Smart military bases – a future trend for smarter states

Crăișor-Constantin IONIȚĂ,
Centre for Defence and Security Strategic Studies (CDSSS) / National Defence University "Carol I", Bucharest, Romania
ionita.constantin@unap.ro

Abstract
One main characteristic of the Forth Industrial Revolution is represented by an unprecedental revolution in `smart` devices and their interconnectivity to networks in order to improve our lives. Taking the model of smart cities, which have been adopting advanced technologies for years, the military decision-makers started to reconsider the role and functions of military bases, especialy the forward operating ones (FOB) and those necessary to deploy. Therefore, this paper will analyse how these smart military bases should look like in the medium and long terms to face all current and future risks and threats a headquarters or capability might encounter in the modern operating environment. These aspects include the critical insfrastructure and required joint functions linked in a network and connected to a smart city, when possible. In order to do so, the approach is based on a multidimensional analysis of what have been developed so far in NATO and some Western military, their best practices and research programmes and where thei stend for now. The paper's implication is for Romanian defence authorities and reserachers, because it highlights the necessary steps and measures to establish such type of military bases. As a result, this paper will present to the military decision-makers some clear ideas of the necessity to have such critical military infrastructure inside the Romanian Armed Forces until 2040, as well as the ways forward to develop and experimentate them. This endeavor will ensure originality of the paper and its unicity in the military domain.

Keywords: smart city, key functions, critical military infrastructure, advanced technology.

1. Introduction

More and more modern cities from around te world, including European ones, have adhered to the smart cities programmes for social and economic transformation. This increasingly engagement became possible because of the 21st century revolution – the Forth Industrial Revolution (Industry 4.0 or 4IR) -, which started in the mid-2010s, as an era of connectivity, advanced analytics, automation, and advanced-manufacturing technology. Following this trend, some Western military leaders considered the idea of using civilian proven methods, technology and principles already developed and implemented for smart cities to design and build smart military bases. Their endeavor also includes the Internet-of-Things (IoT) sensor systems, as part of the integrated smart city programmes.

Good governance and military decision-making have almost similar trends. As a general consideration, both have to fundamentally change their way of creating, exchanging and distributing values, by merging the physical, digital, and biological domains into one and governing those smart solutions provided by fast-devoloping technologies. In doing so, military bases face the same challenges as the communities within which they are located. Therefore, it is worthwise considering a military base (or garrison) as a small municipality, dealing with same risks, threats and challenges in providing services to residents, sharing date for improved decision-making, or implementing security measures.

What differentiate a military base from a small municipality is the level of security provided, as well as the protection of military versus civilian critical infrastructures. One aspect is represented by cybersecurity, which increses the security management challenge

and is well orchestrated by the military through integrated cyber defence measures. At the civilian level, the dispersion of cyber protection efforts among different local institutions make it very hard to counter cyberattacks efficiently and quickly. Other difference is seen in the type of security focus between military and civilian managements. If a small city is interested on public safety and privacy, a military base looks more on securing the access to military facilities and weapons systems, relinquishing some privacy of their personnel.

Regarding the protection of military infrastructure, everything is well organised and planned for managing different threats and risks against all facilities. There are action and intervention plans for each type of security protection, which are regularly updated and exercised. For small municipalities, it is very difficult to ensure an adequate level of protection for all critical facilities, especially during peacetime, when local authorities don't envisage an upcoming threat. Therefore, the respective civilian action plans are almost all the time outdated and poor rehearsed.

Not of a lesser importance is the civilian management versus the military command. A small city has a Mayor and other local institutions that ensure democracy and the balance of powers between judicial, executive, and legislative branches. A military base is more regimented and based on orders. Therefore, some times, this military leadership is more efficient and beneficial when integrating and securing smart tehnologies.

When a smart military base is in its permanent location it is easy to connect it to the surrounding community's network through various existing technologies and integrate its smart-enabled devices within the city systems. The main issue for the military leaders is how to implement the drivers of a smart military base (quality of life, local economic growth, security and safety, and efficiency) when deploying such capability outside its permanent location or, even worse, when building a Forword Operationg Base (FOB) in a volatile operating environment.

