Digital Twin Technologies in Urban Systems: Integration with Telecommunications for Smart City Development

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ABSTRACT: This paper examines the role of digital twin technologies in urban infrastructure management and smart city development, focusing on their integration with modern telecommunications systems. It reveals the potential of digital twins for real-time monitoring, network optimization, predictive maintenance, and improved service quality. The international best practices and the present technological landscape in Bulgaria are analysed in order to find opportunities for implementing digital twins in cities such as Sofia.

KEYWORDS: Benefits, digital twins, smart city, telecommunication, urban systems

INTRODUCTION

Cities serve as engines for local, national, and global economies. However, rapid urbanization also involves the imperative of making intelligent decisions that ensure a better quality of life for citizens with simultaneous environmental protection and the mitigation of climate change. In response to rapid urbanization and challenges like those mentioned earlier, there is an increased affirmation of the concept of smart cities to answer questions on the management of urban infrastructure. Innovative use of technology in the framework of smart cities enables the design and management of more sustainable and efficient urban areas. The use of modern digital and intelligent technologies is the basis for making a city smart. In recent decades, there has been significant growth in smart cities, with almost every major city in the world adopting or developing smart city technology. Despite its undeniable advantages, the smart city concept also has its limitations, related to the lack of integrated models for its development, which leads to the use of formal strategies that do not always succeed in achieving the set goals. The limitations to the development of smart cities can be overcome by utilizing a digital twin as a next step, which enables the creation of a virtual copy of the city for simulations and management. The report aims to analyse city management through digital twins and the opportunities for the telecommunications sector.

METHODOLOGY

The study applies a structured qualitative approach including:

1. a review of academic and industry literature from 2021–2024 related to digital twins, smart cities and telecommunications.
2. a comparative analysis of international case studies (Singapore, Helsinki, Rotterdam) to identify good practices;
3. an assessment of the current technological context in Bulgaria with a focus on the potential for digital twin implementation.
4. The applied methodology supports the formulation of conclusions on the applicability of digital twins for urban management and telecommunications systems.

Digital twins and smart cities

The development of technologies such as IoT (Internet of Things), artificial intelligence, and augmented reality has enabled the development of digital twins. In essence, digital twins are virtual counterparts of people, physical objects, processes, and systems, representing models based on the use of large volumes of data on real objects, used to monitor, maintain, manage, and predict the

behaviour of real objects. The technology used to develop digital twins is based on connected systems and networks for collecting and transmitting big data.

A digital twin uses data and information collected from sensors and other sources to create a virtual model of a real-world physical object, system, or process. The basis of digital twin technology is the understanding that the digital information structure or construction of a given physical system can be used independently of the real one. The digital information used, which is embedded in the technical system, is used throughout the entire life cycle of the digital twin. The specified technology enables a digital representation of a physical object from the real world, which can be used for analysis and monitoring to achieve real-time optimization of its efficiency. Digital twins are used in various industries because they are important for analysing the behaviour of various physical systems, to improve productivity and overall efficiency, as well as reduce downtime (*Armyanova, 2024a*).

Digital twin technology uses real-time data collected from various internet sources and sensors. Once the data is collected, artificial intelligence, machine learning, or expert systems are used to analyse it. Digital twins have three main functions, namely as a prototype, as an instance, and as a summary of a real object. A digital twin as a prototype is created before the physical object exists to test the design and analyse the processes required to create the future product. A digital twin instance shows a version of an existing physical object and is used to verify its behaviour in different situations. A summary digital twin is based on data collected from different instances of the product and is used to determine opportunities for improvement when creating a new version of the product. The above-mentioned functions of digital twins are implemented using big data and IoT (*Mondal et al., 2024*). To guarantee the security of the data, authorization and authentication mechanisms are used during their collection and transfer between the different components, as well as security protocols (*Armyanova, 2024a*).

