

**“THE INFRASTRUCTURE ORGANISM AND BIM
FOR SAFEGUARDING NATIONAL INFRASTRUCTURE”**

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*EGM THEME: THE NIGERIAN ECONOMY AND THE CHALLENGES OF CONSULTING
ENGINEERING PRACTICE UNDER THE THREATS OF INSECURITY*

1. INTRODUCTION

This paper addresses the challenges posed by insecurity to critical national infrastructures from two perspectives.

- I. The need to tackle the root cause of national insecurity and other factors which militate against the development of national infrastructures on a sustainable basis.
- II. The need for consulting engineering practices to leverage technology to mitigate the impact of insecurity on the development of national infrastructures.

2. DEFINITIONS: In tackling the first part of the presentation, we shall begin with some definitions. **Infrastructures** are the facilities and systems that are essential to the development and growth of society, enterprises, and economies. At the national and subnational levels, infrastructures may be classified into four broad categories:

2.1. Physical infrastructures include roads, housing, public buildings, water supply, sanitation and sewage, power supply, transportation, pipelines, telephone, and internet etc. Engineers are familiar with this group of infrastructures; they play key roles in their creation and maintenance.

2.2. Social infrastructures are those facilities that help sustain the development and growth of society such as educational institutions and systems (schools/universities etc.), healthcare institutions (hospitals etc.), law enforcement institutions (police force), religious bodies etc.

2.3. Organizational infrastructures are those organs and systems required for government and the economy to function. These include the political system, judicial system, legislature, financial system, revenue generation system, defence system etc.

2.4. Knowledge infrastructures are those systems that enable us leverage technology to enhance performance in all areas of human endeavour. They comprise the network of people, artifacts and institutions that generate, share, and maintain specific knowledge about the human and natural worlds. Shared reliable knowledge is one of human societies most precious resources. Key elements which drive this resource have changed very rapidly in recent times. These **disruptive technologies** include Artificial Intelligence (AI), Internet of Things (IoT), Cloud Computing (CC), Robotics (R) etc. The application of these technologies has resulted in new ecologies and changed embedded social norms, relationships, ways of thinking and working with resultant redistribution of power and authority. For instance, data-driven decision making (DDDM) which involves decision making backed up by hard data is replacing decision making based on observation, intuition, or experience in many areas of human endeavour. We saw this play out during the Covid-19 pandemic when, in the highly organized economies, the vast amount of data generated from GSM usage was used to predict the spread and therefore management of the Covid-19 disease. GSM activity was also used in some states in Nigeria to determine those to access the Covid-19 palliatives thus transferring power from the local chiefs and community leaders to technology.

3. THE INFRASTRUCTURES ORGANISM

National, human, and economic development require extensive interplay of the nation's physical, social, organizational and knowledge infrastructures. It has been established that for a nation to have security and sustained economic development, it must put in place a national framework that provides the platform and methodology for the four infrastructure categories to work together. Such a national Infrastructures System may be likened to a human body. Fig.1 shows the **Infrastructure Organism** which is comprised of a head, heart, stomach, and limbs.

3.1. The Head of the infrastructures organism is **Knowledge Infrastructures**. It is here that all the thinking, planning, and coordination necessary for the success of any part of the body is done. It is a fact of life that no matter how beautiful the rest of the body may look, if the head is defective, the functions of all the other parts of the body will lack coordination and over time, may result in paralysis or death of the organism. Nigeria's infrastructures are so dilapidated because Nigeria's Knowledge Infrastructures, as defined above, have been ignored over the decades.

3.2. The Heart of the infrastructures organism is the **Organizational Infrastructures**. The heart sends the lifeblood to all parts of the organism. Just as a defective heart results in stunted growth because it cannot maintain adequate supply of nutrients to the parts of the body, defects in the political system, judicial system, legislature, financial system, revenue generation system, the defence system, etc. result in insecurity and stunted national development.

3.3. The Stomach of the infrastructures organism is the **Social Infrastructures**. The stomach produces the nutrients that feed all other infrastructures. The nutrients are the human beings who are the products of the educational institutions and systems, healthcare institutions, law enforcement, traditional and religious institutions etc.