This paper will analyse some developments and experimentations made by the Alliance and some modern Western Armed Forces regarding the building up of smart military bases as future capabilities to face all possible risks, threats and challenges in the modern battlespace. The analysis will describe the conceptual elements of a smart base framework and will focus on what and how to integrate its components of interconnected sytems with smart cities' ones. It will be followed by a description of where we stend today regarding this concept and how different pilot programmes of it are developed and experimented. At the end, some proposals for the Romanian Armed Forces will be highlighted in order to update the "2040 Armed Forces" transformation, modernisation and endowment programme.

2. Conceptual elements of a smart military base

It is very difficult to start the framework of smart military bases without diffining and understanding the terminology first. The definition of this concept was not yet established or agreed at the military leadership level. This is because the term 'smart city' is still difficult to comprehend, not being yet clearly defined and having multiple facets of initiatives all around the world.

In order to improve operational efficiency, share information with the public and provide a better quality of governmental services and citizen welfare, smart cities implement the Industry 4.0's information and communication high-tech. Therefore, there is a unanimous agreement that the main goal of a smart city is to implement smart technologies and data analysis for optimising city functions, promoting economic growth, and improving the quality of life of its citizens. For the purpose of this article, I will propose the IBM definition of a smart city, as *"one that makes optimal use of all the interconnected information available today to better understand and control its operations and optimise the use of limited resources* [1]*."*

Moreover, evan if there are currently 29 cities in the world with more than 10 million inhabitants, with a trend to increase their number to 43 by 2030 and the fact that the UN predictes that up to 70% of the world's population will live in cities and urban areas by 2050 [2], only few of these cities are in different stages of implementing smart city programmes and initiatives and investing in smart technologies. Among them, the 2023 top smart cities in the world includes: Singapore (contactless payment technology, digital health system, and eco-smart city that is entirely vehicle-free); Helsinki (carbon neutral by 2035); Zurich (sensor technologies for streetlights and environmental data collection, smart building management system to connect city's heating, electricity and cooling), Oslo (electric vehicles by 2025, zero-emission construction sites and retrofitting exiting buildings); Amsterdam (energy efficient roofing insulations, automatically dimming light switches, smart meters, and ultra-low energy LED lights); New York (smart sensors and technologies, smart hubs with contactless technology, and car sharing services); Seoul (the world's first smart city – urban patterns analysis data, senior citizens movement detection and aid, AI detective to flag up potential crime patterns, and the use of 5G technology in mobility and transportation) [3]. Of course, this list does not include some Chinese well advanced cities in this domain, like Shanghai, Hangzhou or Heze. Very exiting is the European Union (EU) project of a smart city in Santander, Spain, where the respective organisation installed 12,500 sensors to measure available parking spaces, traffic conditions, crowd sizes, trash levels, air pollution levels, soil moisture levels, and let people know about surfing conditions, find parking spaces, and provide tourists with information about points of interest around the city [4].

As the Town Hall is at the heart of the small city's management, same are military bases the backbone of the national defence because of housing many thousands of military personnel, employees and their families. To underpin this role, a military base should employ smart technologies in the near future to be better positioned in carrying out its mission. Therefore, the development of smart military bases is the key to tomorrow's fighting force. Nevertheless, their evolution will be based on incremental funding, technology acceptance, and strategic initiatives.

Even if there is no agreed definition of smart military bases so far, the most appropriate is the one provided by Deloitte. In the company's view, a smart military base is *"the integration of technological and process innovations that improve the performance, efficiency, and convenience of the managed assets and services on a military installation*

[4].*"* The main idea of this definition is about the integration of smart devices and best practices to provide a comprehensive set of solutions for the challenges associated with operating installations [4]. A model of this integration of systems within the civilian community is shown in figure 1.

