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PREDICTION OF THE EDT TRENDS – NATIONAL AND SUPRANATIONAL ACTIVITIES

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ABSTRACT

Defence capabilities have always been heavily dependent on technological capabilities. This dependence is significantly emphasized nowadays due to the very rapid advancement of science and technology relevant to defence, and especially due to the emergence of disruptive technologies. However, emerging and disruptive technologies are well known throughout human history (fire, wheel, metals, gunpowder, external and internal combustion engines, etc.). Today, the cycle of emergence, application and response to the EDT is much faster, due to globalisation and maturation of information technologies. Smaller countries, because of their modest industrial and technological base at the national level, have problems to follow the emerging and disruptive technologies. In modern civilization, the military is losing its traditional centuries-old role as a privileged customer for purchasing new, technologically advanced products and must face competition in the open market. In this case, defence must be actively involved in monitoring and predicting technological trends, with an emphasis on disruptive technologies. Countries, especially those with strong armed forces and a long military tradition, have been doing this for a long time, but supranational activities (NATO and the EU) are relatively recent. These supranational activities are an important complement to national efforts and it is recommended that they should not be neglected by smaller NATO and EU member states.

KEYWORDS: technology prediction, emerging and disruptive technologies, TechWatch

1. Introduction

The armed forces have always been one of the main drivers of the technical and technological progress of civilization. The need for new, advanced and more powerful weapons that would ensure dominance on the battlefield and thus directly affect the power of the state, led rulers to priority investments in the military, and provided manufacturers with the largest and most prestigious clients.

The rudimentary state structures – the ruler with his retinue, the military and the associated structures of the religious organization visibly singled out the military as the largest and most elite client for the

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goods produced. This simple formula worked for centuries, until the emergence of modern civil societies and the Industrial Revolution in the West. Then, on the one hand, social structures multiplied enormously, and due to the atomization of society and raising general welfare, the number of clients – buyers/users of produced social goods increased accordingly, as well as the number of producers of these social goods, while on the other hand, recently, the technological progress of modern weapons reduced the total number of soldiers. Thus, the military was no longer the main consumer of mass production, such as clothing, canned food, vehicles and a whole range of other products, but would soon lose its position as a privileged trading client in the so-called high-tech domain. The IT industry has long ceased to be primarily a military sphere and mass digitalization has become an inevitable factor in every household, while the commercialization of space suggests that the same is expected in, e.g., satellite communications, space travel and other space exploitation.

Thus, in modern civilization, the military has lost its traditional, centuries-old role of a privileged customer for the purchase of new technically advanced products. Even the modified status of the military that dominated during the Cold War is lost, although it still emphasized a certain privilege of the military as a customer for advanced products that find their use within the military and only then become commercialized for wider use (e.g. GPS) (Gerstein, 2019).

With the further atomization of society, encouraged by the unprecedented development of digitalization, globalization trends point to the hitherto unimaginable global availability of industrial products. Global connectivity in all three basic phases of production: development, direct production and distribution, imposes on the participants of all three phases a key distinguishing factor of success – time.

Success is the commercial success of the product – does it make money or not?

Unfortunately, the military as a customer, by its essence (scope, organizational principles, doctrine, etc.) significantly slows down this three-phase production system and thus directly affects the commercial performance of the product in a negative way.

Therefore, it is to be expected that in the future the military will not only lose and lose the traditional privileged customer status for the purchase of more technically advanced products – in the sense that manufacturers consciously adapt to the needs of their privileged customers and only then think about other ways to adapt and commercialize their product for extra profit – it will be very difficult to compete in the order market even as just one of a multitude of customers.

Hence the need for a key change in the mindset of military planners: how to organizationally move from a privileged position in which you are the exclusive buyer of new technologies and technically advanced products to a position of frantic market competition with customers who are better than you? In other words, they are faster in reaction, they do not have large legal restrictions like the military (in modern societies, the military force as the focus of the state defence function, is generally the only state organization operating from monopoly positions (Coffey, 2013) – health, education and other traditional state spheres have been in market competition for a long time), and they are globally oriented – they get investment capital faster and easier, and they quickly and visibly capitalize their investments and make economic profit.

The new position of modern militaries described in this way will pose special challenges to small and medium-sized militaries (armed forces the size of small and medium-sized states). As previously stated, due to the monopoly

position of the state, defence, primarily the armed force, is placed in a position of national exclusivity (Encyclopaedia Britannica, 2021) with some pleasant advantages of this position, in the sphere of market attraction of producers, especially in the most sensitive category of the so-called emerging and disruptive technologies, due to legal and other restrictions, the military is primarily oriented towards national solutions.