The increased use of digital twin technology is due to its many benefits across various sectors. In healthcare, the use of digital twins improves patient outcomes through prevention, early detection, and cost reduction. Using digital twins helps organizations in manufacturing to optimize production, reduce costs, and thereby identify problems in the process. It proves equally effective in the remote management of supply chains in logistics. In construction, digital twins allow for real-time analysis of the functioning of buildings and construction sites, allowing for process adjustments and improved efficiency. The data collected from a digital twin can be used to design future buildings (*Aleksandrova& Parusheva, 2021*). Digital twins can also be used in retail to improve customer experience. To make cities smart, digital twin technology is aimed at creating a simulation environment, testing different public policies, and revealing dependencies and interoperability between different economic and social objects. In addition, the technology improves the engagement of citizens and communities in the more efficient use of natural resources (*Sharma et al., 2022*).

The development of digital twins uses various technologies for interconnected networks and systems, for the collection and transmission of big data, IoT, along with the capabilities of augmented reality and artificial intelligence. An extremely important component of digital twins is good connectivity, which is why 5G infrastructure is used. When building digital twins, two approaches can be used. One approach is related to managing the digital twin from a model, and the second is based on data. Because the first approach requires the use of a mathematical model to create a duplicate of real systems, the implementation processes are often extremely complex due to the constantly changing real object. The second approach uses the capabilities of machine learning and collects large volumes of data reflecting the state of the systems in real time. As established, digital twins use real-time data, which is collected from sensors and various Internet sources. After the data is collected, expert systems, machine learning, or artificial intelligence are used to enable digital twins to perform functions related to prototyping, monitoring, and control of the real object (*Sharma et al., 2022*).

Digital twins are divided into several main types, namely digital model, digital shadow and digital twin (*Mondal et al., 2024*). According to other researchers, the division of digital twins is into prototype (DTP), DT instance (DTI), DT aggregation DT environment, as the capabilities of the digital model and the prototype coincide. The digital shadow and installation contain a one-way influence relationship between the real system and the digital twin. A full-fledged digital twin and digital aggregation have similar functions, but digital aggregation is used to create a prototype of a real object, and not a system of interacting objects. The twin in the environment is connected to interacting groups of real objects (*Armyanova, 2024b*).

The main differences between digital twins and smart cities are presented in *Table 1*.

Table 1. Differences between digital twins and smart cities

CHARACTERISTICS	DIGITAL TWINS	SMART CITIES
ESSENCE	Using technology to create a virtual twin of a physical asset or system (such as a city building).	Using technology to improve the living conditions of citizens, infrastructure, and urban governance.
GOAL	Improving the performance and efficiency of a physical system through real-time data analysis.	Improving the efficiency and sustainability of the urban environment.
INTERACTION	Strategy for visualizing and managing urban environment data in real time. Helps make cities smart.	Concept for urban environment management.
BASIC ELEMENTS	A virtual model, sensors, and data from various sources.	A network of connected systems and technologies embedded in the infrastructure.
APPLICATION	Stimulating the real use of buildings, predicting maintenance of urban infrastructure, monitoring energy use in real time, etc.	Traffic management, sustainable energy use, improving public services, etc.

The technologies used in digital twins are essential for making cities smart. The main goal of smart cities is to address various contemporary challenges, such as population growth and achieving sustainable resource management. Digital twins are crucial in this context because they allow for a virtual representation of city systems and infrastructure. The integration of various digital twin technologies in smart cities allows for more efficient, secure, and sustainable city management.

An important aspect of applying digital twin technologies in urban systems is their integration with Building Information Modelling (BIM). While BIM provides detailed architectural and engineering models, digital twins extend these models by incorporating real-time sensor data, behavioural simulations and lifecycle monitoring. The integration of BIM and digital twins allows for better predictions of building performance, energy use, and maintenance needs. This supports data-driven decisions in urban planning and infrastructure management.

The role of telecommunications

Digital twin technology is built on different layers. The first layer is the device layer, which consists of various sensors and IoT devices that form the real-world object system itself. The device layer is used to collect and send data about the environment and the devices that operate in it. The collected information is key to maintaining the real-world system. Often, the device layer also performs the initial processing of the collected data, as well as trains some of the IoT devices (*Leirmo, 2024*).

