THE FUTURE OF DIGITAL TWINS: CHALLENGES AND IMPLICATIONS FOR NATIONAL SECURITY

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Abstract: *Digital Twins (DTs) are transforming how knowledge is generated and used. A Digital Twin is a set of data and information that fully describes a potential or actual physical object, process, or system. They are used in products, systems, and processes before and after their development, creating a means for determining the feasibility of production and modes of failure. Developments in computing power, artificial intelligence, big data and other new technologies are enabling replication of large complex systems with greater fidelity and predictive power. The purpose of this research paper is to present and identify the future prospects for Digital Twin applications, to understand where and how digital twins are used today, the prospects for their future use, and the potential implications for national security.*

Key words: *digital twin, definition, standardization, benefits, challenges, national security*

INTRODUCTION

A digital twin is a virtual representation of a physical product, process or system that is paired with that physical entity over the course of life-cycle management to help it develop from a concept to a prototype to its final version. A digital twin is a comprehensive digital model of an product, process, or system with associated environment used for testing, integration, and simulations without impacting its real-world counterpart. The term was coined by Michael Grieves and John Vickers in 2003; since then, the concept has been broadly accepted and applied in many fields, to the point that it was listed as a key strategic technology trend in 2019 by Gartner, a technology research and consulting company. This development is largely driven by advances in technologies such as Internet-of-Things (IoT), multiphysical simulation, real-time sensors and sensor networks, machine learning, artificial intelligence, big data, data management, and data processing.

The digital twin has been intended from its initial introduction to be the underlying premise for Product Lifecycle Management and exists throughout the entire lifecycle (create, build, operate/support, and dispose) of the physical entity it represents. Since information is granular, the digital twin representation is determined by the value-based use cases it is created to implement. The use of a digital twin in the create phase allows the intended entity's entire lifecycle to be modeled and simulated. A digital twin of an existing entity may be used in real time and regularly synchronized with the corresponding physical system.

The dynamic and rapid development of new technologies makes national security a priority, and how new technologies can be used in different segments. Specialists working in this topic are adamant that new technologies can be useful in operational-tactical processes, processes in which ad-hoc decisions must be made, processes in which real data, data collection, geographic information systems (GIS), mapping, cartography etc.

It is an undisputed fact that much of the new technology in the digital decade, especially the use of technologies related to digital twins, has many advantages, but parallel to this, there are also challenges. The presented article analyzes and presents the technologies that can be used in national security. Unfortunately, at this point, the challenges and unknowns are more, and the reason for this is precisely the fact that the technology is new and not yet clearly defined. Too many questions remain to be clarified about the relationship between national security and digital twins, their uses and challenges. The fact is that every new technology to be usable, it is necessary to be standardized, to be regulated and to be described with indicators that report its progress in a strategic document for a certain period of development. Also, the positive effects on national security that all new technologies have is indisputable, but it is a serious challenge to use them because they are not clearly conceptually defined.

1. DEFINITION OF DIGITAL TWINS.

There are different definitions for the new technology that is developing at a dynamic speed. In technology circles, one of the most commonly accepted definitions is:

„*A digital twin is a dynamic virtual copy of a physical asset, process, system or environment that looks like and behaves identically to its real-world counterpart. A digital twin ingests data and replicates processes so you can predict possible performance outcomes and issues that the real-world product might undergo”*.

The presentation and introduction of the new technology has no specific defined time frame. It is introduced into technological processes for different purposes and reasons. A digital twin is a digital representation of a real-world entity or system. The implementation of a digital twin is an encapsulated software object or model that mirrors a unique physical object, process, organization, person or other abstraction. Data from multiple digital twins can be aggregated for a composite view across a number of real-world entities, such as a power plant or a city, and their related processes.