However, small and medium-sized countries generally do not have a sufficiently broad and competitive industrial base or the scientific potential to overcome this position of their military and acquire new products from the category of emerging and disruptive technologies that only enable long-term stability and maintenance of qualitative advantage of their armed forces over potential adversaries (Levy, 2021).

It is possible to overcome such position of the armed forces through close cooperation with the so-called trend-setters, the armed forces of powerful countries that have a sufficiently wide and competitive industrial base and the appropriate scientific potential (Leider, 2020) to set long-term trends in the field of world production for the needs of the armed forces. For countries such as the Republic of Croatia – members of NATO and the EU – this primarily means full-fledged integration into the relevant planning and scientific bodies of these two organizations (NATO, 2018; National Research Council, 2014) (e.g. NATO Science and Technology Organization and European Defence Agency), as well as the formation of scientific and professional multilateral interest groups.

To put it simply, the challenge is no longer to develop an idea of a new product within the military and then look for a suitable manufacturer at the technical and technological level, but to systematically review the novelties and trends in many private entrepreneurial initiatives, to identify solutions that ensure the long-term dominance of their own military capabilities in the environment.

Moreover, it would be ideal to identify such solutions even at the stage of scientific research. At the same time, such solutions must fit into a cumbersome, technically and doctrinally very complicated military system, and for the members of multilateral organizations such as NATO and the EU, they must also be interoperable.

This will certainly require new organizational and legislative solutions in relation to the existing structure, at least in most NATO and EU members. The military will increasingly have to rely on the exceptional expertise of its specialized personnel who will be forced to look for modern technical and technological solutions to improve their capabilities in the endless multitude of private initiatives in the market. This means strengthening the scientific and professional potential in specialized organizational units of the defence system that will be positioned so that they have direct access to key military planners and strategic decision makers in the field of defence.

The so-called emerging and disruptive technologies are nothing new in the development of civilization, but the effects of globalization and digitalization in a revolutionary way have accelerated the cycle of emergence of such technologies that have the characteristics of the so-called game changer. The armed forces must find a modality to adapt to this global trend (Sapolsky & Gholz, 1999).

1.1. EDT Identification

It is commonly known that not all fields of science are equally active, some fields develop faster than the other, new fields emerge with new technologies and all of them can have military applications. In this section, we aim to examine which trending fields in science and technology

are identified as trending by different institutions. This is done by analysing multiple sources and by examining their techniques used to identify trending topics and classification of fields. We have analysed: Elsevier Scopus database reports, Clarivate Web of Science reports and European Union approach. Our final goal is to give an overview of trending research and emerging technologies from different sources.

1.1.1. Scopus Division

Elsevier's citation database Scopus (Scopus. Abstract & Citation Database, 2021) provides a vast number of information on topics that can be found in database. Most of detailed analytics and custom queries are not free for use, but some partial data can be found in form of their report named "Research and trend Topics" (Elsevier, 2021; Scopus for Research & Development, 2021). Scopus classifies trending fields in 6 main categories: Quantum computing, Internet of Things (IoT), Green chemistry, Digital oilfields, Digital equipment manufacturing, Cybersecurity, and Green & digital constructions. Each of main categories has subcategories as shown in Table no. 1. As far as authors are aware, they do not provide any information on how they identified and classified the identified fields, but they do provide detailed instructions on how they identified the common key phrases. The key phrases are identified by analysing the number of records and the frequency of keywords in the Scopus database. In addition, they provide information on top authors in the field and their affiliation.

Table no. 1

Trending fields according to the Elsevier Scopus database

Field	Common key phrases
Quantum computing	Computing, algorithms, simulations, Q bits
IoT	Edge computing, advanced analytics, machine learning, artificial intelligence, cloud computing, smart homes and smart cities
Green chemistry	Extraction, organic synthesis, pharmaceuticals, analytical chemistry, nanoparticles
Digital oilfields	Drill, optic, temperature, flow, pressure, decision making, remote/wireless, logging, monitoring
Digital equipment manufacturing	Safety, security, sensor, monitoring, connectivity, life cycle, additive manufacturing
Cybersecurity	Privacy, data protection, unmanned, drone, IoT, wireless, supply chain
Green & digital constructions	Building information model, information management, digital storage, computer – aided design, structural design, architectural design, project management, construction, construction project, etc.