The next layer of the digital twin architecture is the communication layer, which provides the necessary infrastructure for data transfer between the real object and the digital twin. In digital twin technology, three types of communication are implemented: between the digital twin and the real object; between the digital twin and the other digital twins in the environment; and between the digital twin and the expert systems that interact with it. The main purpose of the communication layer is to transmit information that guarantees the reliability and security of the digital twins. The communication layer can use various gateways to collect and simultaneously process information from different devices and sensors that have less computing power. The communication layer also includes communication protocols. It is important to specify that, due to the limitations of the network infrastructure, different communication protocols are used to accelerate data transfer (*Horvath&Pouliou, 2024*).

The systems layer in digital twins is used to process and map the data received from the communication layer, which achieves the localization of the various resources. The data is then analysed by artificial intelligence, whose analysis models use machine learning or deep learning. The results of the analysis and predictive data are used to manage individual devices and are transmitted to the last layer of the digital twin architecture, namely the end-user application layer. In the user layer, the user sends various requests to the digital twin to be able to receive up-to-date information and forecasts, and through it to have an impact on real devices (*Yang, 2024*).

IoT devices are used in the architecture of digital twins to collect information from sensors on the real object or end devices. To achieve data collection and to have correspondence with the real object, there must be a high-speed connection that allows the inclusion of devices in the IoT. Technologies are also used to collect and analyse big data from devices, which is then provided to machine learning systems. The main goal of machine learning in digital twin technology is to detect possible problems and reduce unwanted results. In this regard, the security of data and its transfer between the different components should be guaranteed by using authorization mechanisms and security protocols (*Armyanova, 2024b*; *Leirmo, 2024*).

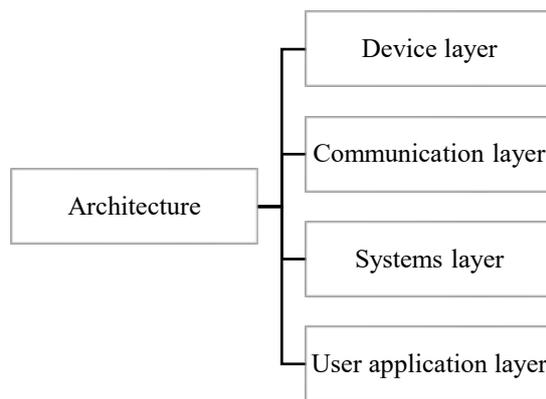In summary, the architecture of digital twins is presented in *Fig. 1*.

Fig. 1. Architecture of digital twins
(authors' source)

Connectivity is essential for digital twin technology. For example, smart cities should ensure that data is extracted and transferred from one device to another for analysis. In this regard, cities should consider the quality of the telecommunications networks used as part of the digital twin strategy. 5G technology allows for secure and reliable data movement when using digital twins. On the other hand, digital twins can improve the deployment and use of the 5G network. The use of digital twins will allow different telecommunications operators to configure, test and optimize their existing infrastructure and explore the possibilities of using 5G while limiting the risks of making mistakes and deviations from preliminary goals. To make cities smart, digital twins will allow telecommunications operators to perform various calculations to plan the network load and limit potential failures when it is overloaded. Digital twins are also a prerequisite for faster replacement of existing infrastructure and accelerated access to the 5G network for more users (*Nguyen et al, 2021*).

Digital twin technology has significant advantages for the telecommunications sector. In telecommunications, digital twins are used to reproduce assets, activities, and telecommunications systems. The benefits of digital twins for the telecommunications sector are not only associated with the simple reproduction of systems. Their use allows data analysis, through which the benefits of different types of solutions can be modelled and predicted, which to improve the efficiency of the telecommunications network used. Digital twin technology has the prerequisites to allow the overall improvement of the efficiency of communication networks and infrastructures, as well as the management of telecommunications in cities. The significance of digital twins for the telecommunications sector is related to increasing the productivity and flexibility of decision-making and reducing operating costs for telecommunications operators (*Attaran & Celik, 2023*).