3.4. The Limbs of the infrastructures organism is the **Physical Infrastructures**. The limbs provide the structures which enable mobility and facilities for the convenience and well-being of the organism

Just as the object of human beings is the life-long pursuit of physical emotional and spiritual fulfilment, the object of the infrastructure organism is the pursuit of human development and prosperity on a sustainable basis. The quantum and quality of national development depend on the effectiveness of that interplay. For example, an effective educational system (social infrastructures) will produce people who effectively man the political system, the knowledge generation and application systems, the organs responsible for the provision of water, roads, etc. On the other hand, if the heart is defective, i.e. the political system, judicial system, legislature, financial system are defective, they cannot provide the organizational framework necessary for the development of power supply, water supply, education, healthcare delivery or knowledge generation and application systems.

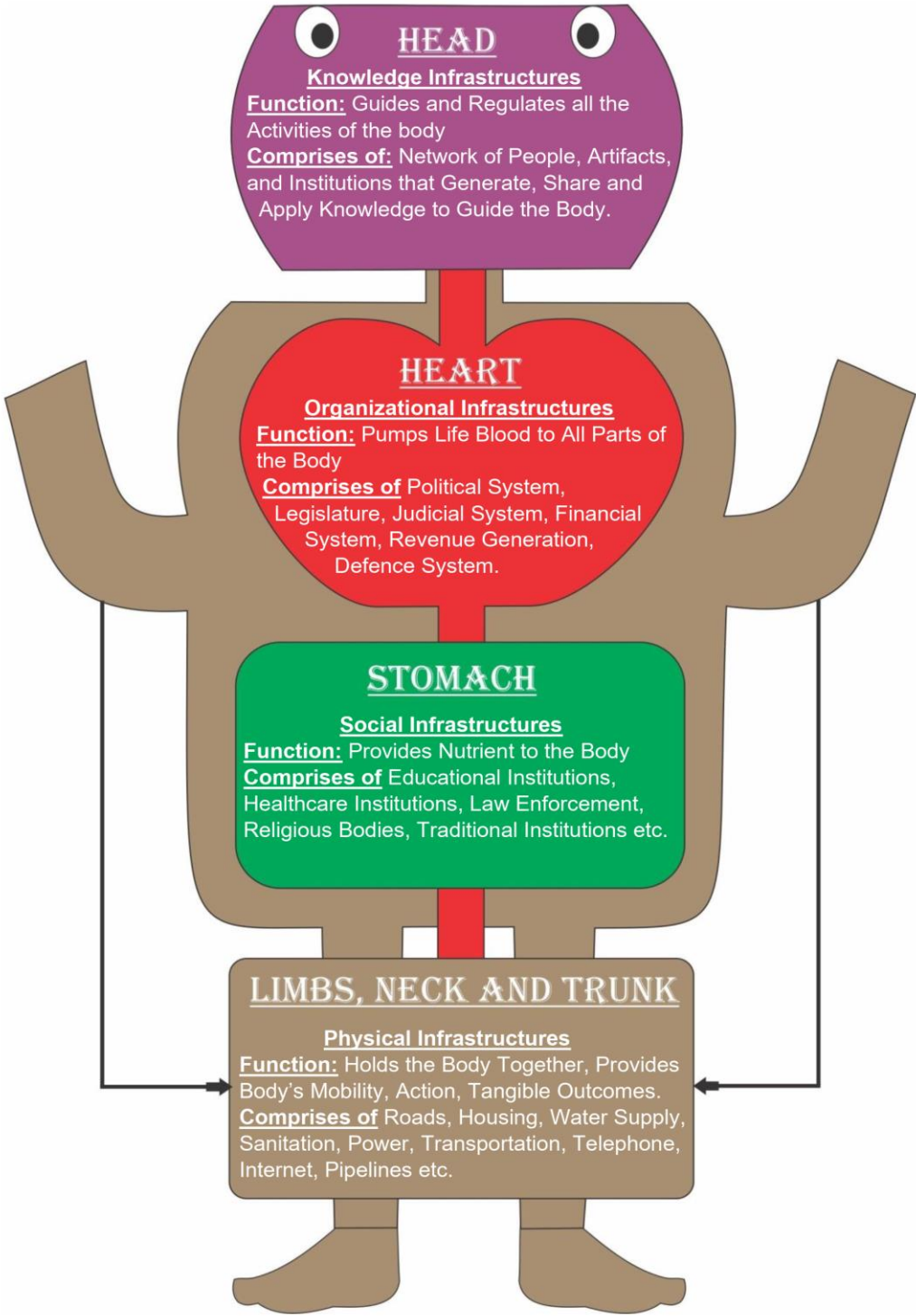


FIG. 1: THE INFRASTRUCTURE ORGANISM

4. MORE DEFINITIONS

In order to understand the key factors that impact national development, we need more definitions as follows:

4.1 Science is the reasoned investigation or study of phenomena aimed at discovering enduring principles among the elements of the phenomena. The scientific method involves the identification of such phenomena, gathering relevant data, using the data to formulate a hypothesis, and the testing of the hypothesis empirically.

4.2 Technology is the knowledge, making, modification, and usage of tools, machines, techniques, crafts, systems, methods of organization to solve problems, improve on pre-existing solutions to a problem, achieve a goal or perform a specific function. It can also refer to a collection of such tools, machinery, modifications, arrangements, and procedures. Technology is the consequence of science and engineering. For instance, science might study the flow of electrons in conductors and the knowledge gained, used by engineers to produce tools such as semiconductors, computers, and other forms of advanced technology. The development of technology may draw from many fields of knowledge including scientific, engineering, mathematics, linguistic, and historical knowledge to achieve some practical results. In other words, there is no area of human endeavour which cannot be managed through appropriate technology.

4.3 Engineering - Consulting Engineer: Engineering is the goal-oriented process of designing and making tools and systems to exploit natural phenomena for the convenience of man often using the techniques of science. The consulting engineer is that engineer who is equipped with the knowledge of science, technology, and business makes a livelihood by providing independent engineering services to clients for a fee.