Digital Twin Consortium presented the following definition of DT to the academic community:

“A digital twin is a virtual representation of real-world entities and *processes, synchronized at a specified frequency and fidelity. Digital twin systems transform business by accelerating holistic understanding, optimal*

decision-making, and effective action. Digital twins use real-time and historical data to represent the past and present and simulate predicted futures. Digital twins are motivated by outcomes, tailored to use cases, powered by integration, built on data, guided by domain knowledge, and implemented in IT/OT systems” (Olcott, & Mullen, 2020).

2. TECHNOLOGIES NEEDED FOR DT’S IMPLEMENTATION

Digital twin technology uses machine learning algorithms to process the large quantities of sensor data and identify data patterns. Artificial intelligence and machine learning (AI/ML) provide data insights about performance optimization, maintenance, emissions outputs, and efficiencies. The main technologies which are included in process of implementation are (Fuller et al., 2020):

- Physics-based modelling;
- Data-driven modelling & big data cybernetics;
- Infrastructure and platforms;
- Human-machine interface;
- Data management.

It should be noted that Digital Twin is an evolving concept and could in the future come to include other technologies, especially as new ones mature. However, the following can be considered a collection of some of the most important current aspects of Digital Twin implementations.

Physics-based modelling - Digital twinning often begins with a modelling activity. Indeed, many SMEs already have models of their products available in one form or another, which can be an ideal starting point for Digital Twin implementations. In cases where the physical asset does not already have a corresponding 3D model, reverse engineering (RE) can be useful. RE involves converting scans of a physical object (e.g., laser scans) back to a geometric model. Computer aided design (CAD) software is often required both when modelling the object from scratch or via reverse engineering.

Data-driven modelling & big data cybernetics – An alternative to modelling physical processes via known mathematical models is to make measurements of actual conditions on the physical twin and apply data-driven modelling methods (Kukushkin, Ryabov, & Borovkov, 2022). One advantage of datadriven modelling is that the data can encompass both known and unknown physics, thus providing a more complete account of the physical processes. However, in order to model physical processes in this way, huge amounts of data are typically required. The internet of things (IoT) is one potential source for such data (Oracle, 2017). The IoT consists of a web of interconnected sensors, instruments and other devices that can gather large amounts of data and continuously stream that data for further processing. Hybrid modelling approaches aim to combine the physical modelling and data-driven approaches. Hybrid analytics often provides a more flexible and robust approach and has the advantage of preserving the known physics of the model while also dealing with the low quality or quantity of data that plagues data-driven approaches. Nevertheless, the combination is often more complex and requires a more tailored approach.

Infrastructure and platforms - All the models and data involved in a Digital Twin typically require significant computational resources when they are to be processed. One of the major technologies that enables processing in a big data context is cloud computing. Cloud computing offers computational resources from a remote location over a network. One of the key benefits of cloud computing is that it offers flexible scalability of compute resources without SMEs having to invest in their own infrastructure, which can be useful considering the different computational requirements at different stages of Digital Twin implementations (e.g., training DNNs). Cloud computing can be contrasted with edge computing which aims to bring computational resources closer to the source of the data. A major benefit of edge computing is that the data can be processed without ever having to leave the local network, solving issues with latency by avoiding transferring huge amounts of data. An additional benefit of edge computing is that it is easier to ensure the data remains private and secure. However, it often requires a significant investment in local computer hardware. Fog computing automatically combines edge and cloud resources to optimize the processing of the data. Similarly, to cloud computing, high performance computing (HPC) is also typically offered from a remote location but in contrast to cloud computing, it targets solving hugely complex problems that cannot typically be solved by a single consumer grade computer (Callcut et al., 2021).

Human machine interface - Digital Twin brings excellent possibilities to exploit advanced visualization methods such as augmented reality (AR) and virtual reality (VR). If a Digital Twin of a physical asset is available, it makes sense, in many settings, to superimpose data extracted from the Digital Twin onto the physical twin. This can be done in a variety of ways, from using AR headsets or other screens to directly projecting the information onto the physical twin. AR and VR provide visual feedback to the user, but there is also the need for passing information from the user to the twin, (e.g., for control). Both AR and VR can be combined with technologies such as natural language processing or gesture control to provide effective environments in which the twin can be controlled either through voice control, or via physical movements.