The benefits of using digital twins in the telecommunications sector should not be considered the same as those of artificial intelligence. The used artificial intelligence algorithms allow for data analysis based on which predictions can be made. Digital twin technologies allow analysis and predictions to occur in real time for a specific object, including critical infrastructure, thereby increasing efficiency and limiting risk situations. The transition from using artificial intelligence to digital twins in the telecommunications sector is a significant advance, and for the time being, the transformation is extremely slow. The basis of the mentioned transition in development is the use of artificial intelligence algorithms, through which data can be predicted and

analysed. The inclusion of digital twins in the telecommunications sector allows for upgrading the system and immediate monitoring of the real results of the decisions made (*Weichbroth et al.,2024*).

There are many examples of digital twins in telecommunications, the main ones of which are presented in **Table 2**.

Table 2. Use Cases of Digital Twins in Telecom

AN EXAMPLE	BENEFITS
NETWORK OPTIMIZATION AND RESOURCE ALLOCATION	• IMPROVING EFFICIENCY. • INTELLIGENT ALLOCATION.
PROACTIVE MAINTENANCE	• ANTICIPATE POTENTIAL PROBLEMS. • FLEXIBLE RESPONSE.
ACHIEVING SUSTAINABLE ENERGY EFFICIENCY	• REDUCING COSTS. • REDUCING CARBON FOOTPRINT.
IMPROVING THE QUALITY OF SERVICES OFFERED	• POSSIBILITY FOR PERSONALIZED SOLUTIONS. • INCREASING THE NUMBER OF SATISFIED CUSTOMERS.
ANALYZING USER BEHAVIOUR	• ANALYSIS OF BEHAVIOURAL DATA. • PERSONALIZED OFFERS AND MARKETING.

Network optimization and resource allocation – digital twin technology allows for increased efficiency of telecommunications networks and intelligent distribution of communication. The use of digital twins allows telecommunications companies to allocate their available resources more efficiently by simulating the traffic and network conditions and predicting the areas where more resources will be needed. The use of digital twins allows for realistic network modelling and testing, which, on the one hand, reduces costs for telecommunications companies and, on the other hand, limits the risks of network outages. This is an exceptional technological progress because it allows the telecommunications sector to analyse and predict data in real time and to react flexibly, according to the specific situation (*Nguyen et al, 2021*).

Proactive maintenance – digital twins can predict network-related problems before they happen. Predictive network maintenance reduces costs and limits downtime. By using digital twins, telecommunications operators can minimize downtime for their customers by flexibly organizing the necessary network maintenance activities (*Weichbroth et al.,2024*).

Achieving sustainable energy efficiency – in telecommunications, the use of digital twins is a prerequisite for creating environmentally friendly routes. The reduction in carbon footprint is due to more efficient use of energy, both in data centres and for various network operations. The use of digital twins is a prerequisite for telecommunications companies to reduce their costs by using energy more efficiently and adopting sustainable practices.

Improving the quality of services offered – digital twins allow for simulating the network used and its efficiency, which is a prerequisite for improving the quality of services provided. Another advantage of digital twins for the telecommunications sector is a flexible solution to customer needs and personalization of services, which increases customer satisfaction (*Attaran & Celik, 2023*).

Analyzing user behaviour – analyzing customer habits allows for the creation of personalized conditions, depending on specific telecommunications needs. In the process of providing flexible solutions, the analysis of data from digital twins is key to achieving efficiency. The specified data also allows for the use of more effective marketing strategies by analyzing data related to user behaviour, which is a prerequisite for increasing their engagement (*Seilov et al., 2021*).

Digital twin technology enables improved relationships between telecommunications companies and their customers. Simulating the interaction between users and the network allows the telecommunications sector to analyse the preferences and overall behaviour of its customers in detail. This information allows the creation of flexible solutions and personalized offers.

