WHITE PAPER

5G Campus Networks

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Content

Until recently, private cellular networks were little more than a niche market typically serving the special requirements of capital-intensive industries such as mining, shipping, oil, and gas. Today, however, we are standing at a crossroads; localized 5G deployments, also known as campus networks, are set to become the ubiquitous connectivity fabric for manufacturing, logistics and transport facilities, and large-scale entertainment and commercial venues. This article will help you as your company sets out on its journey to the next phase of connected innovation.

The Most Valuable Resource

The Economist proclaimed a few years ago that data had replaced oil as the most valuable resource[1], and indeed, successful enterprises rely on production and logistics processes that are increasingly dependent on the uninterrupted flow of data to stay competitive. *Gartner* has predicted that by 2021 companies will be valued on the basis of their information portfolios.[2] In much the same vein, *IDC Research* expects that by 2022 the worldwide expenditure in big data and business analytics will exceed $270 billion, driven by the need for "better, faster, and more comprehensive access to data and related analytics and insights".[3] Having real-time access to data and analytics for decision-making is a sustainable competitive advantage in the marketplace of the 2020s. A 5G private campus network lays the foundation on which a strategic position of this type can be built.

5G can provide seamless, campus-wide, single-standard, wireless connectivity with mobility support, low latency, and high reliability. 5G features several industrial-grade services[4] ranging from facility maintenance using augmented and virtual reality (AR/VR) applications anchored to on-premise edge computing to high-precision asset tracking to production automation and supply chain integration. The exploitation of business transformation potential is accelerated by the availability of 5G and presents to enterprises around the globe the opportunity to review and revamp their legacy approaches and upgrade them to the level of the hyper-connected digital world of today.

5G Campus Networks Benefits

Data-centricity

High-performance networking is at the heart of a data-centric enterprise. A 5G campus network is a ubiquitous indoor and outdoor connectivity fabric with predictable key performance indicators (KPIs) such as service data rates and end-to-end latency that combines seamless mobility support with data control and astonishing device density with gigabit throughput. In essence, a campus network serves as the dependable unifying system substrate for the implementation of a data-centric enterprise architecture.

Operational agility

Wireless connectivity means that there is no need to "rewire" the premises to accommodate process, equipment, or organizational changes. Introduction of new connected devices can be centrally controlled reliably around the clock, and network access can be granted and withdrawn remotely and instantaneously. The same campus network system architecture can cope with such varied requirements as high-bandwidth, low-latency, and ultra-reliable communications. Device density in 5G is expected to reach 1 device per square meter (cf. 1 device per 10 square meters in 4G/LTE) with deterministic network performance enabling massive Internet of Things (IoT) deployments.

Business resilience

A wireless network using licensed spectrum is designed with several layers of fault tolerance and can be restored to service must faster than wired networks as we have seen in all major catastrophes over the last 25 years. It is also less prone to the unintentional interference often experienced when using technologies based on unlicensed spectrum. Moving equipment, sealing off areas, and establishing crisis centers is not hindered by damaged cables or power supply. Overlapping or extending coverage may be a simple configuration issue rather than an implementation one. Furthermore, connected devices are available in various form factors (both industrial and consumer grade) and can serve the entire spectrum of business needs. In the event of supply chain interruptions or radical production changes, integrating new supply chain partners can be as straightforward and speedily realizable as providing a SIM card.

Safety at work

5G has recently attracted unfavorable attention due to the allegedly negative impact on human health from electromagnetic field (EMF) exposure.[8] 5G uses mostly the same spectrum (<4GHz) that previous generations (2G/3G/4G) have employed since the 1990s. Strict adherence to the guidelines[9] of the *International Commission on Non-Ionizing Radiation Protection* (ICNIRP) for 5G deployments is a must in all private as well as public 5G deployments and is enforced by well-established protocols.Furthermore, the capacity to integrate easily augmented and virtual reality (AR/VR), robots, drones, automated guided vehicles (AGVs), and big data analytics can improve day-to-day work safety and address demographic challenges.

Technological complexity reduction

Introducing a campus network as a single versatile IP-based network fabric not only facilitates uninterrupted data flow, but enables an enterprise to capitalize on web-scale technologies for all its communication needs throughout its premises, connecting seamlessly all assets and personnel both indoors and outdoors. A 5G campus network can consolidate a host of siloed communication technologies used in a wide spectrum of activities from professional mobile radio (PMR) command and control structures to wireless office applications and business process management (BPM). Moreover, existing or planned enterprise Wi-Fi networks can be integrated into the 5G campus deployment seamlessly on the basis of standards. This way, the enterprise can introduce innovations at a much faster pace owing to the reduced complexity in the underlying connectivity fabric.

Yet a recent article in the *Harvard Business Review* argues that in the case of 5G "limitations in conventional business thinking" translate into "trapped value" as "traditional approaches to strategy and planning" lead to "delayed investment and missed opportunities".[5] Nevertheless, the article concedes that when it comes to 5G, there is still "a great deal of uncertainty about the when, how, where and who." Since the publication of that article in early 2019, however, the technological and regulatory landscapes have cleared to a significant degree.

On the technological front, as we detail below, the gear needed to deploy a campus network (from antennas and the radio access network elements to the 5G Core and cloud edge) is now readily available. 5G non-standalone (NSA) end user devices are already being marketed while various types of devices supporting 5G standalone (SA) mode are expected to enter the mass market in the second half of 2020.