4.4 Innovation And National Innovation System (NIS). Innovation is the process of making an idea or invention into a good or service that creates value and brings about positive change. The innovation process may involve improving existing methods, practices, and technology, or starting from scratch. The National Innovation System is the flow of technology and information among people, enterprises, and institutions in a nation. This is key to the innovative process at the national and sub-national levels. Put simply NIS includes all the economic, political, and social factors which sustain the national development process. These include the financial system, organization of private firms, the elementary, secondary and university education systems, labour markets, culture, regulatory policies, and the strength of the innovation institutions.

So, NIS is ***“the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies.”*** Because of the

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large variety of factors involved in NIS, no nation's innovation system is the same as others. Each system is unique and needs to be developed and implemented by local expertise.

The Nigerian NIS policy is captured in the Science, Technology and Innovation policy (2011) which reflects the renewed commitment of the Nigerian government **“to deploy S&T as the fulcrum of all activities, geared towards realizing the nation's potential as a global economic power.”**

4.5 Research And Development (R&D) refer to innovative activities undertaken by corporations, institutions, or government agencies for developing new products or improving existing ones. National Economic development results from the R&D ecosystem which comprises universities, research institutes, technical businesses, entrepreneurs, start-ups, venture capital etc.

4.6 Data are characteristics or information that are generated in devices or collected through observation and are stored for reference and analysis. **Hard data** are data generated from devices and applications such as phones, computers, sensors, smart meters, bank transaction records etc. Such information is called hard data and can be measured, traced, and validated. Users have confidence in information from hard data. **Soft data** are based on qualitative observations such as ratings, surveys, polls etc. We also have **Big data** which is a combination of structured, semi-structured and unstructured data collected by organizations that can be mined for information and used for predictive modelling and other analytical applications. Companies use big data to provide better customer services and making faster and more informed business decisions. Hard, soft, or big data can be used nationally as a tool to make more informed economic decisions that greatly impact national economic development.

4.7 Corruption is defined as a form of dishonesty or criminal offense undertaken by a person or organization entrusted with a position of authority, to acquire illicit benefit. Forms of corruption include bribery, extortion, cronyism (improper appointment of friends and associates to positions of authority), nepotism (favoring of relatives or friends, especially by giving them jobs), parochialism, patronage, graft, and embezzlement.

