21ST CENTURY INFORMATION ENVIRONMENT TRENDS OUT TO 2040

THE CHALLENGES AND OPPORTUNITIES IN THE INTEGRATION OF ITS PHYSICAL, COGNITIVE, AND VIRTUAL DIMENSIONS

OPEN PUBLICATIONS

ISSN 2957-7160 (Online)
ISSN 2957-7799 (Print)

Volume 8 | Number 1 | 2023

OPEN Publications (2023)

"21st Century Information Environment Trends out to 2040: The Challenges and Opportunities in the Integration of Its Physical, Cognitive, and Virtual Dimensions"

Contributing Author	**Dr Lawrence A. Kuznar** **Emeritus Professor of Anthropology** **Purdue University, Fort Wayne** **Fort Wayne, Indiana, USA**
OPEN Capability Leader	Col Geert Marien
OPEN Managing Editor	Mr Oke Thorngren
OPEN Operations Manager	Col Georgios Kotas
Action Officer	Dr Mehmet Kinaci
OPEN Editorial Review Board	Cdr Silvio Amizic Cdr Alban Morel LtC Stig Frankrig LtC Christopher Soemod Cdr Jeff Gulliver LtC Alfredo Marroccelli Maj Mithat Almaz Mr Ian Birdwell Ms Rachel Grimes Mr Neil Schuehle SGM Neculai Arghire

OPEN PUBLICATIONS

Disclaimer

Let us know your thoughts on

“ 21st Century Information Environment Trends out to 2040: The Challenges and Opportunties in the Integration of Its Physical, Cognitive, and Virtual D”

by emailing us at:

editor@openpublications.org

21st Century Information Environment Trends out to 2040: The Challenges and Opportunities in the Integration of Its Physical, Cognitive, and Virtual Dimensions

Abstract: The transformation of societies in the 21st century due to rapidly advancing information communication technologies (ICT) is creating disruptions and opportunities of a magnitude not seen since the Industrial Revolution. The 21st C. information environment (IE) is composed of physical, virtual, and cognitive dimensions. The social, technological, economic, environmental, and political (STEEP) implications of 21st C. IE dimensions are reviewed, as well as their trends into the future and how they will impact the national security concerns of NATO allies. Some of the more notable aspects of the 21st C. IE include instantaneous communication over vast distances that reaches whole populations or in other cases targets individual tastes, smart technologies that increasingly cocoon people in a web of devices that share vast amounts of information with one another, greater dependence and interaction between human cognition and machines, and the tendency of an information-rich environment to encourage people to think less and react more based on emotion and cognitive biases. Scholars and practitioners are learning more every day about the dynamics of competition in the information environment (IE), producing new theoretical concepts to match these phenomena and data to test hypotheses, search for patterns, and monitor effects. To tackle these complexities, this emergent IE will be framed as a complex system. The paper will conclude with challenges as well as opportunities for NATO allies and partners in the IE, as well as suggestions for how they might need to adapt to a new environment that will not be going away.

Key words: information environment; smart technology; strategic competition; virtual worlds; metaverse; cognitive bias; political polarization; complexity; decision-making.

OPEN PUBLICATIONS

Executive Summary

The rapidly developing 21st Century information environment (IE) is providing unprecedented interaction between humans, technology, and information at the speed of light across vast distances and scales. This paper examines the physical, virtual, and cognitive dimensions of this new IE, assesses the social, technological, economic, environmental, and political (STEEP) implications of these changes, and projects them into the next decades. The strategic challenges and opportunities these trends present for NATO are discussed and DOTMLPFI implications for NATO allied militaries are suggested.

Key trends in the IE include:

- Physical Dimension
    - Increased energy consumption
    - Increased extraction of minerals and consequent pollution
    - Increased industrial efficiency and tailored manufacturing to customer needs
    - Economic advance of people with STEM skills
    - Economic advantage to countries with STEM-educated work forces and entrepreneurial business climates
    - Need for establishing international and global interoperability standards; advantage to corporations and countries that influence global standards
- Virtual Dimension
    - Futuristic; the requisite technology does not yet exist for massive scaling of virtual worlds. However, futurists predict that people will immerse themselves in virtual worlds that will blend reality and computer-generated worlds.
    - Mixed evidence exists that immersion in virtual worlds can lead to addiction to them and anti-social behaviors.
    - Virtual worlds may be used to indoctrinate people for political ends.

- Cognitive Dimension
    - The 21st C. IE appears to increase cognitive biases such as confirmation bias, recency bias, availability bias, in-grouping, and echo chambers, and work against deliberative, rational thinking.
    - Reinforced cognitive biases are associated with social and political divisiveness and extremism, undermining the potential for deliberative compromise in democratic systems.
- NATO Security
    - The billions of interacting devices in the 21st C. IE create a vast attack surface, not only by virtue of their numbers and ubiquity, but also because of the much greater numbers of connections needed to network them.
    - However, there are theoretical reasons to think that the fact that all actors face the daunting task of defending this vast system that mutually beneficial, cooperative regulation is possible.
    - The reinforcement of cognitive biases and increased sociopolitical divisions in the 21st C. IE work against democratic institutions and provide NATO adversaries with opportunities to further weaken these institutions.
    - The necessity of rare earth and other strategic minerals is likely to create intensified global competition for the control of their mining and refinement.

- The advantage in setting interoperability standards will intensify competition between NATO allies and their adversaries for this control.

- DOTMLPFI Implications
  - NATO information doctrine lacks attention to the human dimension of the IE.
  - Organization and interoperability are well-covered in NATO doctrine but should probably be revisited considering the rapidly changing IE.
  - Training, education, leadership, and personnel needs to incorporate information-related social science disciplines such as psychology, communication, and anthropology.
  - As the 21st C. IE physical dimension evolves, NATO allies must invest in materiel and facilities to maintain modern command and control.

These trends are creating unprecedented abilities for states to influence populations and for populations and non-state organizations, from multi-national corporations to violent extremist groups, to influence states and one another. For instance, modern ICT enables individuals who will never meet one another to emerge as influencers, robbing states of controlling power while new developments in AI and technology enable states or other organizations to control what populations will see and how it will influence them. Never before has the brain been so dependent on technology and technology been so focused on manipulating the brain. Given the availability of information, people can approximate a rational actor's "complete knowledge," but information overload and cognitive biases drive people to rely on heuristic short-cuts and emotive cues which depart from rationality and often lead to social fragmentation. NATO allies must explicitly develop concepts that cover the impacts of the 21st C. IE on the human and cognitive dimension, and develop personnel through recruitment, education and leadership, and training prepared to meet the challenges and leverage the opportunities of this transformational IE.

Introduction

The nature of conflict remains constant, but its character changes.