Data management - Digital twinning involves many different model versions that can represent different aspects throughout the lifetime of the twin, from design and simulation to manufacturing and actual use. Product lifecycle management (PLM) provides a platform for integrating, storing and accessing data throughout the lifetime of a product. Key benefits of PLM are that it provides configuration control and traceability. PLM can be used for many different types of data, from product structure data and CAD drawings to documentation and related e-learning information. PLM is also an important driver for the use of standards, which is vital in Digital Twin implementations for ensuring that there is interoperability between the different components, and also interoperability between the Digital Twin and the outside world. Blockchain is a technology that has in the past few years been popularized through its use in various cryptocurrencies. However, blockchain does have a wider use that can be of interest in Digital Twinning. Blockchains provide a permanent decentralized historical record of information that is secure, traceable, and transparent; all of which are important in the Digital Twin context. There also exist alternatives to blockchain technologies, such as directed acyclical graphs (DAGs), that address some of the issues with scalability.

3. STANDARDIZATION OF DTS – TECHNOLOGY OR METHODOLOGY?

In the scientific academic community, there are different claims and opinions from experts as to whether digital twin is a technology or a methodology. From the analysis carried out, we currently believe that the hypothesis that *digital twins are a methodology is correctly stated* as a scientific statement. Also, at the moment there is no precise regulation - legally normative schedules regarding digital twins as well as defined standards.

It is very important to reach a consensus on a standardized definition of a digital twin. One such example of a standardized description is written in the ISO 23247-1:2021, which states that "digital twin <manufacturing> digital representation (3.2.2) of an observed production element suitable for a specific purpose, with synchronization between the element and its digital representation".

A key part of the methodology is the appropriate definition of the real system and its subsystems, which we want to map into the digital world. It is also important to define the reasons why we want to do this. The next research problem is defining the level of real-world detail that is directly related to solving a real-world problem. It also depends on the definition of relevant data sources and the determination of their quality, which will affect the quality of the digital twin. With the level of detail, we will also determine the smallest unit that can authentically describe the elements of a real system. Unlike technical systems, where humans are not directly involved, the definition of the real world in the organizational system is more complex precisely because of the presence of humans and also the physical environment.

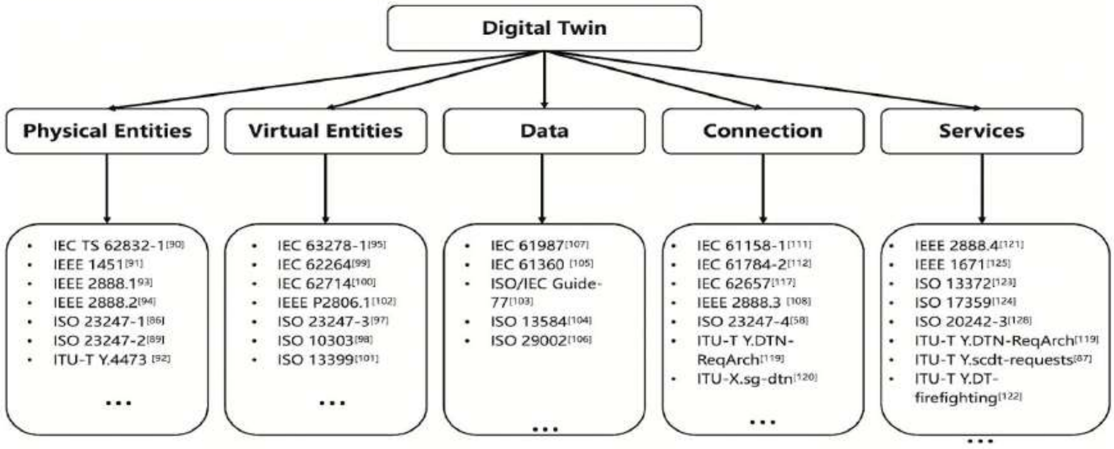

Figure 1. Framework of DTs standards (*Source*: Wang et al., 2022)