There are different scales of corruption. **Petty corruption** are small favours between a small number of people. **Grand corruption** affects the government on a large scale. When corruption is so prevalent that it is part of the everyday structure of society, it is called **Systemic Corruption**. Nigeria suffers from a high degree of systemic corruption. The National Bureau of Statistics publication of August 21, 2017, revealed that **“on average, about one bribe is paid by every adult citizen of Nigeria to a public official and that the average amount paid in cash for a bribe is equivalent to a fourth of the average monthly salary.”** The other forms of corruption, which may be called non-financial corruption, abound

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in Nigeria. Cronyism, nepotism, parochialism, and patronage destroy confidence in the system and dull the competitive edge. The damage to the national ethos caused by non-financial corruption is as bad if not worse than that caused by financial corruption because of the absence of the legal framework to apprehend and punish those guilty of those forms of corruption. Corruption is a hydra-headed monster that consumes everything in its path. The way to curb corruption is not just finding and punishing corrupt people. Tackling corruption requires educating our people, from kindergarten to adulthood to eschew corruption in all its forms, acquire the right attitude to life, and respect/obey rules and regulations set up to regulate orderly management of society. Corruption can be curbed by extensive deployment of technology in all areas of our activities.

4.8 Politics and Political Engagement. Wikipedia defines politics as a set of activities that are associated with making decisions in groups or other forms of power relations between individuals such as the distribution of resources or status. The Concise Oxford Dictionary has two definitions for a politician. (1) A person who is professionally involved in politics, especially as a holder of an elected office. (2) In certain climes politicians act in manipulative and devious ways typically to gain advantage. While we must reprehend politicians, who act in manipulative and devious ways, it must be stated that politics provides the framework for making decisions that involve the distribution of resources. The importance of politics in the delivery of infrastructures is underscored by the fact that the which, why, where, what, when and how of infrastructures are all political decisions. We note that Political System is a component of the Organizational Infrastructures that we defined earlier. Absence of an enlightened, healthy political system spells doom to the delivery of infrastructures.

In addition to having a political system and players that are enlightened and committed, for sustainability, there must be political engagement between the political elite and the people to get their buy-in and ownership.

5. TACKLING NATIONAL INSECURITY AND FAILED INFRASTRUCTURES

Insecurity means that people are beset with fear and anxiety and cannot go about their normal life activities with confidence. The widespread acts of terrorism, kidnapping, raiding villages and shooting unarmed citizens, murder, rape, robbery, destruction of economic facilities etc, have massive negative impacts on national human and economic development as no investment can take place in an insecure environment. Placed against the infrastructures organism template, we see that this is the result of defective organizational infrastructures. If our political system, legislature, judicial system, defense system etc, were effective, the insecurity we are witnessing would not have happened. Our insecurity and infrastructure challenges are therefore

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symptoms/outcomes of defective organizational infrastructures. To fix these symptoms, we must turn our focus from the symptoms to the root cause of the problem.

5.1 We must fix our political and other governance systems. Nigeria's elite have over the years exploited the failed political system for myopic personal gain. Corruption in all its ramifications have eaten deep and destroyed the fabric of society. This same elite have the God-given responsibility to take actions necessary for the healing of Nigeria's defective **Heart – Organizational Infrastructures**. In whatever organization we find ourselves, we must support and promote the evolution of political and governance systems that are not exploitative, but knowledgeable and responsive to the developmental needs of the people. General Charles de Gaulle, the legendary French leader said in 1958, "I have come to the conclusion that politics is too serious a matter to be left to the politicians". Plato, one of the world's greatest philosophers who lived 427 BC – 347 BC said, "one of the penalties for refusing to participate in politics is that you end up being governed by your inferiors". John F Kenedy said, "let us not seek to fix the blame for the past. Let us accept our own responsibility for the future".

5.2 We must mobilize our Knowledge Infrastructure systems. Next in importance to the Heart is the Head – the Knowledge Infrastructures are driven by connectivity, research and development, deliberate promotion of National Innovation System (NIS) defined earlier. The tendency of the Nigerian government to believe that others will come and solve Nigeria's technical and infrastructure problems is what has driven our best minds to migrate to other lands where their expertise and hard work are appreciated. The situation in which major national physical infrastructural developments are contracted out to foreigners and indigenous engineering practitioners go out of business due to lack of patronage spells doom to our country. Knowledge infrastructures are intangible in nature and so are not easily appreciated and could be relegated, whereas, without their acquisition and effective management, none of the other infrastructures can perform.