(NATO 2017 AJP-01)

The epigraph is as true of the human condition as it is of war. Human beings have changed little in the past 100,000 years. They require fresh water, food, shelter, they seek social connections and mates, they raise their children, and they seek safety–one might say, "the nature of the human condition remains constant, but its character changes." In the 21st century, human nature is interacting with perhaps the most profound transformation in the character of the human condition in all of history, the 21st C. information environment (IE). For perspective, forty-thousand years ago, humans experienced a quantum expansion of technological capability, symbolic communication, and social interaction during the Upper Paleolithic, manifest in new killing technologies (spear-throwers, microblade technology) and elaborate cave paintings. Ten thousand years ago, the Neolithic Revolution ushered in the bow and arrow, settled village life, agriculture, elaborated symbolic communication, the accumulation of wealth, and social hierarchy. Six thousand years ago, growing populations aggregated into the first cities, states, and bureaucracies and writing was added to the information environment. Five hundred years ago the integration of ancient and medieval state systems culminated in capitalist societies based on money as a signal of value and the printing press that mass-produced written information. A mere 200 years ago the industrial revolution used these means to boost production to unprecedented heights, challenge the notion of colonial rule through mass-produced pamphlets, and invent the first computational devices in the form of automated textile looms. These technological advances accompanied advances in food production, manufacturing, and information use, culminating in the computer age of the late 20th century and the Information Age of the 21st.

These transformations boosted human well-being and, in many ways, increased individual human freedom but always with violent disruptions. Humanity appears to be in the middle of another truly historic transformation that will disrupt the current order, foment violent reactions, and hopefully will result in a new human condition of increased human productivity, freedom, and well-being (Ball, 2022; Noord, Koohang, & Paliszkiewicz, 2019). This paper attempts to capture the broad trends of this transformation and project, humbly, their likely future implications for the NATO alliance. Several aspects of the IE need to be defined.

First, what is information? Claude Shannon, the titular father of information theory, famously declared that no singular definition of information would be possible. NATO defines information as "knowledge concerning objects (e.g., facts, events, things, processes or ideas, and concepts) that, within a certain context, have a particular meaning (NATO, 2017)." The US DOD similarly emphasizes that information is "stimuli that have meaning in some context for its receiver (U.S. Joint Chiefs of Staff, 2018)." The key is that information consists of stimuli that have meaning to a receiver, that is, whatever bits, text, images, or verbalizations are transmitted, a receiver must be able to derive some meaning from the transmission. A message, no matter how well crafted, has no meaning if it falls on deaf ears, whether because of inadequacies in translation, noise in a channel, or lack of relevance to its audience.

Information therefore does not exist outside of communication. It is important to recognize that communication is constantly occurring. As pioneering communication theorist Paul Watzlawick and his colleagues noted (Watzlawick, Beavin, & Jackson, 1967), “one cannot not communicate.” All actions, gestures, and words potentially communicate something to someone, whether we intend it or not, and furthermore what a receiver understands from a communication is up to the receiver; there are limits to how much a communicator can control the meaning of a message. Furthermore, communication is a dialogue between two or more parties, each of whom receives information from the others, interprets it, and responds, creating a complex and cyclic ecosystem of information exchange in which all parties adapt to one another’s messaging (Barnlund, 1970; Schramm, 1954; U.S. Department of State, 2020).

NATO defines the information environment (IE) in the following way:

> Information Environment (IE): IE is comprised of the information itself, the individuals, organisations and systems that receive, process and convey the information, and the cognitive, virtual and physical space in which this occurs (NATO 2018).

This definition captures the IE as a dynamic, interactive system that stretches from information communication technology (ICT), through software interfaces, and ultimately into the human and cognitive dimension of human life and thought, consistent with academic definitions (Rottger & Vedres, 2020). Significantly, permeates all aspects of a military’s operational environment. There is no escaping the 21st C. IE in modern military operations. The purpose of this paper is to explore this emergent dimension and how it may represent a major transformation of the human condition in the 21st century, and in turn how it will impact NATO.

Methodology and structure of the paper

This paper will review relevant literature that scopes the challenges and opportunities of operating in a 21st C. IE. Three primary dimensions of the IE will be examined (Physical, Cognitive, and Virtual), and the future of each will be assessed with a STEEP (Social, Technology, Economics, Environment and Political) framework. Once each dimension has been characterized, its security, defence, and military implications will be addressed. The paper will conclude with key results and future DOTMLPFI (Doctrine, Organization, Training, Materiel, Leadership/Education, Personnel, Facilities, and Interoperability) implications for NATO.

Projecting future trends has limitations. History, especially over long periods of time, is rarely predictable. This is because human and environmental systems are complex, they are composed of many interacting parts that often have non-linear effects on one another, allowing for disproportionate effects that can spiral out of control or dampen effort to change the system. Furthermore, systems are subject to random shocks (an earthquake, a hurricane, a pandemic, the fall of the Berlin wall, or an Arab Spring) that can transform one state of affairs into another. This does not mean that anything is possible in the future or that it is impossible to make reasonable projections. Future courses of events are constrained by the “adjacent possible (Kauffman, 2000).” There may be a number of moves from one point in time to another, but those moves are constrained by what a possible next move might be. However, a next move nearly always creates new, unforeseen possibilities, allowing for, in the long-run, wildly divergent historical paths to take place. This introduces an inherent creativity in complex systems that is seen in the evolution of life, technology, economics, and culture (Kauffman & Roli, 2021). Therefore, the trends and projections suggested in this paper should be taken as, at best, mid-range (a decade or two) projections. What the world may look like a century from now is anybody’s guess.

The Physical IE Dimension

Many overlapping terms are used to refer to the physical dimension of the IE, including cyberspace and the Internet of Things (IOT). Some researchers prefer to limit cyberspace to any interconnected electronic communication system whether or not it includes the internet (Raghuvanshi 2021), yet others are resolved that any interconnected electronic communication system involves the internet (Noord et al., 2019). Whether one thinks of the physical dimension as incorporating the internet or a closed circuit, the fundamental aspect of the physical dimension in the IE is that it is an ecosystem of machines that communicate with other machines. These communications occur at the speed of light over vast distances, which is truly unprecedented in human history.