With respect to regulation, nationwide spectrum licenses have already been assigned in many countries. 5G national deployments are in progress and current measurement studies indicate that "5G offers faster average download speeds than Wi-Fi in seven out of eight leading 5G countries"[6], the rather early stage of national rollouts notwithstanding. It is important to keep in mind that private 5G campus deployments do not require spectrum ownership. A 5G private network can be implemented using spectrum owned by a carrier that is then locally and exclusively dedicated to a campus deployment. And let's not forget that a campus network may use a combination of licensed and unlicensed spectrum, which we will discuss later.

Meanwhile, various EU countries are finalizing their regulatory frameworks for localized 5G deployments while Japan is already licensing mmWave spectrum for campus networks. In Germany, for example, a country with a strong manufacturing sector, numerous transport and logistics facilities, and world-renowned trade fairs, interest in 5G private deployments was bolstered by the decision of the federal government in 2019 to accept applications for licenses of up to 100 MHz in the 3.7-3.8 GHz spectrum for exclusive use in campus networks. According to the *Wall Street Journal,* "car manufacturers, chemical companies, and other industrial firms are taking steps toward creating their own private 5G networks".[7] Moreover, the German regulator (BNetzA) envisions offering local and regional licenses in the 26 GHz spectrum.

In the case of 5G “limitations in conventional business thinking” translate into “trapped value” as “traditional approaches to strategy and planning” lead to “delayed investment and missed opportunities”.

(Harvard Buisness Review)

“5G offers faster average download speeds than Wi-Fi in seven out of eight leading 5G countries”

(Opensignal)

“Car manufacturers, chemical companies, and other industrial firms are taking steps toward creating their own private 5G networks”

(Wall Street Journal)

Better Processes and Interconnection Fabrics

The remake of traditional planning and operations into data-centric processes is only just now starting for several industries. A key stumbling block is the lack of ubiquitous, high-bandwidth and low-latency connectivity with mobility support. Today, for example, manufacturing companies may obtain data regarding sales or the effectiveness of social media marketing campaigns in real time, but small changes in production processes or even a simple re-arrangement of factory floors may take months to decide and execute. At the same time, each factory floor produces data and requires connected computation and storage that mandate a connectivity fabric suitable for business-critical communication.

At logistic facilities, exhibition grounds, and entertainment venues, a host of data is updated manually, transferred via a hodgepodge of technologies, or simply left untapped. In the eyes of a teenager, the technologies involved in connecting people and data with compute and storage in many transport hubs and logistics facilities belong solely in a museum. *Omdia* estimates that only 1.3 percent of mission-critical industrial communications[10] are currently wireless. All this is in stark contrast to the advances in wireless connectivity and online services familiar to all of us in our private lives. Ultimately, of course, deploying a campus network is not about being trendy. It is about business enablement, using (for instance) digital twins for "real-time assessments and diagnostics" and "innovation that is faster, cheaper, and more radical".[11]

The connectivity fabric deployed in the world's manufacturing footprint, for instance, use tons of copper wire and optical fiber to run reliably a certain factory floor configuration, moving terabytes of mission-critical data to processing entities on the premises or in the cloud. These facilities are connected, but making changes without interrupting production is a difficult task. Changes to the existing floor plan are expensive. The copper wires and optical fiber that are already in place can become part of the legacy problems that must be dealt with, and because of the sunk costs involved, frequent reconfiguration of the factory floor becomes a daunting exercise. Batch size 1 is hard to attain without a 5G campus network.[12]

Similarly, at a big event or an exposition, organizers have come to rely on PMR (public mobile network) and Wi-Fi as a technology patch enabling chat groups, video calls using consumer services, and other services. Clearly, this is nothing more than a stopgap solution and poses serious questions regarding operations resilience and information security, let alone quality of experience and efficiency. More critically, this can be sustained only at a limited device density and comes without performance guarantees. Massive IoT is out of the question and low-latency communication simply out of reach.

There is no longer any need to accept such restrictions. We are all familiar with the benefits of being wirelessly connected and having instant access to data, services, and people using our mobile devices. Over the past decade, we have seen the pioneering of consumer technology on several fronts with business technology following in its footsteps shortly thereafter. The (re)making of each factory floor, loading dock, tarmac, exposition grounds, and stadium into a wirelessly and reliably hyperconnected facility which is "reconfigurable" and "pluggable" into the enterprise information systems in real time that is already happening is based on the same technological family that has been the workhorse of our essential infrastructure for years now. The technology has advanced by leaps and bounds over recent years, it is mature, and the economic factors have changed so that it is applicable to many industries, as we will consider next in this article.

5G for Industry

The term **5G for Industry** is a catch-all phrase encompassing wireless network deployments that span enterprise premises and are tailored to specific use cases with strategic advantages in the context of state-of-the-art facilities. A reliable, low-latency, and high-bandwidth network is essentially the central nervous system that enables people, data, things, and algorithms to work together seamlessly and securely to increase productivity, resilience, and efficiency based on up-to-date information.

Detecon's 5G for Industry expertise shines as we work together with our clients to define new and improved production environment processes that capitalize on managed latency and edge computing for demanding applications, network slicing for resource isolation, and massive machine-to-machine communication to integrate sensors and actuators of both fixed and mobile objects.