(Source: Scopus for Research & Development, 2021)

1.1.2. Clarivate Web of Science

Analytics on trending fields in the database of Web of Science ™ (Clarivate. Web of Science, 2021) are provided in form of a report published by the Institute for Scientific Information (ISI). In its report for the year 2020 (Adams, Rogers & Szomszor, 2020), the ISI analyses scientific works

coming from G20 countries. Most of the information is presented in a country-by-country manner, with some additional information such as population, BDP, patents, ratio of output per funding, a number of researchers, etc. They analyse the number of citations and their impact – if they are cited more than the world average and how do the authors from specific countries collaborate internationally. The part in which we are interested is their division of disciplines. They divide disciplines into 8 categories without stating how they are derived: medicine, life sciences, maths and physical sciences, engineering and technology, social sciences, arts and humanities, art and design, humanities and languages, subjects allied to medicine. In report, apart for the COVID-19 related terms, there is no mention of specific keywords or fields of research.

1.1.3. European Union Efforts in Identification of Emerging Technologies

The EU's approach to identification of trends can be seen in a series of reports entitled "Weak signals in Science and Technologies" (Eulaerts, Joanny, Giraldi, Fragkiskos, Brembilla, Rossi, Nicula & Perani, 2021; Scopus, 2018) in which emerging technologies are identified by using the Scopus collection as a source and by applying the techniques of text mining, scientometrics and domain knowledge. The process used in the creation of reports starts by identifying common keywords found in the title, key words and abstracts in documents ranging from 2016 to early 2021. Once they have obtained keywords from the last 5 years, they searched the Scopus database again, this time examining the content of the whole citation database dating from 1996 to 2020 against a list of keywords from the last 5 years. They wanted to know how many times a specific keyword was used each year. They performed 4 million queries and identified 75 technologies in the early stage of development that could impact the future. Reports from the year 2019 identified 256 such technologies or signals grouped into 8 categories, and a revised document from 2020 identified 75 technologies grouped in 12 categories. As it is shown in Table no. 2, it is difficult to make a direct comparison between resulting technologies due to the different type of grouping.

In this section, we have examined multiple methods of identifying emerging technologies and trending scientific fields. Results of currently trending and emerging disciplines are presented in Table no. 2. Our comparison shows that identification of trending disciplines is difficult and varies form one author and methodology to the other. All identified disciplines can have military application, and military planners should take these developing fields into account when focusing their interests since all of the listed disciplines can have military applications.

2. EDT Prediction

Systematic and organized monitoring of the development of defence-relevant technologies has been recognized as a vital national interest since the end of WW2 in the work of Vannevar Bush, which resulted in the creation of the National Scientific Foundation (NSF) (Bush, 1945). In his work Bush has successfully linked national scientific potentials with current and future defence needs. Two decades later, Olaf Helmer from the RAND Corporation made a significant contribution rejecting uniqueness, unforeseeableness and inevitableness of the future by replacing them with the "trends in terms of probabilities" and operations research applied on computers and by introducing the Delphi method (Helmer-Hirschberg, 1967). The United Kingdom's Ministry of Defence also made a significant effort in the realistic technological forecasting of its planning needs by maintaining the "Global

Strategic Trends Program" with five "dimensions" intertwined: resources, social, political, science and technology, and military (UK's Ministry of Defence, 2007). Prediction and review of the technology trends are also tasks for intelligence and security community. The well-known civil-military collaboration is the National Research Council (NRC), organized on the Defense Intelligence Agency (DIA) initiative. This body is tasked with: short and long term analyses of military and dual technologies in order to direct the DIA efforts to make objective predictions to develop methodologies and strategies for the timely detection of relevant technologies, to review all available information on foreign technologies with estimates of trends and impacts on defence and security capabilities, regular coordination of scientific and defence institutions and organizations to target critical areas of scientific and technological development, and to draft reviews, reports, studies and other documents on a regular basis and on demand.