However, communication between machines is not seamlessly automatic and fool-proof. The original problem that gave birth to information theory revolved around how to distinguish meaningful messages through the noise in an electronic channel. Today, that problem is exacerbated by the bewildering array of physical devices, electronic channels, and software used to analyse data and interpret messages. Engineers debate how to characterize this multi-layered system, but one common framework proposes three basic layers, a perception layer, a network layer, and an application layer (Chin, Callaghan, & Ben Allouch, 2019; Kumar, Tiwari, & Zymbler, 2019; Noord et al., 2019). The perception layer is composed of the physical devices that, above all, contain sensors that generate data processed by the physical system of intercommunicating devices. A sensor can be an electronic device that senses the emissions from a car engine, a thermometer that senses the ambient temperature of a room, or a human who clicks on a favoured website. A major trend in the physical IE dimension is a move from fixed devices (i.e. desk top computers, main frames, even laptops) to highly mobile sensors and devices such as smart phones (Rottger & Vedres, 2020). The essential thing is that a devise, whether through human input or its own sensing, gathers data. It is important to note that errors in measurement or biases in how the environment is measured introduce noise and error in the very creation of data. The network layer consists of the physical (wired or wireless electromagnetic) connections through which devices communicate with one another. However, to communicate, machines need to be able to understand one another's' messages. The information communications technology (ICT) community has struggled to establish standards for interoperable communications between devices (Ball, 2022; Chin et al., 2019; Kumar et al., 2019), and who influences or sets those standards can have tremendous impact on the physical dimension. Finally the application layer refers to the devices that are sensor-equipped and capable of communicating with the network, which in turn allows them to alter their states and the information they convey to their human users (Noord et al., 2019).

Typical applications in a smart home illustrate the operation of the IoT and its growing pervasiveness in people's lives (Figure 1). You can settle in to watch a movie your smart TV has selected by learning your preferences, while your smart lighting system dims the lights to an appropriate level by sensing the occupancy of the room. You will be optimally comfortable because your smart thermostat has learned your temperature preferences. Your smart refrigerator tailored your shopping list based on reading expiration dates and learning your food preferences, which enabled your smart slow cooker to prepare a meal to go with your movie. You will feel secure while watching your program because your smart security system sensed when you were coming home, let you in, and has now securely locked down your house while continuously sensing for unwanted intruders. This example only touches upon a fraction of smart home technologies available and in use today.

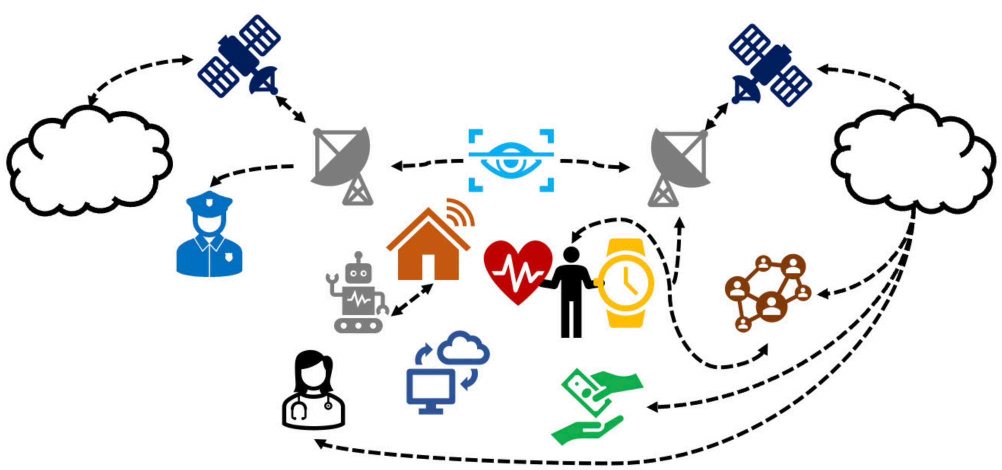


Figure 1. People are increasingly cocooned in a world of intercommunicating devices

By all accounts, the physical dimension, in terms of numbers of devices, is growing at an increasing rate (Alavi, Jiao, Buttlar, & Lajnef, 2018; Chin et al., 2019). In fact, the growth in devices is exponential while the population of humans is growing at best linearly if not levelling off (Figure 2). The demand for IE is growing world-wide in developed and developing regions alike at roughly equal rates (Chin et al., 2019). With every increase in devices, the numbers of possible connections between all of these devices increases even faster. The exponential growth in the physical dimension increases the network connections between devices by a much greater exponential increase. The future will be a vastly more interconnected world.

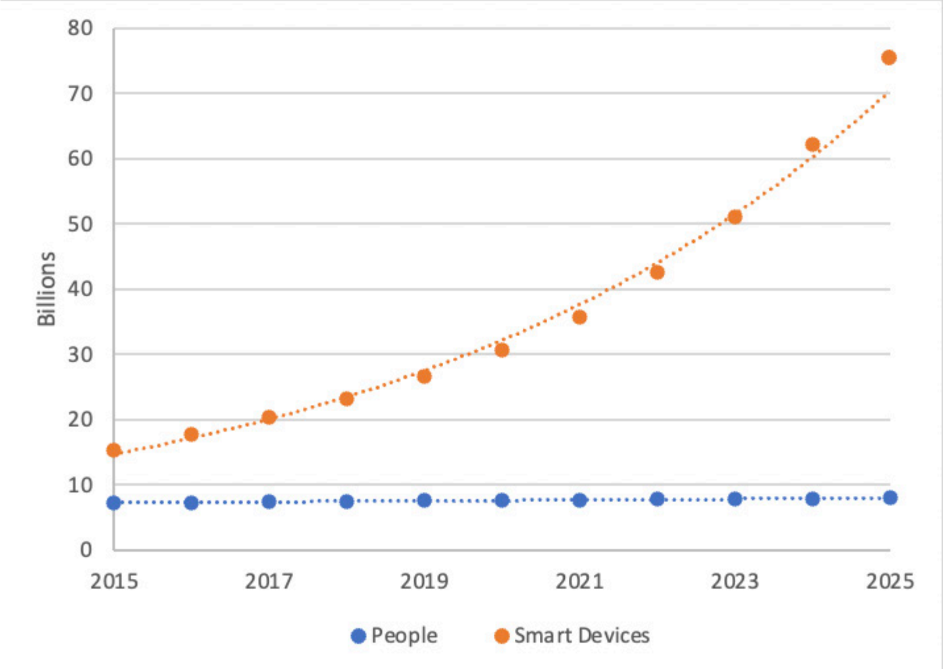


Figure 2. Actual and projected population device and human population increases (from data presented in Alavi et al. 2018)

STEEP implications of trends in the IE physical dimension

The most obvious implication of the growth in the physical dimension is technological. The need for more data about more things creates a need for new sensors, actuators (devices that operate other devices), and processors (Chin et al., 2019). The technology to support the IE will likely advance in effectiveness and quantity as it has been.