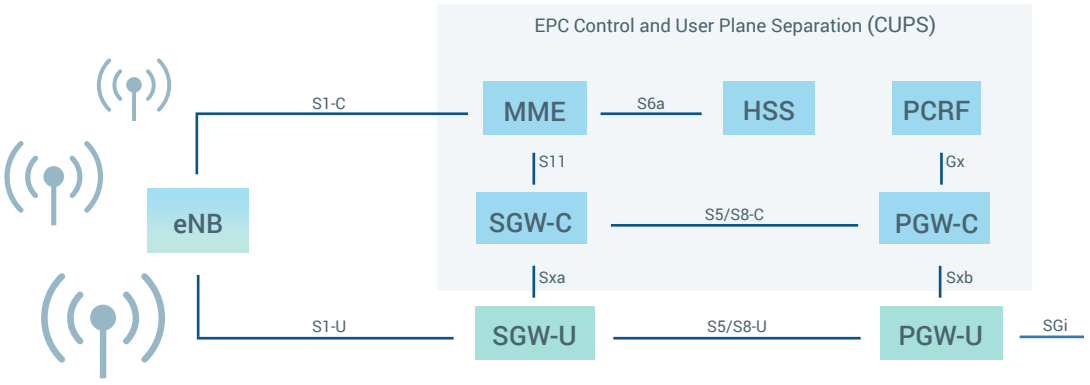
Anatomy of a 5G Campus Network

In principle, industrial-grade, campus-wide networks can be built using different technologies ranging from tried-and-tested 4G/LTE and Wi-Fi to the upcoming 5G, LTE-M, NB-IoT, and edge cloud. Industrials, for instance, recognize 5G as an important building block for digitalization.[13] Nevertheless, the variety of implementation options, use cases, and operation models can be daunting and requires a partner with deep understanding of the entire journey that lies ahead from the perspectives of both business and technology.

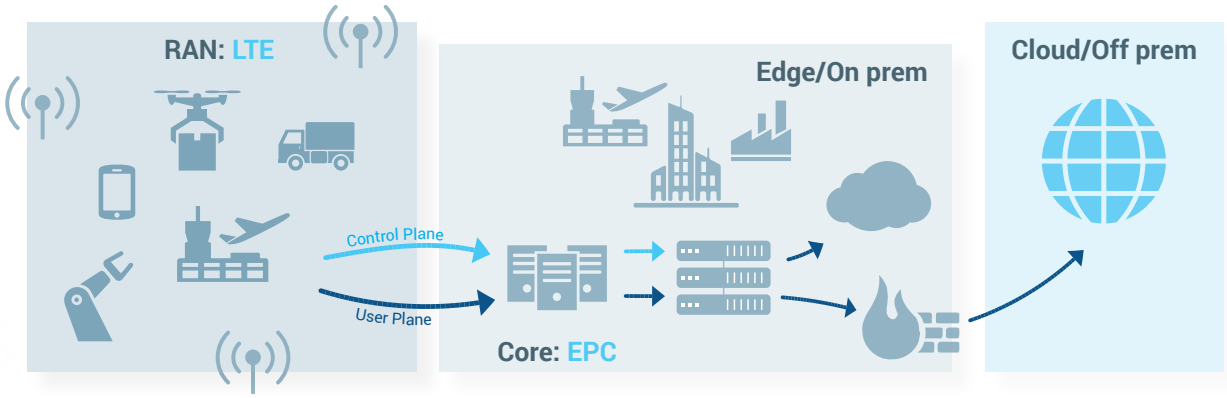
When you look at the technologies available to companies embarking on the creation of a modern interconnection fabric for their premises, the highest-priority element that must be kept in mind is how to build a high-performant, cohesive, reliable, secure, and flexible system that can adapt to business needs without imposing new constraints. Durability and evolvability are critical; the investments for infrastructure and process definition should pay back efficiency dividends and lead to long-lasting transformation gains.

As illustrated in Figure 1 and 2, a campus network system typically involves the following first-order components: a) wireless resources, i.e. spectrum (licensed or unlicensed), base stations or access points, and the intelligence to run them; b) network infrastructure, i.e. routing elements, servers, virtualized network functions, and management and security functions; and c) local, near, or remote compute and storage resources for data. In the case of cellular networks, such as 4G and 5G, the first component is typically referred to as the radio access network (RAN) and the second component as the core network.

Figure 1: Campus network with 4G radio (LTE) and core (EPC)