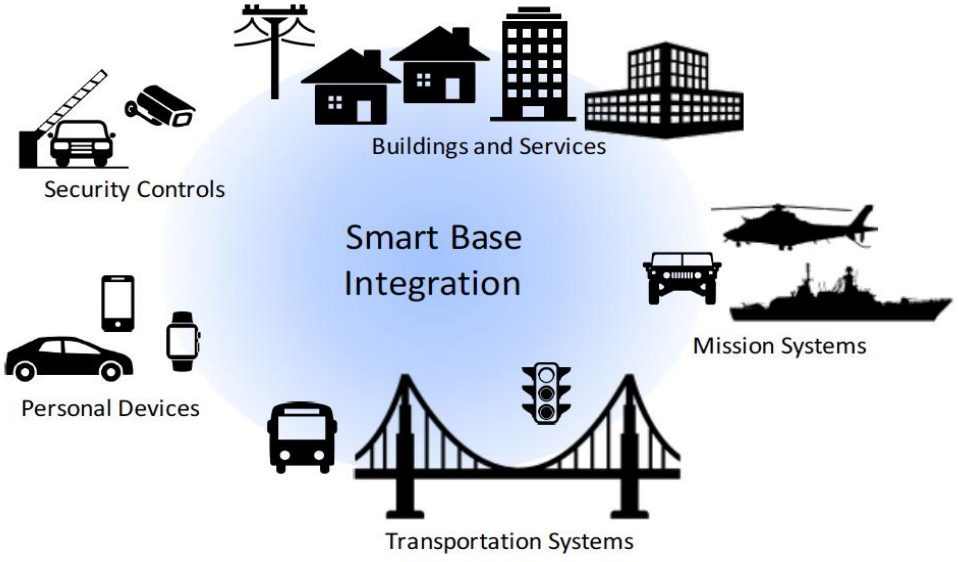

Fig. 1. Smart Base Integration of Systems.
Source: https://nsri.nebraska.edu/-/media/nsri/documents/concept-papers/building-the-smart-base-of-the-future.pdf

According to the 'Smart Base Framework' document elaborated by the US Army in 2021, a smart military base comprises three main components of interconnected systems:

- Security & Safety – those devices relevant to the security of the base's mission and the safety of the workforce (gates, badging access controls, traffic lights, electronic road signs, overhead street lights, and cameras);
- Facilities & Infrastructure – those services frequently reliant on community (power, gas, water, and network connectivity), as well as those that are part of the Building Automation System (BAS) network (elevators, escalatora, lights, alarms, heating, ventilation, and air conditioning);
- Personal devices – IoT that comprises both government-provided and personal equipment (laptops, phones, watches, cars, entertainment systems, toys, and health devices) [5].

The main issue here is whether the base leadership has direct control over these smart-enabled components or not. A centralised command and control (C2) of the interconnected systems creates coordination and efficiency trhough quick prioritisation and resource allocation. It also necessitates the establishment of public/private partnerships with local

authorities and entreprises for a robust base integration, since its services are reliant upon and critical to its surrounding community.

On the other hand, the integrated system could also introduces new risks, like cyber and physical protection. This is why, in the 'Smart Base Framework' document, a solid cyber defence is critical and provides the foundation of the smart military base's components (see figure 2). Potential adversaries, like hackers, criminals, terrorists, or nation - states could provide serious demages, ranging from financial gain, to influence, to information dominance, to denial of service, or to physical destruction [5].

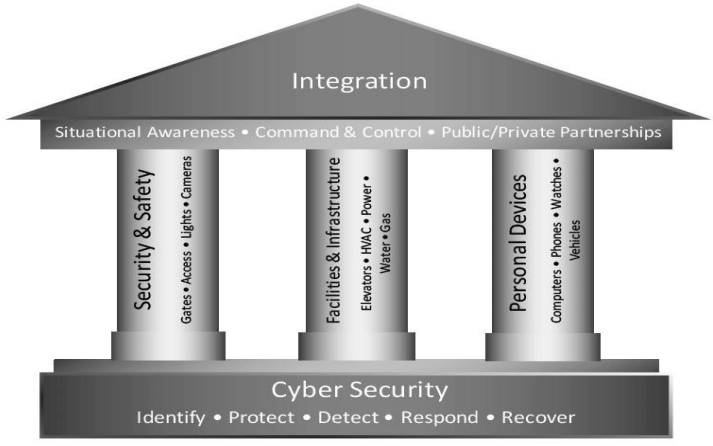

Figure 2: Smart Base Framework

Fig. 2. Smart Base Framework.
Source: https://nsri.nebraska.edu/-/media/nsri/documents/concept-papers/building-the-smart-base-of-the-future.pdf