Table no. 2

Comparison of trending scientific fields according to different sources

Scopus	Web of Science	EU's Weak signals 2019	EU's Weak signals 2020
Quantum computing	Medicine	Biology	Biotechnologies
Internet of Things (IoT)	Life sciences	Materials	Chemistry & materials
Green chemistry	Maths and physical sciences	ICT	ICT
Digital oilfields	Engineering and technology	Health	Health
Digital equipment manufacturing	Social sciences	Physics and engineering	Engineering & physics
Cybersecurity	Arts and humanities	Environment	Environment
Green & digital constructions	Art and design	Energy	Social sciences
	Humanities and languages	Viruses	Blockchain
	Subjects allied to medicine		RNA
			Neural networks
			SARS-CoV-2

2.1. NATO Efforts in the EDT Prediction

Initiatives and efforts mentioned above are only the best known examples. Many nations have conducted similar efforts in futurology and long-term planning of the impacts of the emerging and disruptive technologies (EDT). Along with the national efforts, the EDT is the topic of a significant endeavour of the supranational organizations – NATO and the EU. One of the tasks of the Allied Command Transformation is innovations in military related domains. At the time of writing, the ACT is active in ten innovations (please see Allied Command Transformation (n.d.) for details) supporting future capabilities development. A decade ago, the NATO Science and Technology Organization (NATO-STO) conducted two EDT-related activities under its System Analysis and Studies Panel: SAS-062 "Possible Disruptive Technologies for Defense and Security" and SAS-082 "Disruptive Technology Assessment Game – Evolution and Validation" (NATO Research and Technology Organization, 2010, 2012). Objectivity in the EDT prediction, and the best use of the current expert knowledge was assured by the "serious game" approach. Players in the serious games represent

interests of defence and security, law, economy, academic community, and all relevant areas (the team composition is not unified, and teams are gathered on actual demand). Grouped in "blue" and "red" teams as well as independent controllers of the game, the participants compete to achieve their goals using actual and predicted technological capabilities. This competition enables to define "Technology Cards (T-Cards)" and subsequent "Idea of the System Cards (IoS Cards)". Expected benefits of the serious games are: detection of previously unknown vulnerabilities, identification of a new EDT, building of future defence and security systems along with Courses of Action (CoA). These CoAs have to create a perspective base for a broader context in the defence and security capability development, having in consideration all levels of a conflict; tactical, operational and strategic.

2.2. EU Activities in the EDT Prediction

The European Union is also very active in the EDT prediction efforts through activities of the European Defence Agency (EDA) and the European Commission's Joint Research Centre (EC-JRC). Project PYTHIA was been started in late 2017 in order to improve defence and civil technology forecast for EDA's strategic planning processes, and to develop an EDT foresight methodology at the strategic level. The PYTHIA relies on a vast amount of open source big data tools. The PYTHIA is not only capable to develop a new method but to compare the EDT's forecast with accuracy and reliability. Besides PYTHIA, the EDA has been conducting "Technology Forecast Exercises" since 2015 as a part of the EDA's complex research and technology planning processes. Recently, the EDA conducted four Technology Forecast Workshops (TFWS) on: hypervelocity systems, energy for future military platforms, emerging propulsion technologies for air and space, and a complex technology foresight exercise. All these activities gathered a broad and diverse community. All events had inspirational discussions during which ideas were created, commented and liked. At the end of the exercises, these ideas were collected and grouped according to the number of comments, likes and discussions, their relevance for the EU, their relevance for defence, plausibility and a group of ideas which were most uncommon (for more information visit European Defence Agency, 2014).

During the Technology Forecast Exercise, "weak signals" were identified by the EC-JRC. These weak signals were based on scientometric data, and a number of scientific articles in defence relevant research domains (for more information visit Eulaerts, Joanny, Giraldi, Fragkiskos, Brembilla, Rossi, Nicula & Perani, 2021).

3. Conclusion and Recommendations

The great theoretician of the strategy Collin Gray has once written: *"... there is no golden key, no magical analytical method or amazing new, or even old, technology that can foresee the future in detail. However, a combination of historical contextualization and the appreciation of unending motion in time, should improve the odds on achievement of adequacy in prudent anticipation"* (Colin, 2014). Having this in mind, smaller NATO member countries face a significant challenge of objective and accurate EDT. Despite the complexity of this effort, many methods have been developed and a vast amount of the EDT relevant scientific and professional works has been published. Past experience exists and is in many cases well documented; however, the professional community is also broad and active. Small countries have to organize its own EDT efforts by gathering defence and security organizations, academic institutions and industry. The exact form of the organization is not critical as long as

it enables a continuous technology watch (TechWatch) and EDT predictions. The national EDT prediction organization assures that national peculiarities will be taken into account. To broaden efforts in EDT watch and predictions, all forms of bilateral activities are possible, especially those with neighbouring countries at the same development level. In the end, we recommend that small countries be present and active in all NATO and EU technology forecast events and activities despite relatively small contributions they make.

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