Logical Architecture



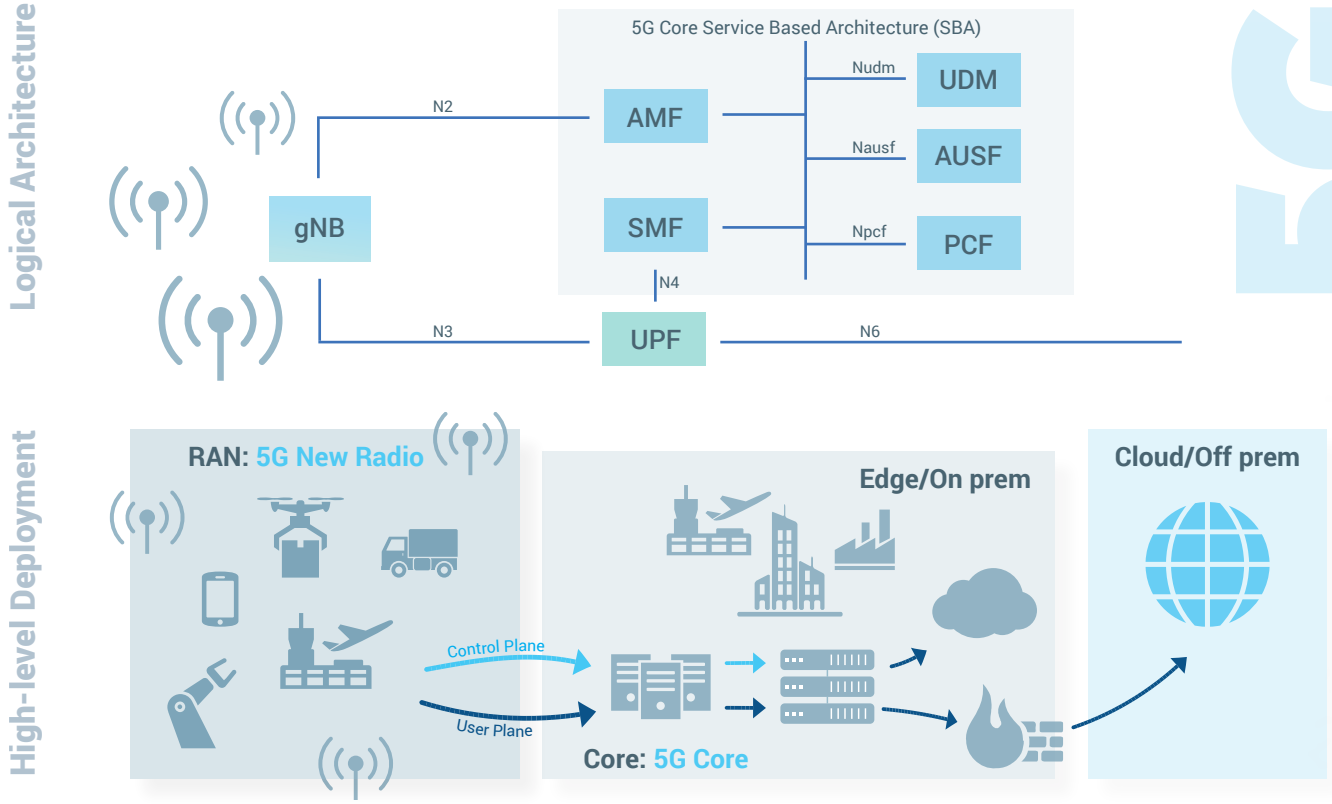
High-level Deployment

Compute and storage resources can be located on premises (typically referred to as edge cloud[14]) or remotely, e.g., in the private company or the public cloud infrastructure. Furthermore, there are market offerings that place compute and storage resources in-between the company premises and the public cloud and that are known as near-edge cloud.

Assembling these components into a cohesive whole is the art and science involved in the creation of an effective 5G campus network. Top-level design considerations that come into play include functional and non-functional requirements and answers to questions ranging from "Should we keep all data local (including all aspects of network, compute, and storage)?" and "Is it more appropriate to move data to compute or bring compute to data?" to "Do we need our 'own' spectrum or is it better to partner with a mobile network operator?" and "How do we run such a critical interconnection fabric efficiently and reliably?"

Creating a clear picture of the as-is technology landscape as well as objectively evaluating the available network technologies (4G, 5G, and Wi-Fi 6), edge/near/public/private cloud and use case platforms, data analytics, and IT that would drive the target technology picture and the associated business transformation are critical. At Detecon, we have developed a well-defined plan-build-run model that we use to support our clients as they embark on their own journey to increased operational efficiency and agility by installing a 5G campus network that is tailored to their specific enterprise and location needs.

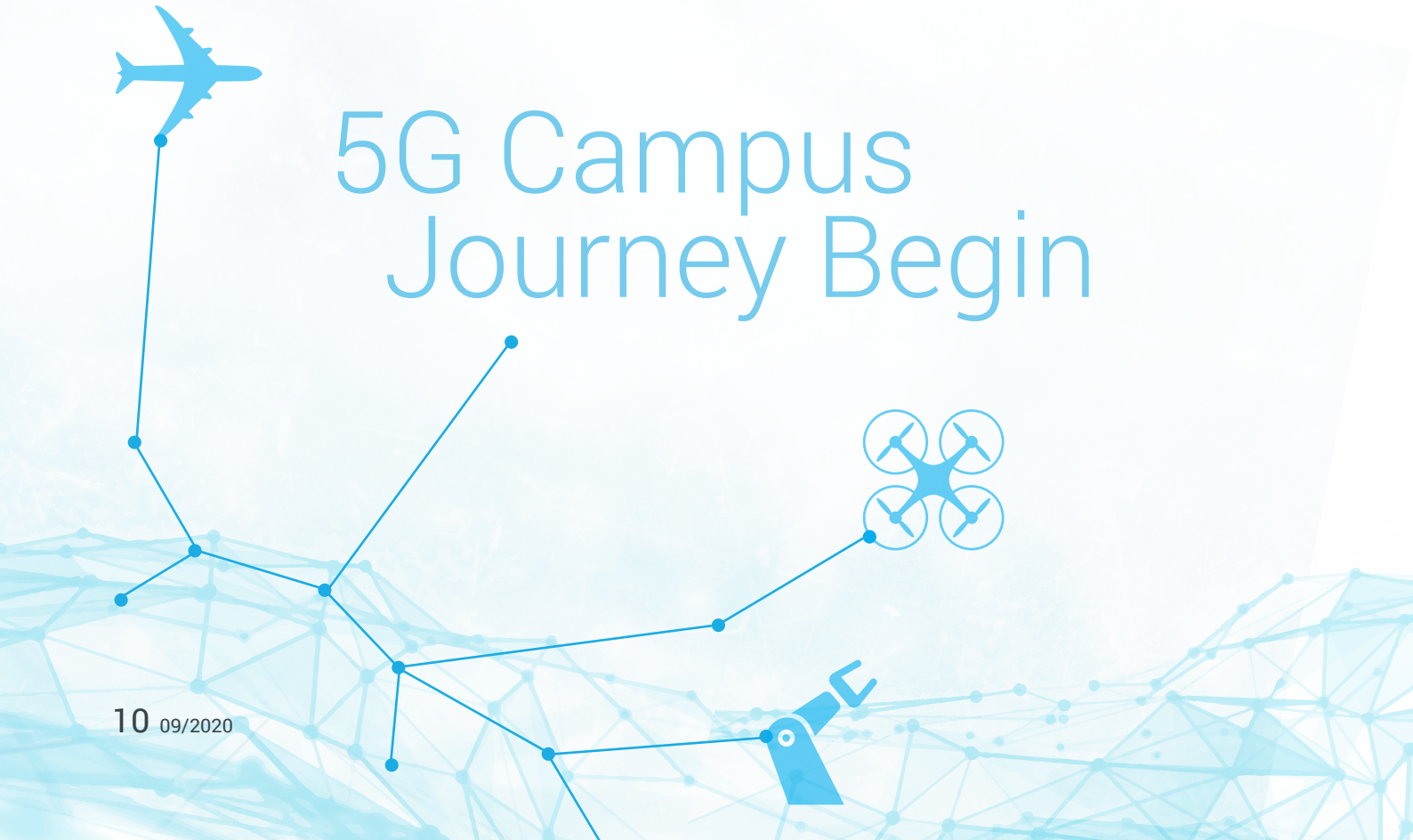
Figure 2: Campus network with 5G new radio (NR) and SA core (5GC)