A model of such smart military base for the future was projected by Honeywell Aerospace for the US Department of Defence (DoD) and is provided in figure 3. Being considered as a true ecosystem, it will encompass advanced technological systems with their equipment to defend against new threats. Thus, the acquisition and introduction of advanced software for digital warehouses or the management and tracking of assets will make these bases more resilient and cheaper to manage, especially if the aim is to upgrade existing ones and not build new facilities [6].

Future smart military bases will adapt the existing model for smart cities, especially with the provision of specific online services and advanced digital platforms. Moreover, in order to be efficient and effective in supporting their emerging missions, smart bases should focus on advanced analytical data systems, artificial intelligence (AI) and robotics to increase their readiness and ensure the multidimensional protection of forces.

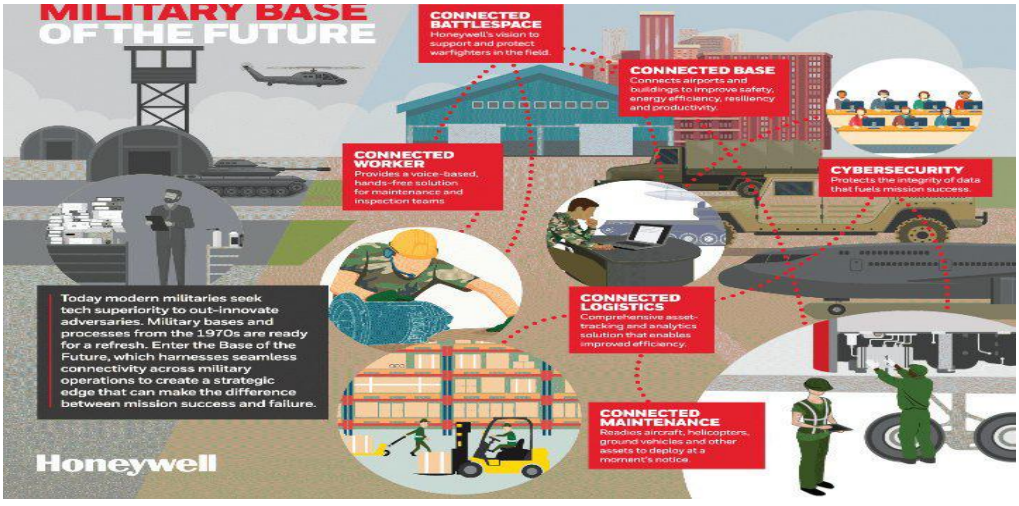

Fig. 3. Smart Military Base for the Future Projected by Honeywell Aerospace.
Source: https://www.army-technology.com/features/connectivity-and-the-military-base-of-the-future/

3. Where are we now in developing smart military bases' projects

In the future operating environment (FOE), military bases are envisaged as integrated into the multidimensional battlespace. This integrated position already pointed out new emerging functions for the respective bases, like multidimensional protection, cyber defence, air resupply, mobile logistic support, or multitasking technical maintenance. All these new emerging functions demand a large volume of data and information (untold terabytes of data every day) to be stored and available at all time in one place. They also necessitate additional fundings either by increasing the defence budget or by obtaining sponsorships from public institutions/private companies. Both requirements make the idea of developing smart military bases for the future realisable for few well developed contries, only.