Economically, the demand for new technology will provide growth in the technology sector. Use of the IE in industry will increase the efficiency of manufacturing and the delivery of services as machines increasingly are able to take the place of costly human labour, and to monitor their own well-being and anticipate needs for replacement or even fix themselves (Chin et al., 2019; Kumar et al., 2019). New business models for how ICT companies will monetize this physical connectivity will be necessary as people increasingly take connectivity to and services from the IE for granted and assume it will be part of the devices they purchase. For example, people are becoming accustomed to free news and are less willing to pay for subscription new services (Rottger & Vedres, 2020). Despite advances in miniaturization and increased efficiencies in manufacturing due to the IE, technology is expensive and someone has to pay for it. Machines run on energy, which represents another necessary cost. A major area of science & technology (S&T) research is low-energy sensors to minimize these costs and green energy-driven devices to decrease their environmental impacts (Barakat et al., 2021; Chin et al., 2019).

Increased efficiencies in the IE physical dimension enable better monitoring of the environment and reaction to climate change. Agricultural sensors enable more effective, resilient, and efficient food production (Chin et al., 2019; Hussein, 2019; Kumar et al., 2019). However, the need for more energy increases demand for fossil fuels, which may counteract environmental gains. Research is very much focused on sustainable powering of environmental ICT to reduce net greenhouse gas emissions. An area of concern with the growth of the physical dimension is the demand for and mining of the minerals necessary for modern ICT. Rare earth minerals (the 15 lanthanides, scandium, yttrium) are essential to many electronics and green technologies, as well as other minerals such as aluminum, antimony, arsenic, cobalt, zinc, and zirconium (USGS, 2022). The mining and processing of these minerals creates serious pollution problems. For instance, China is the leading source of rare earth minerals due to their lack of environmental regulations, and the associated pollution endangers Chinese agricultural production and water supplies (Ali, 2014).

The social implications of the physical dimension may not be obvious to a human population that demands services from the IE but is increasingly unaware of how pervasively the physical dimension impacts their lives. Modern cars contain dozens of sensors, smart phones monitor our whereabouts and tell us when to exercise, sensors communicate with doctors and police, and robots clean our floors (Figure 1). Humans in the developed world are cocooned by the IE physical dimension and people in the developing world are catching up.

Interacting with the physical dimension is becoming easier and more seamless for users. For instance, computer programs are being created that tailor the programming of devices simply by a person's use of the device–no need for any programming knowledge (Chin et al., 2019). However, creating a physical dimension that provides unskilled users with goods and services requires a workforce that is highly trained in STEM (Science, Technology, Engineering, Math) fields. People who have these skills, or who know how to interface with those who do, will thrive in the future IE economy.

The political implications of the IE physical dimension are already being felt and are likely to become exacerbated. Countries with work forces educated in STEM fields and that have entrepreneurial business climates are poised to have an advantage. Countries that influence interoperability standards will have economic and political advantages over those who must adhere to them. It is probably too soon to detect political resentments between the STEM educated and those without. However, the developing world still lags behind the global north in education, and consequently, the global south is unlikely to enjoy the benefits of employment in the rapidly growing IE sector (Rottger & Vedres, 2020). Consequently, global north countries, especially the US, the Nordic countries, and China, will most likely dominate the IE physical dimension into the future. Competition to dominate the IE is most apparent between the U.S. and China, with both governments providing support to their high-tech industries and competing globally for market shares. The Chinese have been particularly aggressive in providing IE physical infrastructure in SE Asia and Africa in a bid to capture those markets and extend its influence (Paul et al., 2021). The political implications of mining for IE minerals are likely to be complicated. On the one hand, Chinese investments in overseas mining, especially in Africa, provide badly needed revenues to those countries but also provide China a means of influence (Page, 2018). However, Chinese development projects often have strings attached, such as predatory loans, that are likely to create resentment toward China. Furthermore, mining only employs a small fraction of any population, leaving only a few who would actually benefit from Chinese investments, potentially leading to further resentments against the Chinese.

The physical dimension of the IE and its associated networking layer provide the infrastructure that enables the virtual and cognitive dimensions. Despite its highly technical and material nature, it has social and political impacts if current trends continue. The next section addresses a particularly intriguing and futuristic IE dimension, the virtual dimension.

The Virtual IE Dimension

The virtual dimension does not exist in a full and scalable way, yet its proponents promise it is on the horizon. Matthew Ball (2022) provides a comprehensive review of the virtual IE dimension's history, development, and possible future. He refers to the virtual dimension as the metaverse and defines it as:

> A <u>massively scaled</u> and <u>interoperable network</u> of <u>real-time rendered</u> <u>3D</u> <u>virtual worlds</u> that can be experienced <u>synchronously</u> and <u>persistently</u> by an <u>effectively unlimited number of users</u> with an <u>individual sense of presence</u>, and with <u>continuity of data</u>, such as identity, history, entitlements, objects, communications, and payments. [emphasis in the original] (Ball, 2022, p. 29)

The metaverse will exist in the IE, be embodied in the physical dimension, and enable real-time interaction via the devices of billions of people through avatars (personae they create) in worlds that they collectively create, that persist when they are not there, and that accumulate their own histories. The term "cyberspace" was coined in the 1984 novel *Neuromancer* and the term "metaverse" was coined in the 1992 novel *Snow Crash*. In the 1970's pioneering computer programmers developed text-based worlds called MUDs (Multi-user Dungeons) in which they would make up worlds, which eventually evolved into the online 2D game *Habitat* that repurposed the Sanskrit term, "avatar" to refer to the online personae players created. The 3D online world, *Second Life*, launched in 2003 enabled players to collaborate in building cities, economies, and attracted real-world organizations such as Adidas, the BBC, and Harvard to set up their own organizations in the virtual world (Ball, 2022, p. 9)–real-life began imitating virtual-life.

The physical IE dimension necessary to support the virtual dimension took decades to develop, and the technology necessary for its full development for massive scaling, unlimited users, and continuity of data are still under development. Furthermore, in contrast to the development of the internet, which was primarily developed by governments and the research community, the virtual dimension is largely being developed by the private sector. According to Ball (2022, pp. 14-17), the tension between the private sector developers of the this dimension, who seek to control and monetize it for profit, and its user communities, are causing industry to erect barriers to its open development, retarding its future success. Therefore, the virtual IE dimension has not fully arrived, and projection of its future development is necessarily speculative. Nonetheless, the future virtual dimension appears to be on an accelerated pathway and will most likely be part of the human condition in the future. It exists enough in its nascent forms to allow exploration of adjacently possible implications.

STEEP implications of the IE virtual dimension

At this point in the virtual dimension's development, it appears more dependent upon the physical dimension than able to influence the physical dimension. However, if demand for immersion in virtual worlds grows, it might spur on the technological developments to make it a full reality.