Physical entities – In a digital twin system, physical entities have two major functions: data collection and device control. The physical entities serve as data sources and actuating units for virtual entities. The DT standards of various fields have slight differences regarding the boundary of physical entities, due to their specific requirements from the application scenarios. In the field of smart manufacturing, ISO 23247-2:2021 identifies the "physical" object as an "observable manufacturing element", which includes personnel, equipment, materials, facilities, environment, products, and logical objects such as supporting documents and processes. The standard IEC 62832-1:2020 further expands the definition of logic objects to include intangible things such as software, concepts, patents, ideas, methods, and anything that could be defined as an asset of the industry. However, these standards were created specifically for manufacturing or industry digital twins, a standardized definition of overall digital twin should be proposed.

Even though there is no published standard for physical entities of the digital twin, many standards can be reused or referenced, existing fieldbus profiles, companion specification and other specifications that define device and component properties should be transferred into standardized dictionaries, and characteristics of conceptual assets, such as planning documents, should be included in standardized dictionaries.

Virtual entities – In a digital twin system, the virtual entities serve as the digital representation for physical entities. Virtual entities are composed of modeling, in order to describe physical entities via multi-temporal, multi-spatial scales. From the structure perspective, IEC 63278-1 ED1 Asset Administration Shell for industrial applications – Part 1: Asset Administration Shell structure[1] shell structure is the very first standard

[1] This standard is a project and is under development. For more information, see the draft version: IEC 63278-1 ED1 *Asset Administration Shell for industrial applications – Part 1: Asset Administration Shell structure*. Available at

related to the topic of virtual entity, it defines a semantic model that describes characteristics of assets, which is the serialization and exchange format between models, submodules, and AAS, so even though IEC 63278-1 ED1 was designed for industrial purpose, smart city and other verticals may also consider using or adapting this standard.

In the field of modeling, many efforts have been made by various Standard Developing Organizations (SDOs) even before the concept of DT draw much attention. All parts in the ISO 23247 series clearly stated its preference of using existing modeling standards for implementing the standard. The ISO 23247 series have listed several standards such as ISO 10303 series "Standard for the Exchange of Product Model Data", IEC 62264 series" Enterprise-control system integration", IEC 62714 series "Automation Markup Language (AML)", ISO 13399 series "Cutting tool data representation and exchange", etc., those standard are not intentionally developed for the digital twin, but those standards can satisfy most of the use cases with implementation of XML, JSON, RDF, AML, OPC-UA, and any other common data description language or format. In addition to the existing standards related to modeling, activities on developing standards targeting at DT are noted. One of the current projects that have been authorized by the IEEE SA Standards Board to develop a standard is P2806.1 - Standard for Connectivity Requirements of Digital Representation for Physical Objects in Factory Environments. This standard proposed digital representation for digital twin, it defines high-speed protocol conversion, unified data modeling, and data access interfaces for heterogeneous data situations in the digital twin. Therefore, it is recommended to adopt existing modeling standards in DT standardization work.

Data – Data is a driving force for the digital twin. In the digital twin system, the models and information representations are not working independently, the cooperation between different digital twin systems is often involved in data and model exchange, therefore it is essential to standardize data structures, and data properties such as default value, data type, and data format. Much of the technologies related to data processing and management in the digital twin can be achieved by adopting existing standards in data processing.