As a technology, digital twins have significant advantages for business. For example, more companies are using the so-called cloud services (Cloud Computing), which change the traditional use of information technology and use a network in which providers unite the resources used by different users. The used Cloud Computing systems are of different types, one of the most used is "Data-as-a-Service", in which the service is provided by providing users with disk space for storing large volumes of information, as well as providing instant and convenient access to it through requests. Digital twin technology can be used in the "Data-as-a-Service" system as providing companies as users with the opportunity to analyse their data in real time, which is stored on the disk space of cloud service providers. The above services can also be provided through public-private partnerships between companies providing cloud services and using digital twin technology with municipalities, thereby supporting the management of infrastructure, including new buildings in municipalities.

Applications and international practices

In recent years, the concept of smart cities has been increasingly gaining popularity for achieving sustainable and efficient urban development. Smart cities use modern technologies in various fields, including the provision of various types of public services, infrastructure management, transport control, efficient use of energy and natural resources, etc. Digital twin technology is key to the development of smart cities because it helps increase sustainability and efficiency. The benefits of digital twins for smart cities can be seen from several aspects (*Hu, 2023*; *Tuker&Paweloszek, 2024*):

- Infrastructure management - digital twins support the monitoring and management of critical objects in cities, such as buildings, roads, and bridges. The integration of sensors and the use of data from various virtual models allows local authorities to optimally use resources, detect problems, and predict the needs for maintenance and restoration activities.
- Traffic regulation - congestion in cities increases pollution, leads to economic losses, etc. Digital twin technology provides real-time traffic data and information by analyzing road conditions and vehicle movement, supporting changes in traffic light signalling and simulating overall traffic in individual areas to improve mobility.
- Improving energy efficiency – smart cities are increasingly focusing on reducing their carbon footprint and optimizing the use of natural resources. Digital twins allow for real-time monitoring of energy use, including street lighting, heating of public buildings, etc., as well as simulating opportunities for reducing energy consumption, which not only saves costs but also protects the environment.
- Urban development – digital twin technology is changing the way urban planning is done by providing information and data related to zoning, land use, and compliance with legislation. Local authorities can create virtual models of urban planning and evaluate them for their environmental impact.
- Water management – digital twins allow local authorities to achieve sustainable water supply while simultaneously reducing the risks of drought or flooding. Digital twins allow for monitoring of water distribution networks, predicting consumption patterns, and using resources more efficiently, thereby achieving water savings.
- Increasing safety and responding to various emergencies - digital twin technologies allow city authorities to monitor in real time the crowding of people, the commission of anti-social acts, and the occurrence of emergencies. The use of data from IoT sensors and video surveillance cameras allows for quick action and more efficient use of available resources. During emergencies, digital twins allow for the rapid creation of various evacuation plans, event analysis, and resource allocation.
- Improving waste management to reduce pollution and improve public health. Digital twins allow for monitoring the rate of waste generation, monitoring the capacity of landfills, and optimizing transportation routes. By analyzing predictive data from digital twins, cities can identify opportunities for waste recycling.
- Involving citizens in city governance - digital twins provide an opportunity for citizens to be more actively involved in the management of communities. The visualization and analysis of information, as well as the creation of virtual models, are a prerequisite for increasing citizens' trust in local government and encouraging their cooperation.

Several cities are already successfully using digital twin technology. For example, Singapore is using the technology to create an innovative project that uses vehicles equipped with lasers and building sensors to create a digital twin of the city. The created twin tracks and analyses in real time the above-ground elements (green spaces, roads and buildings), as well as the city's underground infrastructure (*OECD OPSI, 2025*). In Helsinki, 3D city models have been created to visualize the city environment. The created models are based on photographs of objects and digital twin technology to create images in a network structure (*City of Helsinki,*

2025). The digital twin of Rotterdam uses sensors and real-time data to analyze traffic, energy and natural resource use, emergency services locations to ensure rapid response to emergencies, etc. (*European Commission, 2019*).