The economic implications are much more apparent. While the metaverse has not yet fully arrived, it is economically significant. The *Minecraft* virtual world topped $415M USD in revenues in 2020 and has cumulative revenues of $3.12B USD.[1] The *Roblox* virtual world generated $1.9B USD in revenue in 2021.[2] These are consequential industries and given that fact that they appeal to children and teenagers, are captivating future customer bases; 75% of children in the U.S. played *Roblox* in the second quarter of 2020 (Ball, 2022, p. 11). There are cognitive reasons why virtual worlds are predicted to attract more and more people, and therefore consume more and more wealth, and these are addressed in the cognitive IE dimension section.

1 https://www.businessofapps.com/data/minecraft-statistics/
2 https://www.businessofapps.com/data/roblox-statistics/

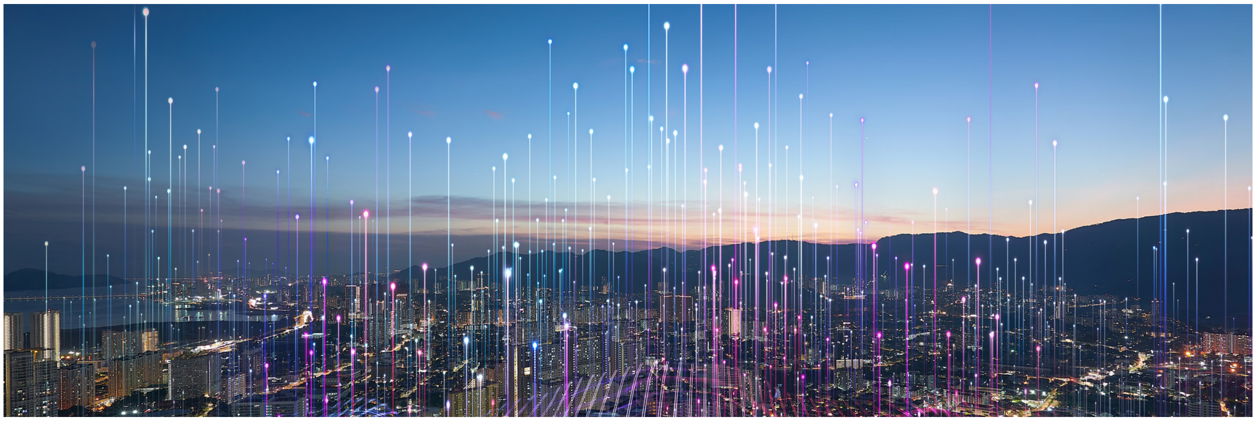
Environmentally, the impacts of a growing virtual dimension will mirror those of the growing physical IE dimension required to support it. Increased energy needs, consumption of fossil fuels if better alternatives are not found, and increased mining for IE minerals which will increase environmental human health hazards are expected outcomes.

The social implications of the virtual dimension are being explored as these platforms grow and their effects on users become evident. The most obvious impacts are on human physiology; immersion using virtual reality (VR) goggles can be accompanied by cybersickness, a combination of vertigo, nausea, and injuries brought about by moving in a physical world, blinded by the virtual reality one experiences (Lavoie, Main, King, & King, 2021). Immersion in virtual worlds has created whole class of adversely affected individuals in Japan, the *hikikomori*, mostly young males who abandon the real world in favour of their virtual worlds, and who often experience depression, obsessive-compulsive tendencies, and become addicted to the virtual worlds (Kato, Kanba, & Teo, 2019). This phenomenon is now spreading world-wide (Martinotti et al., 2021). A literature review by Lavoie et al. (2021) lists negative social/psychological effects of virtual world immersion including, increased aggression due to in-game rewards for violent behaviour, desensitization to violence, decreased empathy to others outside of the game, addiction to play, and using the games for escapism, defined as a maladaptive strategy of immersing in virtual worlds to escape real-world problems. From the viewpoint of these studies, virtual world immersion presents the danger of generating violent, anti-social people incapable of pro-social behaviours in real-life. However, meta-analyses of extant studies demonstrate no strong patterns between anti-social behaviour and virtual world immersion. For instance, the effect size of immersion in violent virtual worlds appears to be less than watching violent TV shows. Research on the psycho-social effects of virtual worlds is on-going. Gamification (rendering an educational experience in the context of a virtual world) is increasingly used in education and has been employed to foster cultural empathy between Israeli Jews and Arabs (Hoter & Shapira, 2022), and Melzer and Holl (2020) note that it is the framing of a game that has an influence on the moral decisions players make during play. Whether or not the metaverse will have adverse effects on human cognition and sociality remains to be seen.

The political implications of the virtual dimension are largely speculative but some attempts to use virtual worlds have been attempted for political purposes. For instance, jihadists have developed their own first-person shooter games to recruit fighters (al-Rawi, 2018). These developments were troubling, but there is no solid empirical study of whether these games had significant effects on recruitment. Nonetheless, these attempts raise the possibility that virtual worlds could be framed and their rules manipulated to influence political sensibilities. Out-group individuals could be portrayed in negative and dehumanizing ways to increase racial, ethnic, or political prejudices, and in-group members could be portrayed in positive ways that might not reflect reality. Social rules in a game could be manipulated to favour certain political systems and their benefits to players. Virtual worlds, especially if Ball's prediction that they may become increasingly centralized, could be used for indoctrination by powerful government or non-government organizations. The potential for the virtual dimension to impact the human condition and result in impacts on the NATO alliance and its missions, depends much on how these worlds interact with human cognition, the nature of which has remained largely unchanged for scores of thousands of years.

The Cognitive IE Dimension

Human cognitive abilities are the product of hundreds of thousands of years of evolution in what anthropologists refer to as the EEA, or Environment of Evolutionary Adaptiveness (Tooby & Cosmides, 1989). This environment occurred largely in tropical grasslands, in small groups averaging 25 people, most of whom were biologically related who moved frequently in search of food. Human cognitive abilities (e.g. expected numbers of close friends, attraction and mate competition, fear of out-groups, reasoning ability, heuristic decision-making) evolved under these conditions. Humans have lived in settled villages for only the last few thousand years, and only a small minority of humans lived in urban environments until only a couple hundred years ago. People in the 21st C. live in dense, interconnected, highly technological societies, but with the brains of their free-ranging hunter-gatherer ancestors of a 100,000 BCE. The question is, "What are the cognitive effects of the 21st C. IE on our prehistoric brains?"