Let the 5G Campus Journey Begin

Various options can be considered for the connection of campus-wide enterprise premises. For example, company premises can be covered by an enhanced public cellular network that enables basic use cases such as gigabit wireless office connectivity (including HD video conferencing) to materialize with full rollout flexibility, mobility support, and predictable OPEX/CAPEX. Larger enterprises with advanced use cases that require on-premise edge computing facilities should consider a hybrid campus network solution or even a fully isolated private 4G/5G deployment.

Enterprises have extraordinarily competent technical departments; nevertheless, establishing a new interconnection fabric without rethinking processes and business needs is at best no more than half the job that must be done. We often see companies starting with some high-visibility use cases such as the adoption of augmented reality (AR) to create better human-machine interfaces (HMI) at the loading dock or to perform preventive maintenance on the factory floor. Automated guided vehicles (AGVs) such as robots that carry materials throughout the campus premises have also been a favorite use case. Both of them address current and pressing business needs and can improve work safety. Digital twins, on the other hand, accelerate innovation through continuous evaluation and faster and cheaper prototyping[11] and require all three elements (wireless connectivity, network, and compute and storage). Technology is, of course, only part of the story. Detecon is currently helping clients from various industry sectors (including manufacturing, logistics, airports, and exposition grounds) in several countries to develop their own 5G-enabled business cases, target picture technology, and transformation strategy.



Selected 5G Use Cases

Remote expert

This use case has broad applicability and can address many business needs. Essentially, an employee wears a pair of augmented reality (AR) glasses and uses wireless connectivity to perform an extensive diversity of tasks — ranging from complex machine repairs and maintenance on a factory floor to checking operational readiness of airport and airline assets to inspecting and evaluating delivered goods — in close collaboration with an expert located somewhere else. We expect that in coming years remote experts will become more common and easily "available" campus-wide via wireless network connectivity.

Facility management and security monitoring

The benefits of 5G come into their own in this case as the inherent mobility support enables enterprise teams to roam freely on the premises and perform tasks more efficiently while remaining constantly connected. This class of use cases includes wirelessly connected robots and drones that are flexibly and seamlessly integrated into company processes. Modernization of their command, control, and dispatching is another quick win from the deployment of a 5G campus network. After all, clear and unhindered communication is important for all teams.