6. BIM AND VARIOUS APPLICATIONS

In the second part of this presentation, we shall discuss how to leverage technology to mitigate the impact of insecurity on the development of National Infrastructure.

Building Information Modelling (BIM) is the holistic process of creating and managing information for a built asset. Based on an intelligent model and enabled by a cloud platform, BIM integrates structured, multi-disciplinary data to produce a digital representation of an asset across its lifecycle, from planning and design to construction and operations. The operations and management of national infrastructure can be enhanced with the use of BIM & GIS.

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6.1 Capture Existing Conditions of Infrastructure: The use of registered and established benchmarks is highly recommended to create a large-scale, intelligent, 3D model of Nigeria infrastructure real-world environment. With BIM, you can easily aggregate large amounts of existing data, including reality capture data, 2D CAD, and raster data. Then incorporate GIS data to enhance accuracy and fine-tune your infrastructure model into high-definition 3D meshes that can be optimized for detailed monitoring, management, and control of physical infrastructure on the ground surface with innovative engineering solutions that can be optimized.

6.2 Detailed Analysis & Evaluation of Connected Transportation Links: Quickly conduct detailed analysis and evaluation of transportation links to other countries to add greater precision to your existing infrastructure monitoring in real-time. For security monitoring of transportation infrastructure links to other countries, use these tools to effectively connect roadway alignments, unpaved paths, water tributaries and overpasses where movement of people & goods are being active. Use specialized tools of drone monitoring with established benchmarks with BIM to monitor defined transportation paths to Nigeria to checkmate illegal movement of people and goods through the country's borders.

6.3 Perform Analysis and Simulations on Existing Infrastructure: Make better infrastructure management decisions with tools for sight distance, flood simulation, dynamic site analysis, land layout zoning for farming, agriculture and food security.

6.4 Improve understanding of Infrastructure Impact: Every infrastructure project competes for scarce resources. With BIM, you can more effectively prioritize how money is invested in projects toward an efficient national security system. You are able to shift your emphasis from cost-centric to consider outcomes and project value – singling out critical infrastructure management approaches, and prioritize new infrastructure provision based on social, economic, and environmental impacts and objectives.

6.5 Reduce Errors and Omissions: Errors and omissions can cause expensive delays and rework in any infrastructure project. BIM tools and processes help you more effectively identify, inspect, and report on interferences in a 3D project model. BIM helps you to better anticipate potential problems with your project before construction and reduces risks of project cost and schedule overruns during construction.

6.6 Smarter Decision: BIM tools enable you to establish a rich contextual setting of your infrastructure model, explore various design options, perform analysis and simulations with vivid visualizations. Improve delivery of your infrastructure objectives and outcomes, mitigate the risks of cost and schedule overruns during construction and producing as-built digital documentation of existing infrastructure which can be synchronized to existing national security apparatus.

6.7 Win Work and Reach Approval Faster: Compelling visualizations can do a lot of the heavy lifting when it comes to winning more business and getting approvals more quickly on infrastructure projects. 3D renderings, AR/VR “walk-throughs”, and animated construction simulations have far great impact and can significantly enhance how your project is perceived. With visuals that reflect your infrastructure project within the perspective of the actual environment, you can facilitate a better understanding of your desired outcomes, more easily sell your design ideas, and get to a

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‘yes’ statement from the government.

6.8 Get the Public on Board: Infrastructure projects affect the general public, and they typically have one overriding concern: how the proposed project will impact them on a day-to-day basis. They have questions like: “What will the project look like?”, “How long will it take?”, and “How will the construction phase impact me?” Now, there are tools that simplify how you convey the impact of infrastructure projects to the general public and help them to better understand the purpose of such projects to promote national security.