Behavioural economists have identified about 200 cognitive biases (Dixon and Fitzgerald, 2019). Evolutionary psychologists refer to these as modules of the brain and they act like sub-routines in a complex computer program (Gigerenzer & Selten, 2001; Tooby & Cosmides, 1989). These sub-routines are activated by environmental stimuli such that they do not fire simultaneously and they can lead to different decision outcomes depending on the environmental context in which they are activated. The behavioural economist Daniel Kahneman characterizes the human brain as consisting of two fundamental modules, a one that thinks slow versus one that thinks fast (Kahneman, 2011). For instance, when contemplating a long-term, strategic course of action, one is probably better off engaging the slow brain by gathering as much relevant information and taking time to consider it carefully. However, when there is a need for a quick decision to adapt to an immediate threat, there may be no time to deliberate, and it is probably better to take a chance on a fast brain heuristic. For instance, if your campmates start running, don't think, just imitate them or you may be food for a bear. A number of cognitive processes are susceptible to the 21st C. IE.

Deliberative slow brain thinking may be especially vulnerable to information overload in the 21st C. IE (Cao et al., 2021). The physical dimension, with its multitude of networked sensors generates unprecedented data about the world. However, data do not speak for themselves. They require interpretation to transform them into meaningful information (see information definition above). The interpretation of multitudes of disparate data feeds into meaningful information is a major challenge in the 21st C. IE. However, information must be understood in a particular context if it is going to represent useful knowledge (Wright, 2021). This requires an additional level of interpretation in which the information is further interpreted in terms of the interests and objectives of relevant actors and the general environmental situation. Multiplying many interacting data feeds and resolving what they could mean and in context is a daunting challenge to the deliberative mind.

The 21st C. IE also presents challenges for the quick brain. When under the time stress of rapidly developing events and the 24/7 news cycle, acquiring information is vitally important. Humans fall prey to a number of heuristics that can easily lead them astray when seeking information (Cao et al., 2021). One is availability bias – it is too easy to uncritically pulse the internet (or a familiar intelligence network) and grab the first piece of relevant information. Recency bias is related and refers to overweighting the last piece of information one can remember. Social proofing refers to relying on information approved of by one's in-group and ignoring diverse voices. This is similar to the problem with echo-chambers in which one communicates only with like-minded in-group members (Rottger & Vedres, 2020). Probably the most pernicious heuristic is confirmation bias–seeking or only noticing information that confirms one's pre-conceived views (Cao et al., 2021; Rottger & Vedres, 2020). Filter-bubbles are created when AI algorithms feed a user information the user is more likely to like, which constitutes IE-enabled confirmation bias (Rottger & Vedres, 2020). Another bias humans appear to have is a preference for emotionally negative and false information (Cao et al., 2021). News messages that are unexpected or elicit feelings of disgust are more likely to be noticed and followed (Cao et al., 2021; Wright, 2021). Disinformation often focuses on negative, false themes that have the added benefit of not being constrained by the truth, which means that they can be better tailored to appeal to an audience. Empirically, disinformation is alarmingly more likely to be noticed and spread (Vosoughi, Roy, & Aral, 2018; White, 2018).

Motivated reasoning refers to the tendency to interpret information in a way that defends a person's worldview, undermines the views of opponents, or otherwise achieves a social end such as greater prestige, acceptance of in-group members, or insulting out-group members (Atran, 2020; Rottger & Vedres, 2020). Motivated reasoning, combined with confirmation bias, echo chambers, and aided by AI filter bubbles can feed radicalization, polarization, and increase social discord (Cao et al., 2021).

STEEP implications of the IE cognitive dimension

As with the virtual dimension, the technological and environmental consequences of the future cognitive dimension accompany any rise in necessary technology to enable influences in the cognitive dimension. However, the economic, social, and political implications are richer, and their future trends are already becoming manifest.

The phenomenon of micro-targeted advertising has become a marketing mainstay of modern business. Every click or keystroke transmits a user's preferences to marketing algorithms, which tailor ads to that individual. This has engendered a controversy over the use of personal data, and the EU has taken the vanguard on protecting consumer rights to their own data through the GDPR (General Data Protection Regulation). Nonetheless, micro-targeting will continue to be a feature of human interactions with the 21st C. IE.

The ability of marketers to engage with fast and slow brains will also have mixed effects. On the one hand, exploiting cognitive biases will undoubtedly increase impulse buying, but on the other hand, having more options and information about products and services will provide consumers with more information upon which their slow brains can ruminate. One example of this might be the real estate engine Zillow®, which provides consumers with unprecedented real-time and comprehensive information on properties for sale.

The social implications of the cognitive dimension are more alarming to most observers. The human tendency to affiliate with those who are similar (homophily) and to seek and notice information that confirms their own biases, and to believe only information that comes from people and channels from their in-group appears to have counteracted the democratizing potential of an interconnected 21st C. IE where everyone has access to just about any information. People are not seeking objective information, AI bubble filters and echo chambers appear to amplify social divisions, and the apparent attractiveness of false information has placed empirical reality and truth in ever more jeopardy. Humanity's grip on reality appears to be slipping.

These social trends have immediate political implications. Democracy rests upon civil, non-violent dispute and ultimately on the ability to compromise. Social and political polarization in NATO democracies has challenged their democratic institutions (Arquilla, 2021; Cook, 2020; Gradon, 2022). The 21st C. IE has enabled echo chambers and filter bubbles to split people apart, and disinformation has challenged the notion of a common, (relatively) objective reality and truth upon which people can agree. An open question is whether this is the result of historic trends within these societies (they are doing it to themselves), to what degree the IE is fomenting discord (societies have broken down into civil wars and global conflicts before the modern IE), and to what degree activities by NATO's adversaries (disinformation campaigns, physical IE market share competition) are having an effect. Anecdotes of disinformation campaigns bringing individuals into conflict exist, but there is no clear consensus based on empirical studies on these issues.

NATO Security and the Operating Environment

Trends in the 21st C. IE have numerous security challenges and opportunities for NATO through impacts on its operational environment. The exponentially expanding physical IE dimension hyper-exponentially expands the attack surface adversaries can exploit in order to hack and exploit the sovereignty of individual NATO countries' communications and data, and that of their citizens. Improved means of detecting hacking attempts are clearly necessary. However, a problem with an expanded attack surface for the adversary is, where to attack? The economic defendability hypothesis has been used by anthropologists to predict when conflict vs. information sharing vs. cooperation are likely to take place (Dyson-Hudson & Smith, 1978). A territory that is so vast that it cannot be adequately defended tends to foster more cooperative interactions between territorial groups, since neither side can effectively exclude others from attacking their territories. The IE in its physical, virtual, and cognitive realms may very well represent such vast territories, raising the possibility that adversaries can find a way to cooperate in its defence since everyone is increasingly dependent upon it. This is not just wishful thinking, the economic defendability principle is a general principle of human and animal behaviour.

The virtual dimension is mostly an unknown dimension. It exists in nascent forms but has not yet fully developed. Nonetheless, some threats are appearing to emerge. Evidence points toward the possibility that virtual worlds could generate anti-social tendencies in their inhabitants and powerful controllers (supra-national in many cases, China in others) may be able to manipulate virtual worlds to indoctrinate their inhabitants. On the other hand, proper framing of scenarios in these virtual worlds can also favour more pro-social tendencies.