Therefore, in 2018 the US Army launched an initiative called 'Installations of the Future' where an approach and vision for smart bases was taking shape, as part of the desired warfighting concept for future conflicts – 'Multi-Domain Operations' (MDOs) versus 'the Mosaic Warfare'. From the beginning of this project, the Department of the Army's aim was to make military bases more mission-effective, letting commanders full access and easy use of all available data to improve the decision-making process in such areas as operations, maintenance, and logistics. In doing so, the Assistant Secretary of the Army Installations, Energy and Environment (ASA IE&E) has involved smart cities' authorities, private companies, academic and military research goups, as well as military bases to incorporate off-the-shelf smart devices that can help to improve readiness, resiliency and sustainability for installations.

Moving forward after the US Army issued, in 2020, the 'Army Installation Strategy', covering 2021-2035 and beyond, ASA IE&E presented, in 2021, the 'Army Report on Creating an Army Installations Test and Demonstration Program Using Commercial Technologies' in front of the US Congress. In this report, 16 technologies were required to

be budgeted and implemented through different pilot programmes in some existing military bases, as follows:
• Perimeter access control, linear sensing – enhances security, reduces manpower and need for physical barriers;
• Smart Child Development Centers – provides visibility for safety, security, building operations, and human interactions;
• Modernized master planning – allows community planners to digitally predict physical impacts and costs for physical structures;
• Digital twin for energy and water – provides for improved operations, resilience and "what if" scenarios;
• Optimization of space utilization – analyzes space usage and provides data for stationing decisions;
• Building fault analytics – monitors building systems and provides data for maintenance;
• Real-time facility control analytics – controls and integrates building systems for enhanced response and planning;
• Automated facility assessments – uses technology such as drones to monitor changes in structures and environmental conditions;
• Frictionless entry – eliminates individual stops at the front gates for cleared personnel, enhancing security, reducing manpower and improving quality of life;
• Computer-aided dispatch and traffic monitoring – assists emergency dispatch for first responders;
• Utility monitoring – connects utility monitoring systems for performance improvement;
• Tactical vehicle micro smart grid–integrated installation and tactical energy for increased resilience;
• 5G infrastructure utility energy service contract–tests top secret 5G capability in a controlled environment to transmit data;
• Integrated sensors – tracks and integrates building environment data; CO2, temperature, occupancy rates, sound anomalies
• Autonomous vehicles–personnel and equipment transportation, environmental sensor collection;
• Barracks/building analytics – full building automation and usage integration [7].

For the US private companies with defence attributes, the interest for and involvement in such endeavor was immense and continues to increase. IT companies, like Cloudera and Verizon, started to prepare and put at the military leadership disposal special researches, analysis, studies and laboratory experiments regarding existing IT technology and how it might be incorporate in the transition to a sensor-driven military base. Solutions like IoT, AI and other data-based programmes are already embracing by the military to collect, manage and analyse huge amount of existing data (Data Silos). For modernising military bases to become data-driven, Cloudera already proposed the solution of creating an 'enterprise data cloud' to make machine learning (ML) and analytics easier and control all available data [8]. The US Ignite company led several distinct use cases to develop the 'Smart Installation and Community Dashboard' (SICD) at Fort Moore and to test the viability of 'Smart Transportation Testbed' and a private 'Citizens Broadband Radio Spectrum' (CBRS) wireless network at Fort Carson, as well as 'Automated Vehicles' (AV) and 'Unmanned Aircraft Systems' (UAS) at Butts Army Airfield [9]. Verizon is also deeply

involved in testing 5G networks at some DoD bases to ensure connectivity and security [10].

Numeorus US military bases and defence research facilities were involved in this project from its inception and they are in different phases of small pilot programmes' development and experimentation. For example, the Army's Engineer Research and Development Center (ERDC) started to seek off-the-shelf solutions to modernise infrastructure, security and facility operations and conducts a research project for development and demonstration of an installation access control technology pilot system at Redstone Arsenal Base, in Alabama. This programme will incorporate smart technologies including biometric sensors coupled with data analytics, data fusion, and AI to provide improved protection, faster awareness, and decision options for the installation [11]. Apart from ERDC, the US Department for Army also involved in its project the US Army Research Laboratory (ARL), the Army Material Command (AMC), and the Installation Management Command (IMCOM). Partnerships with other services and their military bases and education and training institutions were established to run additional separate pilot programmes. Recently, some US military bases, like Fort Stewart and Naval Submarine Base King Bay opened smart energy solar plants that allow operations independent of the local power grid. Fort Moore, Fort Bragg and Buckley Air Force Base are also involved in smart mobility initiatives (driverless vehicles) and smart constructions (taxiway and combat training facilities).