7. BIM FOR FACILITY OPERATION, MAINTENANCE AND MANAGEMENT

The convergence of information technology (IT) and facilities management (FM) is an inevitable trend. The goal for facilities managers has always been to make buildings more energy-efficient, more productive, and more comfortable and secure for occupants and operators. Smart buildings/infrastructure solve all these problems and at a lower total cost of ownership than conventional systems. One tool in the smart buildings/infrastructure repertoire is building information modeling (BIM).

The highly fragmented nature of the construction industry has created a need for a centralized platform for information-sharing and control. With the increasing complexity of facilities, particularly in high-tech, national, or specialized facilities, the sheer volume of disciplines required to design and build a quality facility is large and growing. BIM provides one forum for collaboration, rather than the traditional spider web of individual firms all communicating independently. Additionally, given the traditional approach of individual contractors each using their own data and modeling tools, incompatibilities are bound to arise, causing significant losses to the industry and, subsequently, to client value. The dynamic nature of BIM incorporates changes and modifications made over the years, ensuring that it never becomes obsolete or less useful due to outdated records which currently plagues most of our national assets.

With the added pressure on facility owners and operators to reduce energy usage, environmental impact and high-security challenges, BIM allows for simulated testing and analysis of infrastructure systems before construction to ensure that adequate measures have been taken to guarantee expected performance and to change underperforming systems before they are installed, remote monitoring during construction and operation using visual dashboards to track infrastructure elements against theft and vandalization can be achieved. Radiofrequency identification (RFI) interrogators and intelligent checkpoint planning can negate security weak points on a facility-wide level. BIM also makes integrating the security system with the rest of the infrastructure’s operating systems easier, since the technology allows the integrators to visually demonstrate system design and enable the owner to make better decisions. The very modeling

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capabilities at the core of BIM are what enables the operators to see how the security system relates to the entire facility and how the devices relate to space, people, and activities in real-time.

BIM is useful even in existing facilities that were not built using an integrated, three-dimensional, digital model. Using original and retrofit design plans, and in some cases laser scanning, a BIM model can be generated from an existing facility. This system can then be used to monitor and benchmark systems and suggest retrofit opportunities for operational efficiency and cost-savings, map out areas for security surveillance remotely by attaching a sensor to elements to be tracked using GPS technology if stolen or vandalized. All the ongoing advantages of a BIM platform will then be available to infrastructure owners, operators, and managers, and, while the system will be useful and cost-effective at all but the final stages of the project's life cycle, its benefits increase the earlier it is implemented. The ability to trace performance over the lengthy period of facility usefulness is invaluable. It becomes much easier to monitor, operate and maintain a facility over its lifecycle using an integrated model.

8. EMERGING TECHNOLOGY FOR EFFECTIVE DESIGN, CONSTRUCTION AND OPERATION OF INFRASTRUCTURE

Innovative technology enables massive improvements in the safety, efficiency, and productivity of large-scale infrastructure projects.

Construction has a long history of innovation that has spurred impressive advances in the types of projects we can produce. For example, the development of cofferdams and caissons opened the door for majestic underwater structures. Meanwhile, advancements in tower crane technology propelled construction upwards, opening the possibility for massive skyscrapers.

The Architecture, Engineering, and Construction (AEC) industry is on the rise, and we are seeing a major transformation, especially, across residential, non-residential, and infrastructure areas.

8.1 Digital Twin: A digital twin is essentially a link between a real-world object and its digital representation that is continuously using data from sensors. All data comes from sensors located on a physical object; this data is used to establish the representation of a virtual object. A digital twin analyses real-time data to enable learning, reasoning, and dynamic recalibrating for improved decision making. For example, engineering teams have used 3D renderings of computer-aided design (CAD) models to ensure and validate manufacturability. In the AEC industry, a digital twin technology will help understand how products are performing and will perform in the future. It allows:

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- Visualizing products in use, by real users, in real-time
- Building a digital thread, connecting disparate systems, and promoting traceability
- Refining assumptions with predictive analytics
- Troubleshooting far away equipment
- Managing complexities and linkage within systems-of-systems

8.2 Artificial Intelligence (AI) Brings About Smart Infrastructure: Artificial Intelligence can help industry professionals move faster - starting with construction plan creation, design, Building Information Modelling (BIM), suggesting engineers of best methods to utilize for projects, controlling domestic settings after completion and many more tasks that require less human input.