The data processing and management associated with the virtual entities may need special attention. The models in the digital twin system are changing dynamically according to changes in the physical entities, this means further properties such as timestamps and validity statements are required to be standardized. Also, the synthetic data produced by virtual entities should be ubiquitously identified as different from that from the physical entities, thus identification standards should consider these new

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https://cdn.standards.iteh.ai/samples/72948/d157a3fd85724dc99a7a179b34d2e718/oSIST-prEN-IEC-63278-1-2022.pdf features. These special requirements might lead to the necessity to update some of the existing standards, or even to establish some new ones.

Connection – The connection refers to the communication and interoperability, which jointly enable interconnecting between entities. IEEE proposed an capability framework for this interaction between namely 2888.3, this standard provides a framework overlooking interactions between general objects in cyber and physical world, including capabilities to interact between physical things and digital things (cyber things), capabilities to easily integrate with backend infrastructure / integrate with other external systems, capabilities to access to things by authorized parties, capabilities to describe physical devices, virtual devices, or anything that can be modeled. For interoperability, multiple network coexistence should be considered, to solve this problem, an important standard is OPC UA. With its semantic capabilities, OPC UA supports more than just data transmission, it also contains the information-centric data model, this transfers heterogeneous data into unified information, which enables the secure data exchange industrial systems.

Services - Providing services is the purpose of digital twins. User cases from various fields are collected in standard work. In the field of smart manufacturing, ISO 23247-4:2021 provided three use cases "Dynamic scheduling of manufacturing tasks between multiple robots" in international standards describes model digital twins of product, process, and resources for dynamic scheduling of manufacturing tasks between multiple robots.

In doing so it recommends the development of several standards of varying types around two key themes:

- Digital twin framework for the built environment: This theme takes into account existing work at ISO to develop a digital twin framework for manufacturing so that the built environment approach can be compared to, and aligned with, the approach being taken by other sectors; and
- Digital Built Environment: This theme identifies gaps within the existing standards landscape to facilitate trusted, open, and secure exchanges of information to and between organizations through mechanism such as digital twins.

The presented analysis of digital twin technical standards in this research paper is divided into five dimensions, physical object, virtual object, data, connection and service. Standardization is still one of the main challenges related to digital twins and their use in different fields.

4. DIGITAL TWIN CHALLENGES & BENEFITS

Challenges – There are many implementations in the field of relatively closed technical systems (e.g. wind turbines, aircraft systems or smart factory) and much less in the field of complex socio-technical systems (organizational).

This paper highlights the problem of developing a methodology for establishing a digital twin for the needs of managing complex organizational systems. Although several methodologies for creating digital twins exist in practice, little knowledge exists on how to effectively create a digital twin of a complex organizational system that would support strategic decision-making. Various authors have also pointed out that standardization is key in the development of digital twin methodology. It is important that we have a standardized definition of DTs, because engineers can understand DTs differently from people who are working in the field of organizational science. Only a common language and understanding of fundamental concepts will facilitate the development of this field, enabling better cooperation between the various stakeholders involved in the field of digital twins. It would also contribute to greater clarity in the understanding and implementation of digital twin. The essence of the problem is how accurate and high-quality the mapping of the real world into its digital twin is, and the minimum requirements that define a digital twin. Not every visualization of data from the real world is also its digital twin (Fuller et al., 2020).

Based on the purpose of DTs we must define the granularity which is dependent on the availability of the data and their precision. The quality of DTs is dependent on data quality. And this is also connected with accuracy and quality of the virtual replication of the physical elements. All of these interconnections bring us a challenge when we are intending to create DTs. All of this is also connected to the cost of establishing DTs. During the process we can also try to reduce data sources and instead of that we can calculate virtual data from data we received from sensors. For that we must know correlation between parameters which describe the physical entity. With that we can reduce the costs, but also lose some quality.

Also it is important that at the beginning we don't have a large system but small ones which we can handle. What is also important is that we can later connect different DTs to bigger ones. This could be the case in smart cities or on a country level. The European commission has a project called Destination Earth and the purpose is to provide unique digital modeling capabilities of the Earth to enhance the EU's ability to monitor and model environmental changes, predict extreme events, and adapt EU actions and policies to climate-related challenge.