The cognitive dimension appears fraught with challenges. One possibility is that ease of access to greater amounts of information about one's resources, other's preferences, and their resources should approximate the complete information requirement for fully rational decision making. However, the 21st C. IE appears to play more to humans' fast-thinking, heuristic brains, ironically activating cognitive biases that should not be necessary in an environment where near-complete information is possible. The cognitive biases favoured in the 21st C. IE appear to foster the spread of disinformation, encourage people to associate only with like-minded folk, and further social and political divisions already well underway in Western democracies.

Conclusion: DOTMLPFI implications of the 21st C. IE

Humanity appears to be on the brink of a major transformation in the human condition, driven by a 21st C. IE that will transcend all aspects of life, just as the military recognizes that the IE transcends all aspects of the operational environment. These changes will impact the environments in which militaries operate and how they operate in them. Militaries that adapt to these new conditions will have a decided advantage over those that do not. Therefore, military adaptation must cut across all aspects of a military organization from doctrine, through education and training, through the materiel used by warfighters, in other words, across the DOTMLPFI spectrum. DOTMLPFI (Doctrine, Organization, Training, Materiel, Leadership/Education, Personnel, Facilities, and Interoperability) is the framework NATO allies use for educating, training, and equipping their forces. The implications of the 21st C. IE for each of these aspects of creating an effective military force ready to confront the challenges of its time are briefly addressed here.

Doctrine. NATO Allied IE doctrine is focused on interoperability in the physical dimension of the IE (NATO, 2017). Little is mentioned regarding the virtual and cognitive dimensions, although these dimensions receive more attention in NATO policy regarding information operations (NATO, 2018). Greater attention should be paid to the human dimension in the IE. Furthermore, the networking of devices in the IE, which depends on physical (wired) and WIFI connections and the software that enables communication between physical devices in the IE, should also be well-considered.

Organization. NATO doctrine does address the organizations necessary for operating in the 21st C. IE, and its importance probably warrants a revisitation of these requirements.

Training. NATO allies must prioritize the training of personnel in exercises and practical training in IE systems, networks, virtual environments, and the cognitive effects of the IE.

Materiel. NATO must maintain state-of-the-art physical dimension IE, which is a challenge since technological developments in this area are rapidly advancing. NATO must not fall behind, especially since China appears to be aggressively trying to pull ahead in the physical dimension.

Leadership/Education. Leadership and education are conjoined through the professional military education (PME) process. However, they are not the same. Much more attention must be paid to education in fields relevant to the 21st C. IE. Many military officers have technical backgrounds that should enable them to understand and engage with the physical dimension and its networking layer. If not, this should be ensured. However, the cognitive dimension is understood through disciplines such as psychology, anthropology, communication, political science, and other social science disciplines. To engage with the 21st C. IE and lead forces throughout its operating environment, leadership must also have an educational background in the social sciences. Social science education must therefore be incorporated into the PME process.

Personnel. Infantry and artillery will always be indispensable in warfare, since the "nature of conflict remains constant." At the end of the day conflict is about applying force against an adversary or at the least, influencing an adversary with the threat of force. However, information and its impact on populations has risen to new levels of importance given the 21st C. IE. Therefore, IE specialists (and not just those who understand the physical systems) must become an integral, if not leading, part of NATO forces. Information operations cannot be regarded as an afterthought in otherwise kinetic operations, without realizing that every action as well as word or image, conveys information that can win over allies, sway populations, or undermine adversaries. The information officer must be in the front of the room, not the back. Consequently, education and training must not only cultivate this background, but recruitment must seek personnel from all IE-related fields.

Facilities. Facilities may be the easiest requirement to satisfy. First, once investments in basic material are made, the facilities to house them should become evident. Second, governments and politicians often find it easier to argue for the funding to build rather than funding for more abstract and intangible necessities, such as education.

Interoperability. Much NATO allied doctrine focuses on the need for interoperability. The reality of the 21st C. IE only reinforces the need for something NATO already recognizes is essential for a multi-national, allied force to operate effectively. NATO must track developments in the private sector regarding standards, be wary of private sector attempts to thwart open architectures, and of course develop architectures that will be secure from its adversaries.

When quantum leaps in technology (the bow, agriculture, metallurgy, the wheel, writing, industrialization) emerged the character and conditions of human life were transformed as humans adapted their nature to changing conditions. The 21st C. IE appears to represent such a transformational force. Humans have always interacted with technology, used it to gather information about the environment, and communicated with one another. Now, human interaction with technology occurs on more dimensions than they can track and machines make decisions for people in a way that never occurred before. The 21st C. IE enables people to communicate and influence one another at an unprecedented scale. The divide between the human mind and technology is more blurred than ever and in the future people may exist in a metaverse where physical and virtual realities can no longer be distinguished. As the character of the human condition changes, the character of competition and conflict will expectedly change as well. Hopefully, this paper provides a broad outline of these character changes and the ways that NATO allies must adapt to this new, transformative, environment.

References

al-Rawi, A. (2018). Video games, terrorism, and ISIS's Jihad 3.0. *Terrorism and Political Violence, 30*(4), 740-760. doi:https://doi.org/10.1080/09546553.2016.1207633

Alavi, A. H., Jiao, P., Buttlar, W. G., & Lajnef, N. (2018). Internet of Things-enabled smart cities: State-of-the-art and future trends. *Measurement, 129*, 589-606. doi:https://doi.org/10.1016/j.measurement.2018.07.067

Ali, S. H. (2014). Social and environmental impact of the rare earth industries. *Resources, 3*, 123-134. doi:10.3390/resources3010123

Arquilla, J. (2021). *Bitskrieg: The New Challenge of Cyberwarfare*. Medford, Massachussetts: Polity.

Atran, S. (2020). Measures of devotion to ISIS and other fighting and radicalized groups. *Current Opinion in Psychology, 35*, 103-107. doi:https://doi.org/10.1016/j.copsyc.2020.02.012

Ball, M. (2022). *The Metaverse: And How It Will Revolutionize Everything*. New York: Liveright Publishing Corporation.

Barakat, B., Taha, A., Samson, R., Steponaite, A., Ansari, S., Langdon, P. M., . . . Keates, S. (2021). 6G opportunities arising from Internet of Things use cases: A review paper. *Future Internet, 13*(159), e13060159. doi:https://doi.org/10.3390/fi13060159

Barnlund, D. C. (1970). A Transactional model of communication. In J. Akin, A. Goldberg, G. Myers, & J. Stewart (Eds.), *Language Behavior: A Book of Readings in Communication* (pp. 43-61). The Hague: Mouton & Co.