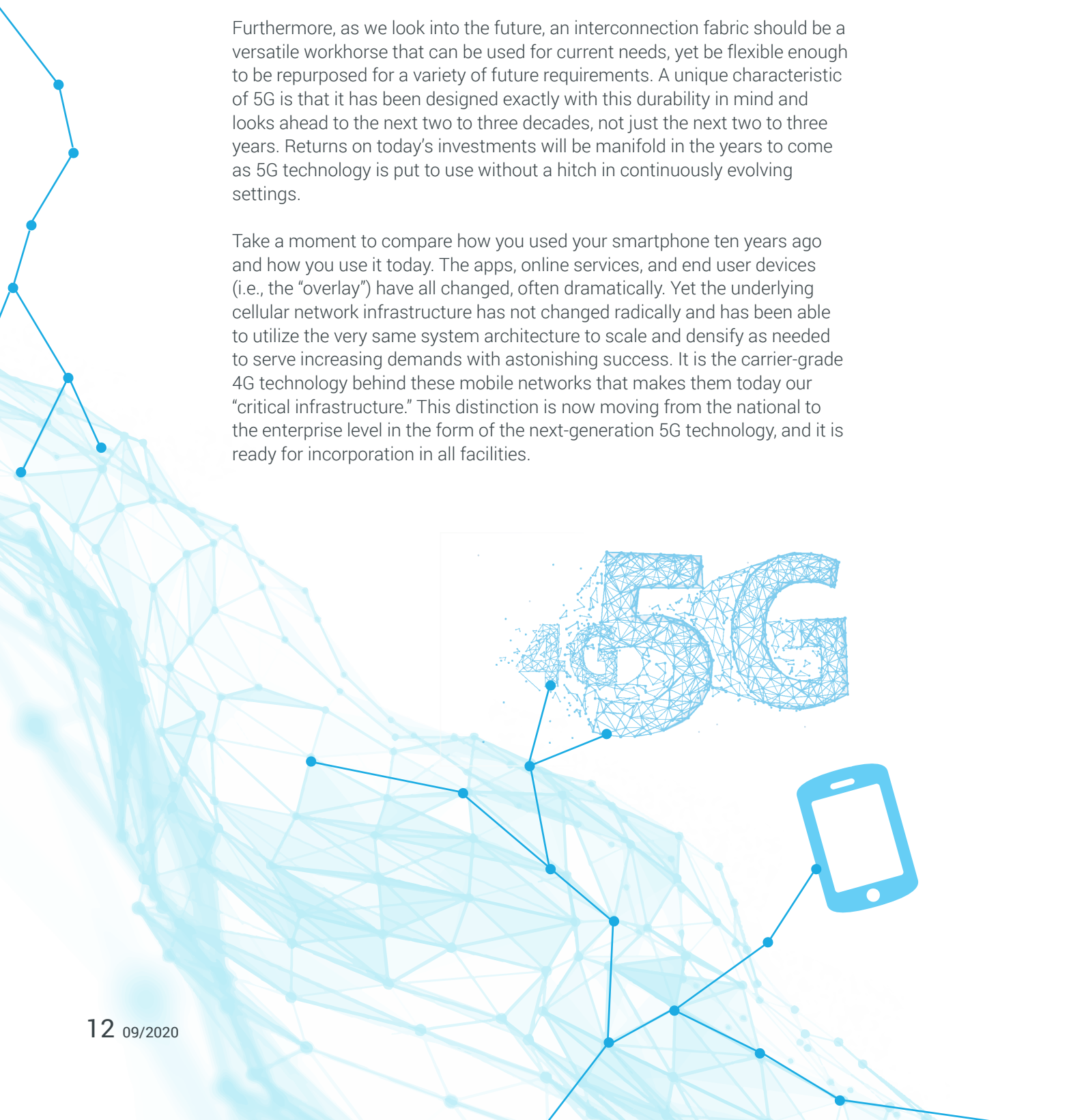
Asset tracking and positioning

Tracking fixed and mobile objects throughout the premises, both indoors and outdoors, is a use case of interest for a broad range of industries from manufacturing and automotive to logistics and the organization of expositions and concerts. 5G is in this case the only technology that can provide support for seamless mobility, assure the scale and density required, and deliver high-broadband and low-latency IP-based communication that can be combined with audio-visual and other technologies anywhere on the premises.

Some organizations may view the initial outlays for the establishment of a campus network as prohibitive when only a few niche use cases are defined. That said, it is important to keep in mind that a campus network is an interconnection fabric deployed locally with a large time horizon that caters to the needs of "traditional" or more conservative companies for predictable technology evolution. It is possible that its initiation today will be based on a set of advanced use cases, but there is tremendous potential for many quick wins beyond that. Rethinking arcane processes can easily reduce sizable outlays in the overall balance sheet and reap tangible results while increasing return on investment (ROI) across the enterprise. Identification of quick wins is part and parcel of a successful campus network deployment.

Furthermore, as we look into the future, an interconnection fabric should be a versatile workhorse that can be used for current needs, yet be flexible enough to be repurposed for a variety of future requirements. A unique characteristic of 5G is that it has been designed exactly with this durability in mind and looks ahead to the next two to three decades, not just the next two to three years. Returns on today's investments will be manifold in the years to come as 5G technology is put to use without a hitch in continuously evolving settings.