People should see Digital twins as "a journey, not a destination" (Callcut et al., 2021). This is very important, because with DTs, we make virtual copies of the real entity, which has a life cycle, which is not limited. And the journey is similar, not limited to the end.

In article "Digital Twins in Civil Infrastructure Systems" there is consensus among interviewees that cybersecurity is an issue that needs to be dealt with regarding Digital Twins (Callcut et al., 2021). Another important issue, raised by interviewee B and supported by survey findings, is that Digital Twins are a "methodology and way of working" as opposed to a "product or technology" (Callcut et al., 2021). In the article "Digital Twin: Generalization, characterization and implementation" VanDerHorn and Mahadevan (2021) also pointed out these challenges regarding DTs.

- Organizational culture: Cooperation and collaboration in the sharing of data and models is required among multiple stakeholders, with potentially competing business objectives. Fair value, data security and intellectual property rights need to be ensured among the stakeholders;
- Technology Maturity: DT are likely constructed from a patchwork of technologies and solutions from several different vendors. Technology development needs to prioritize technologies that offer the most meaningful increases in efficiency and effectiveness, considering the current technology maturity which impacts the timeline and cost for such development;
- Verification and Validation (V&V): The DT is typically comprised of a number of different models and processes which require both V&V individually and as a comprehensive system. However, since the DT by definition is unique to the specifically modeled physical system, it may not be possible to validate a single instance, full system model. Extrapolation from individual component model V&V to the full system is challenging;
- Automation: A prominent targeted outcome in many DT implementations is to reduce the manual effort through automation of data exchange and analysis. While development efforts are underway, there is still a strong reliance on human-in-the-loop as part of current solution.

Benefits – The DT process was given a boost from the rise of new technologies, as it resulted in extremely affordable cost-effective implementation. Virtual twins are popular today in business and have been considered a top trend of strategic technology planning in recent years. One of the most important questions answered in recent years is how is the Digital Twin process changing the way we design, plan, manufacture, operate, simulate and forecast the process today?

In the virtual platform created, a physical twin exists as a real-time digitized copy of its real-world self. This "bridge" between worlds, at its core, is used to optimize business performance. This is done through data analysis and monitoring of systems to identify any issues that come to light and ultimately prevent them from occurring and affecting downtime in a real-world setting. Simulations produced help to develop and plan for the future regarding product or service updates within the process.

The benefits are almost incalculable, as they affect all industries including, agriculture, transportation, governmental bodies, security in all levels and retail for example.

Some other benefits of using the DTs are: comprehensive management with a real world system cost savings, better and improved decision support, carried out simulations for risk management, made it possible to find the root cause, etc.

In the article "Digital Twin: Generalization, characterization and implementation" VanDerHorn and Mahadevan (2021) also pointed out these benefits regarding DTs, like connecting previously unconnected data sources, development of computational models, uncertainty quantification, improvement of output delivery/visualization, improvement of data infrastructure and management, etc.

5. NATIONAL SECURITY & DTS – FACING NEW SECURITY CHALLENGES AND IMPLICATIONS

New technologies are dynamically and rapidly entering all segments of national security, they are used in different ways and instead of typical processes. They are of particular importance in the decision-making process.

The fact is indisputable that a large part of the new technologies in the digital decade, especially the use of technology related to digital twins, has many advantages, but parallel to this, challenges also arise (Stoykov, Dimitrova, & Marinov, 2011, p. 541).

In the article, everything stated as an analysis of this new technology for national security is still challenging for only one reason, namely the fact that the technology is new and not yet clearly defined. Too many questions remain to be clarified about the relationship between national security and digital twins, their uses and challenges.

It is now clear that technology used by digital twin plays an important role and will continue to strengthen national security against future threats and cyber-attacks. In particular, technologies can help to identify potential threats, easily share information and protect mechanisms within them.