Other modern military forces are already involved in developing smart military bases similar with smart cities. India is in a process of elaborating a framework of IoT for smart military bases, focusing on how to monitor a smart base in real time and provide high level security. The Indian Armed Forces' future work includes interconnection of such smart bases with one main headquarter and also in the direction to enhance it's security [12].

Building smart military expeditionary bases in volatile ToO is the biggest challenge for the military in all NATO member states. The special characteristics that a conflict area can have – such as a hostile environment in terms of local population and the existence of an adversary, dangerous weather and climate conditions, land difficult to access, limited resources, reduced or non-existent Host Nation Support (HNS) – and where the North Atlantic Council (NAC) decides to intervene militarily, forced the Alliance to launch a new concept of 'Expeditionary Staging', which it forwarded to a Dutch research and development Consortium of companies for implementation - it includes Royal Haskoning (DHV), Zwarts & Jansma Architects, Poly-Ned Textielarchitectuur and is supported by TNO Defence and Security (D&V). The testing phase will take place at the new established Fieldlab Smart Base Laboratory, in Soesterberg. The prototype developed by this consortium, called 'The Shaded Dome', provides protection against severe weather conditions, low electricity consumption and is easy to lift and dismantle, measuring between 500 and 24,000 m² [13].

So far, the most advanced country in the development of smart military bases' projects remains the US, where the US Army is the cathalist of leading such endeavor. There are several advanced technologies experienced already and in an implementation phase in

some military bases to modernise them. Other modern Armed Forces, from India or members of the Alliance, are in a very incipient phase of discussing the necessity of implementing this theory in the MDO concept or experimenting small pilot programmes. There is no evidence or information regarding the status of the Chinese People Liberation Army (PLA) in the development and experimentation of smart military bases.

4. Conclussions and ways ahead for the Romanian Armed Forces to implement the 'smart military base' concept

The impressive technology evolution and the desire to improve quality of life, economic growth, security and safety, and efficiency demonstrate the necessity of developing smart military bases in the near future, as part of FOE and new warfighting concepts. It should be consider a connectivity network with the surrounding community. Additionally, the leadership of smart military bases could gain increased situational awareness, informed investment strategies, improved C2, and alignment with other military and civilian research innovation initiatives.

There are also some challenges when implementing such smart military bases. The biggest risk is represented by the fact that interconnected systems are easy targets for cyber attacks, especially when this connectivity involves the surrounding community. Some past cyber attacks demonstrated that placing firewalls between IT networks and those smart sensors, cameras, technologies collecting data is not sufficient to prevent them from being exploited by adversary.

Not of a lesser importance is the lack of experienced individuals in the military, having smart cities knowledge and smart technologies expertise or background. Moreover, the military lacks the ability to manage scientific projects and rapidly pilot prototypes. Therefore, it is more suitable and efficient to rely on experts coming from public or private partnerships. At the same level of importance is the additional amount of money which sould be considered for the future. This part of the defence budget will deal with the implementation of the appropriate advanced technologies inside military bases, as well as with interconnecting these technologies to the community network. Therefore, modernising an existing military base will be cheaper than building a totally new smart one.

At the US Armed Forces level there is not established yet a smart military base champion to act as a lead organisation for executing and assessing smart installation pilots, identifying and comparing data collection methods, analysing and determining which installation requirements could be met by smart technologies, and integrating the most promising smart devices into installation operations of the future. An informal proposal was made for the Army Futures Command, considering its role in modernising installations and leading the charge in creating truly smart military bases.