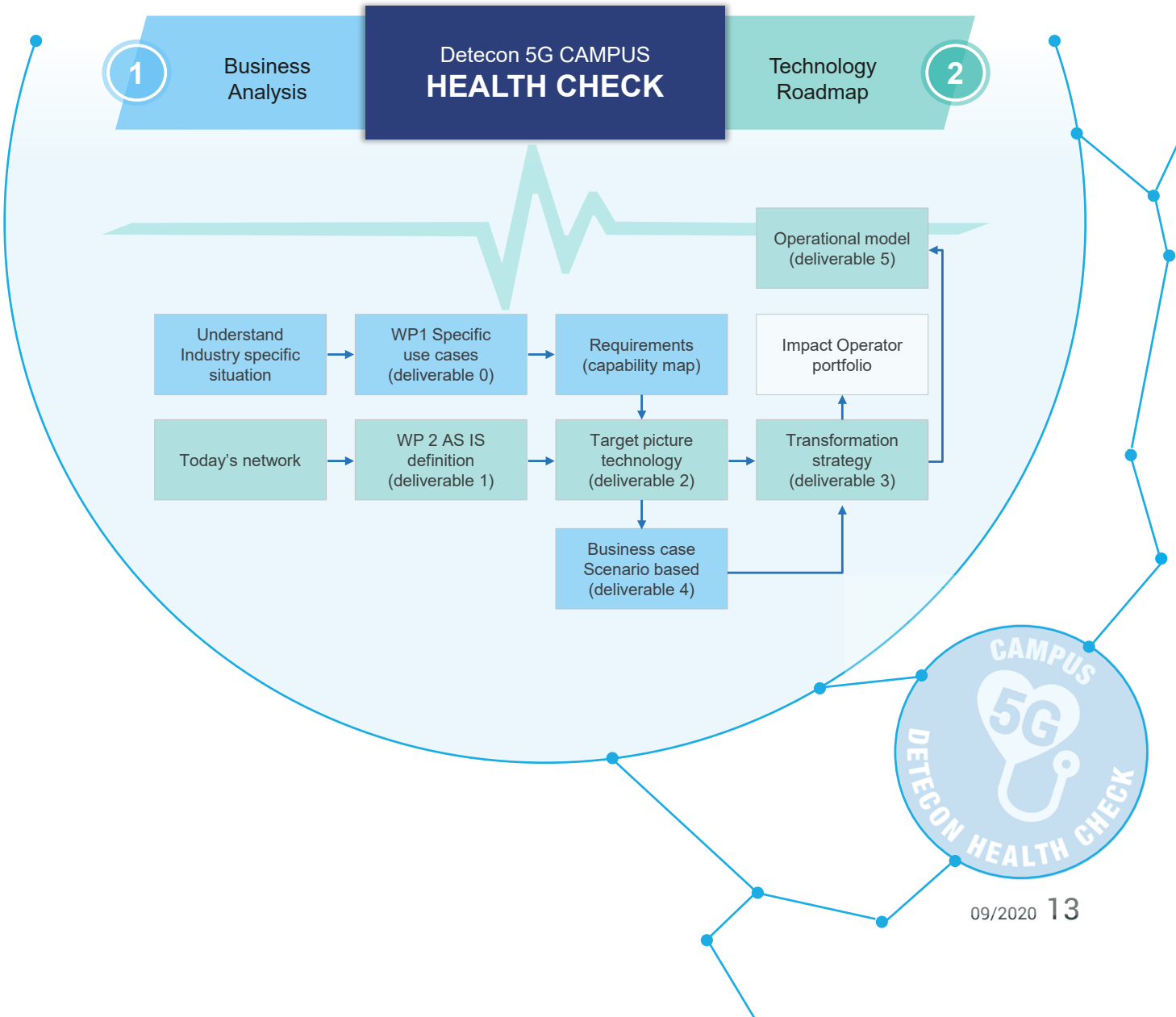
Take a moment to compare how you used your smartphone ten years ago and how you use it today. The apps, online services, and end user devices (i.e., the "overlay") have all changed, often dramatically. Yet the underlying cellular network infrastructure has not changed radically and has been able to utilize the very same system architecture to scale and densify as needed to serve increasing demands with astonishing success. It is the carrier-grade 4G technology behind these mobile networks that makes them today our "critical infrastructure." This distinction is now moving from the national to the enterprise level in the form of the next-generation 5G technology, and it is ready for incorporation in all facilities.



Detecon 5G Campus Network Health Check

So how does one prepare for the 5G campus network journey? Detecon answers this question with its offer of a well-stocked proprietary toolbox; it is available as a standard service offering that aids our clients in the definition of the pertinent requirements, target picture, and transformation strategy. We support our clients to develop an individual strategy and exploit the full potential of 5G campus networks.

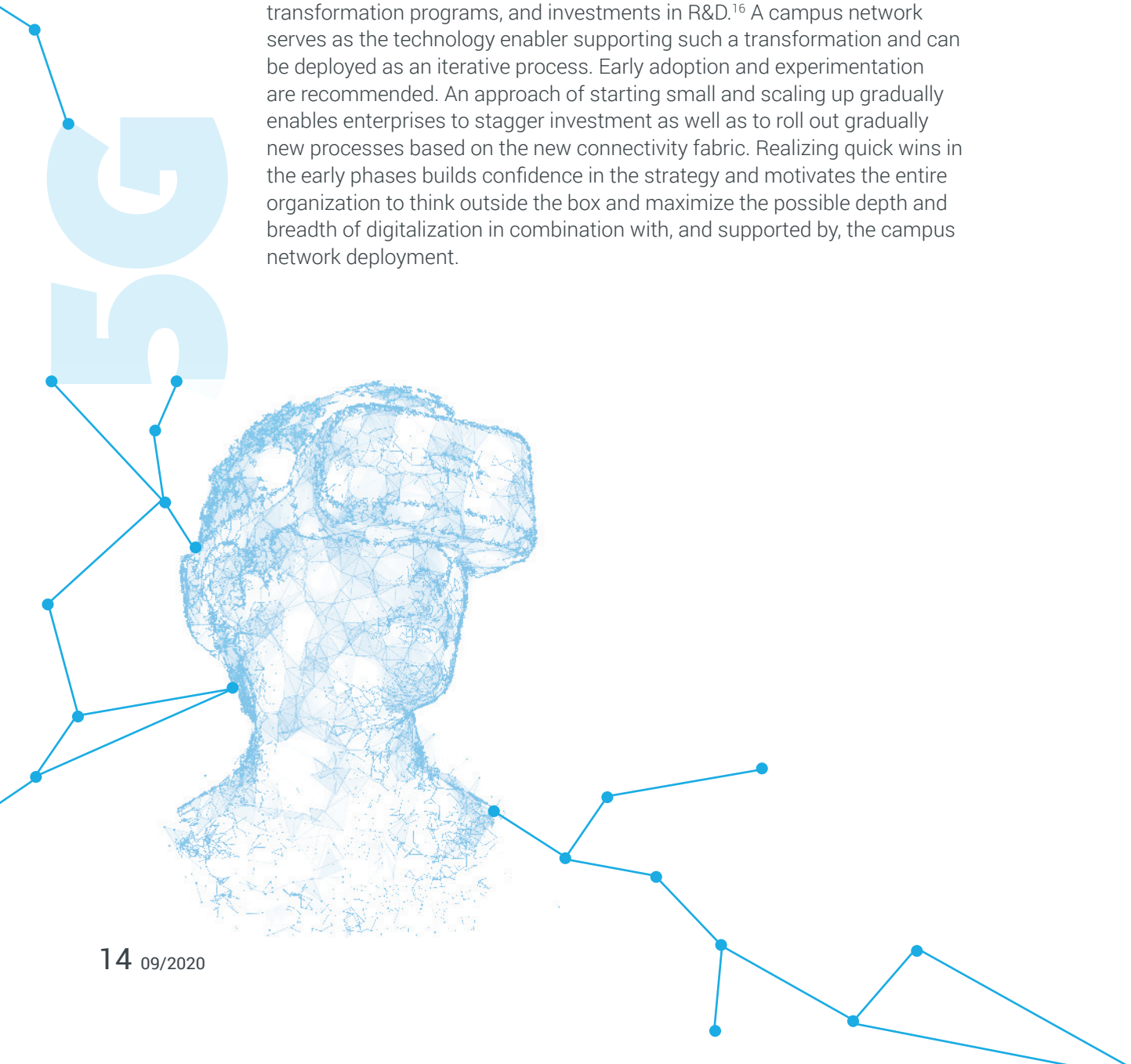
The Detecon **5G Campus Network Health Check** covers aspects of both business and technology. We guide our clients to an understanding of their industry-specific use cases, and we all work together to specify in detail the functional and non-functional requirements. Once the capability map is ready, we collaborate closely with the client to define the target picture technology and the associated business case scenarios. We develop the matching transformation strategy, analyze the applicable operational models, and identify the partnering ecosystem when appropriate. The end result is a clear definition of the strategic options and actionable items for the next steps.