This research paper provides an overview of the technologies that support the development of digital twin technology. The direct connection of national security to digital twin technology emerges from data. Of particular importance is that the very technologies that are the basis of digital twins are data-based. All decisions that are made are based on data, and from here comes the fact that they must be collected, modeled, stored. For all decisions in national security, it is important that the data obtained be in real time.

Digital twin technology includes Internet of Things (IoT), Artificial Intelligence (AI), Extended Reality (XR)[2] and Cloud Computing. In addition, the Digital Twin uses certain technology, depending on the type of application, to a greater or lesser extent in the field of national security itself. In relation to this, whether it is a hybrid type of threat or a physical critical infrastructure.

For every new technology to be usable, it is necessary *to be standardized, to be regulated and to be described with indicators that report its progress in a strategic document for a certain period of development.*

An analysis was made for this purpose the strategic documents related to the technologies used by the digital twins, and we can conclude that are few countries which have strategic documents regarding the development and use of these technologies in national security. Major countries have made national development frameworks for a period of ten years, usually period is to 2030, and indicate the measures and key development indicators to be achieved by that period.

At the moment, all documents refer indirectly to new technologies or they are described in as part of development strategies for a period of 10 years. The dynamics of development of technologies that use digital twins is exactly the opposite. The development and use of these technologies has been rapid and has promised strong progress and success.

After reviewing the interrelationships of the digital twin technologies used with national security, we can make the following conclusions:

- Smart devices connected to the internet, IoT - are making life more convenient, improving factory efficiency, and saving lives. Because these devices are connected to the internet, they can be located and manipulated by malicious actors, as well as by their legitimate operators. The fast-growing IoT poses disruptive challenges for national defense authorities because IoT devices present new kinds of targets, as well as new weapons to threaten economic and physical security. These disruptive challenges are hard to address with traditional national security policy;
- Artificial intelligence (AI) technologies promise to be the most powerful tools in generations to expand knowledge, increase prosperity, and enrich the human experience. AI will fuel competition between governments and companies racing to use it. And it will be used by nation-states to pursue their strategic ambitions and fulfill national security objectives. The creators of artificial intelligence need to abandon their “tech utopian” mindset, according to the terror watchdog, amid fears that the new technology could be used to groom vulnerable individuals. Jonathan Hall KC, whose role is to

[2] Extended reality (XR) is a catch-all term to refer to augmented-reality (AR), virtual reality (VR), and mixed reality (MR). The technology is intended to combine or mirror the physical world with a " Digital twin world" able to interact with it.

review the adequacy of terrorism legislation, said the national security threat from AI was becoming ever more apparent and the technology needed to be designed with the intentions of terrorists firmly in mind. He said too much AI development focused on the potential positives of the technology while neglecting to consider how terrorists might use it to carry out attacks. The security services are understood to be particularly concerned with the ability of AI catboats to groom children, who are already a growing part of MI5's terror caseload. As calls grow for regulation of the technology following warnings last week from AI pioneers that it could threaten the survival of the human race, it is expected that the prime minister.

One of the main tasks of experts in the scientific community and national security is to analyze the advantages and positive directions of new technologies, and how they can be used in different segments of national security. The fact of the positive effects on national security that all new technologies have is indisputable, but it is a serious challenge to use them because they are not clearly conceptually defined.

CONCLUSIONS

The application of Digital Twins is not limited to the battlefield. In the realm of national security, this technology can be used to simulate and predict the impact of various threats, such as cyber-attacks, natural disasters, or terrorist activities. By understanding the potential consequences of these threats, security agencies can develop more effective response strategies and mitigation measures.