The modernisation of Romanian military installations is paramount for the implementation of new warfighting concepts, including NATO ones, to deal with future conflicts. This approach will also highlight how Romania will projest its combat power in strategic areas of interest. Therefore, a complex and comprehensive analitycal study must be conducted inside the Romanian Ministry of National Defence (MoD) to establish what common

technology is necessary for military facilities, at least at minimum standards. The well-known components should include:

- Sensors – Intelligent Lighting, Smart Kiosks, Smart Buildings, Indoor Positioning;
- Artificial Intelligence/Machine Learning (AI/ML);
- Reliable Network (Typically Wireless) - wired, short range networks, wireless 3G to 5G networks, low power wide area range networks;
- Web/Cloud Based Platform (i.e. WebGIS).

Many of these components are off-the-shelf and adopted by smart city solutions, while some approaches for their use in military installations have been already experienced and are available for consultation.

This modernisation should be incorporated into the "2040 Romanian Armed Forces" programme, as soon as possible. Of course, there will be inherent challenges when introducing new technologies inside existing military bases, like security and privacy, networks, data, and cost. These challenges could be exacerbated for smart military bases located far from the front line or projected outside the national territory. Even so, all smart military bases of the future will have to meet the same criteria, such as: security, resilience, protection of installations against any disruption, optimisation of services and increasing the efficiency of installations.

Beyond these considerations, technology can improve life on the base and avoid millions of euros in environmental impact costs. However, it is far more beneficial to modernise an existing military base instead of building a new smart one from the scratch.

References

[1] TWI Global, [Online]. Available: https://www.twi-global.com/technical-knowledge/faqs/what-is-a-smart-city. [Accessed 20 11 2023].

[2] The United Nations Department of Economic and Social Affairs, 16 05 2018. [Online]. Available: https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html#:~:text=News-,68%25%20of%20the%20world%20population%20projected%20to%20live%20in,areas%20by%202050%2C%20says%20UN&text=Today%2C%2055%25%20of%20the%20. [Accessed 20 11 2023].

[3] O. Lai, "Top 7 Smart Cities in the World in 2023," *Earth.Org*, 05 03 2023.

[4] E. Lessel, B. Beyer and T. Johnson, Byting the Bullet. Now is the time for smart military bases, London: Deloitte Development LLC, 2017, pp. 04-06.

[5] L. A. Nolan, Concept Paper: Building the Smart Base of the Future, Kearney: University of Nebraska, 2020, pp. 03-04.

[6] H. Lye, "Connectivity and the military base of the future," Global Defence Technology, New York, 2020.

[7] A. Braszko, ""How the Army does Smart." Smart Cities and INstallations of the Future," Centre for Army Lessons Learned, Kansas, 2021.

[8] Cloudera, "clodera.com," [Online].Available: https://www.cloudera.com/content/dam/www/marketing/resources/solution-briefs/cloudera-smart-military.pdf?daqp=true. [Accessed 21 11 2023].

[9] US Ignite, "usignite," 2020. [Online]. Available: https://www.us-ignite.org/program/smart-bases-and-installations/fort-carson/fort-carson-smart-transportation-testbed/. [Accessed 22 11 2023].

[10] S. Maucione, "5G is changing the way the military connects its bases and its people," 01 02 2022. [Online]. Available: https://federalnewsnetwork.com/federal-insights/2022/02/federal-insights-smart-base-of-the-future/. [Accessed 22 11 2023].

[11] The US Army Engineer Research and Development Center, "ERDC WERX," [Online]. Available: https://www.erdcwerx.org/installation-access-control-technology-capability-assessment/. [Accessed 21 11 2023].

[12] N. Nailwal, "Smart Military Base," *International Research Journal of Engineering and Technology (IRJET)*, vol. 08, no. 04, pp. 1942-1946, 2021.

[13] C. C. Ioniță, "The "Mosaic" Warfare: a New American Strategy for the Future," *Strategic Impact*, vol. 2, pp. 25-42, 2020.