Current situation in Bulgaria

Currently, Bulgaria is experiencing an increase in the use of the transport network and electricity, and the increased use of private cars leads to inefficient use of public transport in large cities. As a result, the temperature in large cities increases, air quality deteriorates, and the carbon footprint on the environment increases. To limit the above problems, various solutions are being sought for the implementation of innovative, low-carbon, and energy-saving technologies. Examples in this direction are the entry of radio networks into the Bulgarian market, which are designed for the use of IoT in various areas, such as the energy sector, air quality monitoring, agriculture, waste collection and disposal, management of communication networks, etc. In Sofia and other large cities, initiatives have been implemented for free Wi-Fi for citizens in public places, including buildings, museums, libraries and parks; a service for shared trips with electric scooters to reduce traffic in the central parts of cities, etc. However, in most of the cities in the country, the process of implementing smart technologies is in its infancy or is completely absent. It is necessary to undertake activities to improve the infrastructure, to use innovative and low-carbon technologies, as well as to improve the awareness of citizens about the importance and ways of using smart solutions in cities.

An idea for a pilot project that can be implemented is the creation of a digital twin of Sofia, which would improve not only transportation but also air quality. *Fig. 2* presents the technologies that should be used to create a digital twin in Sofia, namely smart devices and sensors, IoT devices, big data and high-speed connectivity. Digital twins use IoT devices to collect data from various real-world objects and end-user devices. To collect the specified data, a high-speed connection (preferably 5G) is required, through which all IoT devices can be connected to a single network. Big data storage and processing technology is necessary to achieve their analysis through machine learning. Machine learning itself allows for making predictions and providing various strategies for city management. It is important when creating a digital twin of Sofia to ensure the security of the data that is collected and transferred between different devices.
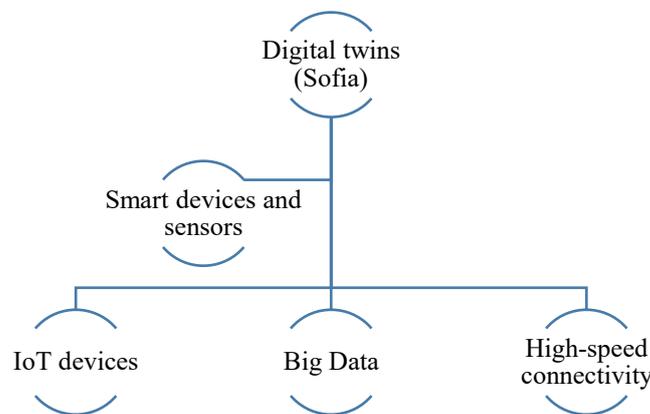

Fig. 2. Technology of digital twins (Sofia)
(authors' source)

The technology mentioned for creating digital twins in Sofia can also be applied to a university campus. Digital twin technology allows for the creation of a so-called living lab on university campuses, in which real processes related to energy, security, mobility, etc. can be modelled. The technologies used in the living lab can be different, such as IoT sensors, private 5G, AI analytics, to support the absorption of knowledge from practical application and the establishment of the results of the digital twin technology. The basis of the living lab created on university campuses is the use of digital twins to model and simulate various processes, to achieve their optimization. The basis of these processes is data and their intelligent analysis, based on a physical process or system and its accurately reproduced digital twin of data, which makes it controllable, repeatable and documentable (for example, the technology can be successfully used to analyse the efficiency of using various energy sources in buildings or improving the electrical energy used after applying a smart grid). The creation of such living labs using digital twin technology creates potential

for knowledge transfer to businesses and municipalities, based on the real-world testing of different models and evaluating their effectiveness.