Cao, K., Glaister, S., Pea, A., Rhee, D., Rong, W., & Rovalino, A. (2021). Countering cognitive warfare: awareness and resilience. *NATO Review*. Retrieved from https://www.nato.int/docu/review/articles/2021/05/20/countering-cognitive-warfare-awareness-and-resilience/index.html

Chin, J., Callaghan, V., & Ben Allouch, S. (2019). The Internet-of-Things: Reflections on the past, present and future from a user-centered and smart environment perspective. *Journal of Ambient Intelligence and Smart Environments, 11*, 45-69. doi:10.3233/AIS-180506

Cook, S. (2020). *China's Global Media Footprint: Democratic Responses to Expanding Authoritarian Influence*. National Endowment for Democracy, Washington, D.C.

Dixon, P., & Fitzgerald, S. (2019). *Understand Your Brain: For a Change*. Oxford Brain Institute, Oxford, N.C.

Dyson-Hudson, R., & Smith, E. A. (1978). Human Territoriality: An Ecological Reassessment. *American Anthropologist, 80*, 21-41.

Gigerenzer, G., & Selten, R. (Eds.). (2001). *Bounded Rationality: The Adaptive Toolbox*. Cambridge, Massachusetts: MIT Press.

Gradon, K. T. (2022). COVID-19 and the Information Ecosystem: Lessons from Russian Malign Influence Campaigns for the Post-COVID-19 World. In S. Pollard & L. A. Kuznar (Eds.), (pp. 207-227). Washington, DC: National Intellligence University Press.

Hoter, E., & Shapira, N. (2022). Simulations in virtual worlds: improving intergroup relations and social proximity. *Intercultural Education*. doi:https://doi.org/10.1080/14675986.2022.2080969

Hussein, A. R. H. (2019). Internet of Things (IOT): Research challenges and future applications. *(IJACSA) International Journal of Advanced Computer Science and Applications, 10*(6), 77-82.

Kahneman, D. (2011). *Thinking Fast and Slow*. New York: farrar, Straus, and Giroux.

Kato, T., Kanba, S., & Teo, A. R. (2019). Hikikomori : Multidimensional understanding, assessment, and future international perspectives. *Psychiatry and Clinical Neurociences, 73*(427-440). doi:http://onlinelibrary.wiley.com/doi/10.1111/pcn.12895/full

Kauffman, S. A. (2000). *Investigations*. Oxford: Oxford University Press.

Kauffman, S. A., & Roli, A. (2021). The World Is Not a Theorem. *Entropy, 23*(1467), e23111467. doi:10.3390/e23111467

Kumar, S., Tiwari, P., & Zymbler, M. (2019). Internet of Things is a revolutionary approach for future technology enhancement: a review. *Journal of Big Data, 6*(111). doi:https://journalofbigdata.springeropen.com/articles/10.1186/s40537-019-0268-2

Lavoie, R., Main, K., King, C., & King, D. (2021). Virtual experience, real consequences: the potential negative emotional consequences of virtual reality gameplay. *Virtual Reality, 25*(69-81). doi:https://doi.org/10.1007/s10055-020-00440-y

Martinotti, G., Vannini, C., Di Natale, C., Sociali, A., Stigliano, G., Santacroce, R., & di Giannantonio, M. (2021). Hikikomori: psychopathology and differential diagnosis of a condition with epidemic diffusion. *International Journal of Psychiatry in Clinical Practice, 25*(2), 187-194. doi:https://doi.org/10.1080/13651501.2020.1820524

Melzer, A., & Holl, E. (2020). Players' Moral Decisions in Virtual Worlds: Morality in Video Games. In P. Vorderer & C. Klimmit (Eds.), *The Oxford Handbook of Entertainment Theory*. Oxford: Oxford University Press.

NATO. (2017). *AJP-06 Allied Joint Doctrine for Communication and Information Systems*.

NATO. (2018). MC 422/6 *NATO Military Policy for Information Operations*.

Noord, J. H., Koohang, A., & Paliszkiewicz, J. (2019). The Internet of Things: Review and theoretical framework. *The Internet of Things: Review and theoretical framework, 133*(November 2019), 97-108. doi:https://doi.org/10.1016/j.eswa.2019.05.014

Page, M. T. (2018). *The Intersection of China's Commercial Interests and Nigeria's Conflict Landscape*. Washington, DC, United States Institute of Peace (USIP), Special Report No. 428.

Paul, C., Dobbins, J., Harold, S. W., Shatz, H. J., Waltzman, R., & Skrabala, L. (2021). *A Guide to Extreme Competition with China*. Santa Monica, California.

Rottger, P., & Vedres, B. (2020). *The Information Environment and its Effects on Individuals and Groups: An Interdisciplinary Literature Review*.

Schramm, W. (1954). How Communication Works. In W. Schramm (Ed.), *The Process and Effects of Mass Communication*. Urbana, Illinois: University of Illinois Press.

Tooby, J., & Cosmides, L. (1989). Evolutionary Psychology and the Generation of Culture, Part I: Theoretical Considerations. *Ethology and Sociobiology, 10*, 29-49.

U.S. Department of State. (2020). *Pillars of Russia's Disinformation and Propaganda Ecosystem*.

U.S. Joint Chiefs of Staff. (2017). *JP 3-13 Information Operations*.

U.S. Joint Chiefs of Staff. (2018). *Joint Concept for Operating in the Information Environment (JCOIE)*. Arlington, Virginia.

USGS. (2022). *2022 Final List of Critical Minerals*. Washington, DC.

Vosoughi, S., Roy, D., & Aral, S. (2018). The spread of true and false news online. *Science, 359*, 1146-1151.

Watzlawick, P., Beavin, J. H., & Jackson, D. D. (1967). *Pragmatics of human communication: A study of interactional patterns, pathologies, and paradoxes*. New York: W.W. Norton & Company.

White, S. P. (2018). Information Warfare in the Digital Age: A Study of #SyriaHoax. *Journal of Technology Science*. Retrieved from https://techscience.org/a/2018111302/

Wright, N. D. (2021). *The future character of information in strategy: forged by cognition and technology*. Report for the Pentagon Joint Staff Strategic Multilayer Assessment Group. Washington, DC.


03
02
01
04
METAVERSE

OPEN
PUBLICATIONS


Multi-modal
Multi-user
Transportation
Logistics
Import export
Network
Distribution

21ST CENTURY INFORMATION ENVIRONMENT TRENDS OUT TO 2040

THE CHALLENGES AND OPPORTUNITIES IN THE INTEGRATION OF ITS PHYSICAL, COGNITIVE, AND VIRTUAL DIMENSIONS