While the benefits of Digital Twins are undeniable, their implementation is not without challenges. Issues such as data security, privacy, and the need for high-quality, real-time data are significant hurdles that need to be overcome. Moreover, the integration of Digital Twins into existing systems and processes requires careful planning and execution. Nevertheless, the potential of Digital Twins to transform defense and national security is immense. As this technology continues to evolve and mature, it is likely to become an integral part of defense strategies, providing a significant edge in an increasingly complex and unpredictable world. Digital Twins represent a powerful tool for defense and national security. By providing a real-time, comprehensive view of the battlefield, enhancing equipment maintenance and readiness, and improving training and preparedness, this technology can significantly enhance the effectiveness of defense strategies. Despite the challenges, the potential benefits of Digital Twins make them a secret weapon worth investing in.

The main purpose of the scientific article is to present to the scientific academic community through the analysis of the main characteristics of this methodology, the main advantages and the benefits of its use, for different cases. We believe that development and improvement of the methodology is ahead because the new technologies that are used are yet to be integrated at higher levels of technological development. For every new technology to be usable, it is necessary to be standardized, to be regulated and to be described with indicators that report its progress in a strategic document for a certain period of development.

BIBLIOGRAPHY:

Callcut, M., Agliozzo, J.-P. A., Varga, L., & McMillan, L. (2021*)*. Digital Twins in Civil Infrastructure Systems. *Sustainability, 13*(20), 11549. https://doi.org/10.3390/su132011549

Fuller, A., Fan, Z., Day, C., & Barlow, C. (2020). Digital Twin: Enabling Technologies, Challenges and Open Research. *IEEE Access, 8*, 108952-108971. doi: 10.1109/ACCESS.2020.2998358

IEC 62832-1:2020 (en-fr) – *Industrial-process measurement, control and automation – Digital factory framework – Part 1: General principles*. Available at https://cdn.standards.iteh.ai/samples/103676/0268bdc5f4e74bc9bdb1c7a082cfc377/IEC-62832-1-2020.pdf

ISO 23247-1:2021(en) *Automation systems and integration – Digital twin framework for manufacturing – Part 1: Overview and general principles*. Available at https://www.iso.org/obp/ui/en/#iso:std:iso:23247:-1:ed-1:v1:en

ISO 23247-2:2021(en) *Automation systems and integration – Digital twin framework for manufacturing – Part 2: Reference architecture*. Available at https://www.iso.org/obp/ui/en/#iso:std:iso:23247:-2:ed-1:v1:en

ISO 23247-4:2021(en) *Automation systems and integration – Digital twin framework for manufacturing – Part 4: Information exchange*. Available at https://www.iso.org/obp/ui/en/#iso:std:iso:23247:-4:ed-1:v1:en

Kukushkin, K., Ryabov, Y., & Borovkov, A. (2022). Digital Twins: A Systematic Literature Review Based on Data Analysis and Topic Modeling. *Data*, *7*(12), 173. https://doi.org/10.3390/data7120173

Olcott, S., & Mullen, C. (2020, March 12). *Digital Twin Consortium Defines Digital Twin*. Digital Twin Consortium. https://www.digitaltwinconsortium.org/2020/12/digital-twin-consortium-defines-digital-twin/

Oracle. (January 2017). *Digital Twins for IoT Applications: A Comprehensive Approach to Implementing IoT Digital Twins*. https://pdf4pro.com/fullscreen/digital-twins-for-iot-applications-oracle-5b4880.html

Stoykov, S., Dimitrova, S., & Marinov, P. (2011). Is science management of knowledge in the system for national security? *International scientific conference, Conference Proceedings 1: Management and military, 14 (2)*. Romania MND "N. Bălcescu" Land forces academy – SIBIU.

VanDerHorn, E., & Mahadevan, S. (2021). Digital Twin: Generalization, characterization and implementation. *Decision Support Systems*, *145*. https://doi.org/10.1016/j.dss.2021.113524

Wang, K., Wang, Y., Li, Y., et al. (2022). A review of the technology standards for enabling digital twin [version 2; peer review: 2 approved]. *Digital Twin*, *2*:4. https://doi.org/10.12688/digitaltwin.17549.2