In creating digital twins, telecom operators in Bulgaria, such as A1, Vivacom, and Yettel, play a significant role, because they can create an exclusive 3D model of telecom equipment in cities and individual buildings. As a result, an exact digital copy of a physical asset is created, which can be used for simulations and planning of various scenarios for managing telecommunications in the city. There are also significant challenges in using digital twin technology in Sofia. The main challenge is related to financing, due to the need for significant investment in smart devices, sensors, and high-speed connectivity. A video surveillance system and analytical processing of video information should be built in the city; a street lighting system should be built with adaptive light regulation capabilities, depending on the load on the road sections; implementation of smart sensors for traffic management, including in surface and underground urban transport; creation of new digital communication connectivity; provision of communication equipment from MAN connectivity, improvement of the optical network, etc. A significant challenge is also associated with 5G technology, which enables the use of IoT devices. Although 5G technology is available in Bulgaria, it is not accessible to all users, because new antennas and infrastructure to support the network need to be installed. However, in the future, there is expected to be a significant increase in the number of antennas and network coverage, which will allow more users to benefit from the technology. As it has been established, digital twins combine various technologies with artificial intelligence, and their use provides an opportunity to increase the intelligent management of systems and objects. However, for the use of the digital twin to make sense, it is necessary to have effective communication through which to achieve data transfer and processing in real time. In this regard, a significant challenge remains the effective use of computing resources, networks, and secure data storage.

DISCUSSION

The analysis shows that the implementation of digital twins in urban systems requires not only technological readiness but also coordinated governance, integrated data platforms and reliable communication infrastructure. Although international examples demonstrate clear benefits for traffic optimisation, infrastructure monitoring and energy efficiency, Bulgarian cities still face several limitations — fragmented data systems, uneven deployment of IoT networks, and insufficient high-capacity computing resources.

Bulgaria's telecom industry has immense potential for the adoption of digital twin technology mainly due to the expansion of 5G and cloud services. However, a digital twin will effectively work if there are standardized mechanisms for data exchange and cybersecurity along with long-term investment in sensor networks.. The results highlight that progress depends on collaboration between municipalities, telecom operators and universities, as well as pilot implementations such as a digital twin of Sofia.

LIMITATIONS

The paper is bound by a number of limitations: first, the lack of any empirical implementation of an urban-scale digital twin in Bulgaria prevents any quantitative validation; second, many international sources describe general conceptual frameworks without detailed engineering specifications, hence limiting technical comparisons. Conclusions are therefore mostly based on theoretical analysis and documented case studies.

CONCLUSIONS

The emergence of smart cities is driven by the need to address significant urban challenges related to population growth, resource scarcity, and sustainability. Digital twins play a key role in making cities smart because, by integrating artificial intelligence technologies, digital twins enable more efficient, secure, and sustainable city management. A digital twin of a city should be created as a virtual replica of its physical infrastructure and operating systems, and the model should include buildings, roads, transportation systems, energy networks, network communication, etc. Using real-time data collected from IoT sensors, digital twins allow city authorities and planners to visualize, analyse, and optimize city management. The future development of smart cities is increasingly linked to the need to use digital twins and high-speed connectivity. As technology advances, digital twins are expected to become more sophisticated in terms of technology and devices used, and more accessible for application in various fields. Digital twins are already being applied in the transformation of many cities into smart ones, such as Singapore, Tokyo, London, Barcelona, etc. In the future, the integration of emerging technologies, such as advanced artificial intelligence, 5G, and machine learning, is expected

to further enhance the application capabilities of digital twins. By using them, cities will be able to more effectively manage their resources and respond to various urban challenges with greater precision and flexibility.

Digital twins represent a strategic foundation for future urban development, especially when combined with advanced telecommunications and 5G connectivity. Future work should focus on pilot implementations in Bulgarian municipalities and the development of unified digital platforms enabling real-time data exchange between urban systems.

In summary, recommendations should be made to:

- Municipalities - use of digital twin technology for more effective management of urban infrastructure, including through public-private partnerships with business.
- Telecoms - use of digital twins to improve network optimization and resource allocation, achieve sustainable energy efficiency, improve the quality of services offered and analyse user behaviour.
- Universities - use of digital twins to create the so-called living lab, to create prerequisites for practical acquisition of knowledge by students, as well as test the effectiveness of various technologies (such as IoT sensors, private 5G, AI analytics, etc.) for intelligent management of systems and processes.

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