One of the main concerns to date is reducing error rates, cost, and increasing productivity and efficiency. With AI-powered systems, engineers and facility operators can work smarter and achieve faster.

Let us take the example of BIM with AI, it is a great way for AEC professionals to collaborate, communicate and execute their projects as it allows to visualize the entire construction project and progress in real-time, record and removes the risk of data breach or misplaced paperwork.

We are also going to see Robotic Process Automation (RPA) and AI joining forces to create digital workers for more than 40% of enterprises. AI building block technologies such as Machine Learning (ML) and text analytics with RPA features to drive greater value for digital workers in four use cases: analytics that solves nagging platform issues; chatbots that boss around RPA bots; internet-of-things (IoT) events that trigger digital workers; and text analytics that lifts RPA's value.

8.3 Internet of Things: The increasingly connected world is being dominated by the Internet of Things, or IoT, which lets digital devices communicate and interact with each other. Everything can be connected to the IoT, from drain covers to manholes to vehicles and more. The AEC industry can leverage the IoT to transform its operations as well.

8.4 Smart City: Smart cities are on the rise as more countries are looking into embracing and investing in this trend. The concept of a "smart city" is there to help economies become more agile, move faster and keeping critical infrastructure and Human lives safe as possible.

Countries, Developers and Professionals need to think about how to plan, design, and construct more smartly and think about sustainability, security, and safety in the long run. Criteria for building a smart urban area include smart economy, smart mobilization (convenient transport systems –

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good technical infrastructure), good living environment, natural resources reasonably used, preserved, smart urban management (e-government), and high-qualified human resources.

As more and more growing cities are facing challenges with security, mobility, sustainability, and affordability, development authorities and professionals need to think more about improving urban infrastructure through technological solutions and tackling these issues.

The more connected a series of infrastructures are, the closer we will get to truly smart cities. In such an arrangement, the IoT will enable buildings to communicate with each other, share clean energy sources, and ensure the reliability and safety of infrastructure.

9. CONCLUSION

9.1. The Infrastructure Organism, with **Heart, Head, Stomach** and **Limbs** provide a model for a clear understanding of the interrelationships of national infrastructures.

9.2. Insecurity, corruption, political instability and strife are symptoms of weak Governance Infrastructures - **Heart**. Everything about the development and growth of the organism depends on having a healthy heart. A weak heart results in stunted growth and possible death of the organism.

9.3. Fixing the defective Nigerian Governance Infrastructures is the responsibility of Nigeria's elite. Action must be taken now to develop, support and promote political and governance systems that are not exploitative but knowledgeable and responsive to the developmental needs of the people.

9.4. Nigeria's Knowledge Infrastructures systems – the **Head** must be mobilized by deliberately energizing those facilities which promote technological engagement such as connectivity, R&D, and National Innovation Systems (NIS).

9.5. A situation in which major national physical infrastructural developments are contracted out to foreigners and indigenous engineering practitioners go out of business due to lack of patronage spell doom for our country.

9.6. Nigeria's intellectual body is bleeding profusely as the best Nigerian talent are all emigrating to other climes where their talent and hard work are appreciated and utilized.

9.7. There is need for consulting engineering practices to leverage technology to mitigate the impact of insecurity on the development of national infrastructures using BIM, one of the emerging technologies.

9.8. Enabling government policy frameworks, and incentives are necessary if Nigeria's infrastructure sectors are to respond to and take advantage of the opportunities that the spiraling technological developments offer.

9.9. To resolve insecurity and infrastructure challenges, we must strategize on the use of technology to manage systems to get the most out of Nigeria's current infrastructure situations.

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Innovations such as these do not depend on a particular product being diffused, but rather the application of combined technologies that increase the overall efficiency of the system.

9.10. There must be a collaborative effort among security agencies and professional organizations such as ACEN for a holistic approach to tackling insecurity.

9.11. Let us not forget the admonition of General Charles de Gaulle, “that politics is too serious a matter to be left to the politicians”. Professionals, and Engineers in particular must leave their lofty intellectual heights and get involved in politics if we hope to replicate the Chinese development miracle. In China, by design about 80% of the top governing elite are engineers.

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