreover, Defence should seek to understand strategies and approaches for communicating with audiences in this environment, such as those emerging from current mis- and disinformation evaluation frameworks that emphasise the explainability of evidence in the context of counter-misinformation efforts.
- Thirdly, Defence should remain cognisant of the **impact of technological change on the formation of cultural identities, particularly in the UK**. Given Defence's strong association with the nation-state, the UK population's increasing dissociation from a nation-state cultural identity and the emergence of new cultural identities may significantly affect UK Defence's relationship with the public, including public perceptions of Defence and the perceived value of UK Defence to national prosperity. Further potential implications include issues such as military recruitment and the Defence budget. Similar trends may be evident in other countries, which Defence should monitor to anticipate potential changes in Defence policies among allies and partners with possible implications for the UK.

5.2.3. Navigating a changing sociocultural context for developing and exploiting emerging technologies

The third set of implications relates to sociocultural trends affecting how different actors, including UK Defence, can utilise emerging technologies in the information environment. These are as follows:

- Firstly, Defence should **explore and continuously monitor the cultural norms and values around using key emerging technologies and how these may impact perceptions of acceptable use within the Defence context.** An example is the evolving perceptions of automation and AI applications that shape acceptance levels of military uses of autonomous systems. Proactively exploring the normative context of technological innovation may also help Defence understand relevant ethical and normative standards to incorporate into technological development. Besides helping Defence position itself as a responsible end user aligned with societal perceptions of acceptable technology uses, this exploration may help establish and maintain Defence personnel's trust in the technologies they may be using or enabling.

- Secondly, Defence may benefit from a more **in-depth understanding of the technology access's future dynamics, potential inequities and digital exclusion patterns**. As digital exclusion may materialise without different audiences from online spaces, Defence should understand how to reach and interact with these audiences and how access inequities for different technologies may inform different audiences' attitudes and behaviours.

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