Critical Success Factors

The debate over what technology should be employed for a campus network has been going on for several years.[15] It is important to avoid entanglement in such a debate as it often leads to indecision and inaction. Instead, the goal should be to obtain a complete technology landscape picture covering the similarities and differences between (for instance) a campus network based on 4G, Wi-Fi 6, and 5G, including spectrum and radio coverage aspects, in licensed versus unlicensed connectivity fabrics as they apply to your company environment. The pros and cons of opting for a standardized 5G campus network system as opposed to the integration of different technological components into a cohesive whole should also be documented so that an informed C-level decision can be based on transparent information. Finally, aspects such as end device and cloud support as well as enablers for data-centricity, operational agility, and business resilience should be taken into consideration.

Research indicates that company transformation success, especially in turbulent times, correlates with long-term strategy, ambitious, formalized transformation programs, and investments in R&D.[16] A campus network serves as the technology enabler supporting such a transformation and can be deployed as an iterative process. Early adoption and experimentation are recommended. An approach of starting small and scaling up gradually enables enterprises to stagger investment as well as to roll out gradually new processes based on the new connectivity fabric. Realizing quick wins in the early phases builds confidence in the strategy and motivates the entire organization to think outside the box and maximize the possible depth and breadth of digitalization in combination with, and supported by, the campus network deployment.



TL; DR

Assuring transparency when investing in a campus network is not possible unless a crystal-clear, end-to-end view of the transformative power, business value, and opportunities generated by a new interconnection fabric reliably covering the entire company premises has been obtained. Now is the time to evaluate the impact that a campus network can have on your company and your competition and to act accordingly.

Acknowledgements

The author would like to thank Falk Schröder, Wolfgang Kranz, Richard Majoor, and Pramadityo Tjondronegoro for their valuable comments on earlier drafts of this article and the Detecon 5G Community for sharing openly and generously their technically-competent and business-savvy insights.

"The variety of implementation options, use cases, and operation models can be daunting and requires a partner with deep understanding of the entire journey that lies ahead from the perspectives of both business and technology."

(Detecon)

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Detecon International GmbH

Management consulting with pronounced technology expertise

Detecon is the leading, globally operating technology management consulting company with headquarters in Germany, which has been combining classic management consulting with high technological competence for over 40 years. The focus of its activities is on digital transformation: Detecon supports companies from all areas of business to adapt their business models and ¬operational processes to the competitive conditions and customer -requirements of the digitalized, globalized economy with state-of-the-art communication and information technology. Detecon‘s expertise bundles the knowledge from the successful conclusion of management and ICT consulting projects in over 160 countries.

From concept to implementation

Detecon is a subsidiary of T-Systems International, one of the world‘s leading vendor independent providers of digital services and subsidiary of Deutsche Telekom.

Detecon is driving forward its consulting approach Beyond Consulting, a significant evolutionary step forward in traditional consulting methods adapted to meet the demands of digitalization today and in the future. The concept features top consulting that covers the entire spectrum from innovation to implementation. Groundbreaking digital consulting demands ever greater technology expertise and a high degree of agility that incorporates flexible, but precisely fitting networking of experts for complex, digital ecosystems in particular. At the same time, it is more and more important in digital consulting to accompany clients from innovation to prototyping to implementation.

This factor prompted Detecon to found the Digital Engineering Centers for Cyber Security, Analytical Intelligence, Co-Innovation, and Industrial IoT in Berlin in 2017 as facilities that extend the added-value chain of consulting and accelerate the realization of digital strategies and solutions by means of prototypes and proofs of concept.

Endnotes

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Detecon International GmbH.
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