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THE ROLE OF SYSTEM INTEGRATORS FOR ENTERPRISE 5G DEPLOYMENTS

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INTRODUCTION: 5G IN THE ENTERPRISE DOMAIN

From the start of its development and the first standardization work in The 3rd Generation Partnership Project (3GPP), 5G has always focused on providing cellular connectivity for enterprise verticals, in addition to the legacy consumer focus in which previous generations excelled. For the enterprise community, 5G is much more than just "4G + another G," as the distinct features of 5G allow for completely new applications for connectivity on several enterprise verticals as Figure 1 depicts.

Figure 1: Selected Target Key Performance Indicators of 5G According to the ITU-R

(Source: 5G-ACIA/ZVEI)

Peak data rate	10 Gb/s (uplink) 20 Gb/s (downlink)	Connection density	1 thousand – 1 million devices/km²	Reliability	99.999 % (of packets)
User experienced data rate	10–100 Mb/s	Battery life	10 years	Position accuracy	<1 m – 10 m
Latency	1–10 ms	Availability	99.999 % (of time)	Security	Strong privacy & security, and purification

- The connectivity of up to **1 million devices per square kilometer** (km^2) will enable setting up highly dense wireless sensor networks for the permanent monitoring of workflows in different enterprise environments.
- The supported bandwidth of **10 Gigabits per Second (Gbps) in the uplink and 20 Gbps in the downlink** (through Enhanced Mobile Broadband (eMBB) capabilities) will further enable automating, particularly data-intensive processes, and therefore allow for more remotely operated and automated workflows.
- The **guaranteed network availability and reliability** allows for particularly mission-critical use cases to be automated, while the **sub-10 Millisecond (ms) latencies** make industrial 5G fit for real-time enterprise applications.

To quantify the importance of enterprise business for successful 5G monetization, ABI Research recently undertook a Return on Investment (ROI) study. If Communication Service Providers (CSPs) only rely on consumer subscriber adoption, 5G will take approximately 14 to 15 years to break even, while it would only take 10 years if enterprise business models were also in place. Successfully addressing the enterprise opportunity requires the telco industry to adjust their offerings to more demanding conditions than what they are used to from the consumer domain.

Importantly, **enterprises are looking to deploy a cellular 5G network to automate very heterogenous use cases**. Therefore, requirements will be considerably more complex than what the telco industry is used to from deployments within the consumer domain.

Secondly, **enterprises approach 5G deployment projects from a pain point-focused perspective**. Industrial digitization projects will likely be driven by a desire to increase Overall Equipment Efficiency (OEE) and the quality and output of workflow processes. The 5G value proposition needs to be targeted toward these specific pain points. 5G will also need to interface with legacy technologies, especially when enterprise implementers typically approach digitization projects with a technology-agnostic perspective, as this will result in a multitude of different connectivity technologies present on enterprise premises.

Finally, **enterprises are looking for easily deployable and manageable connectivity solutions**, rather than building up traditional telco knowledge themselves. In addition, enterprises require one company as their central interface to introduce connectivity solutions.

THE ENTERPRISE 5G ECOSYSTEM

Traditionally, the ecosystem for cellular connectivity in the consumer domain has been relatively linear. Mobile network spectrum was licensed to a certain CSP that would then purchase telecommunication network infrastructure to deploy a network for consumers to use. When it comes to the enterprise domain, the ecosystem becomes considerably more complex, as enterprise network requirements and buying patterns differs substantially from consumers.

Figure 2: The Enterprise 5G Ecosystem

(Source: ABI Research)

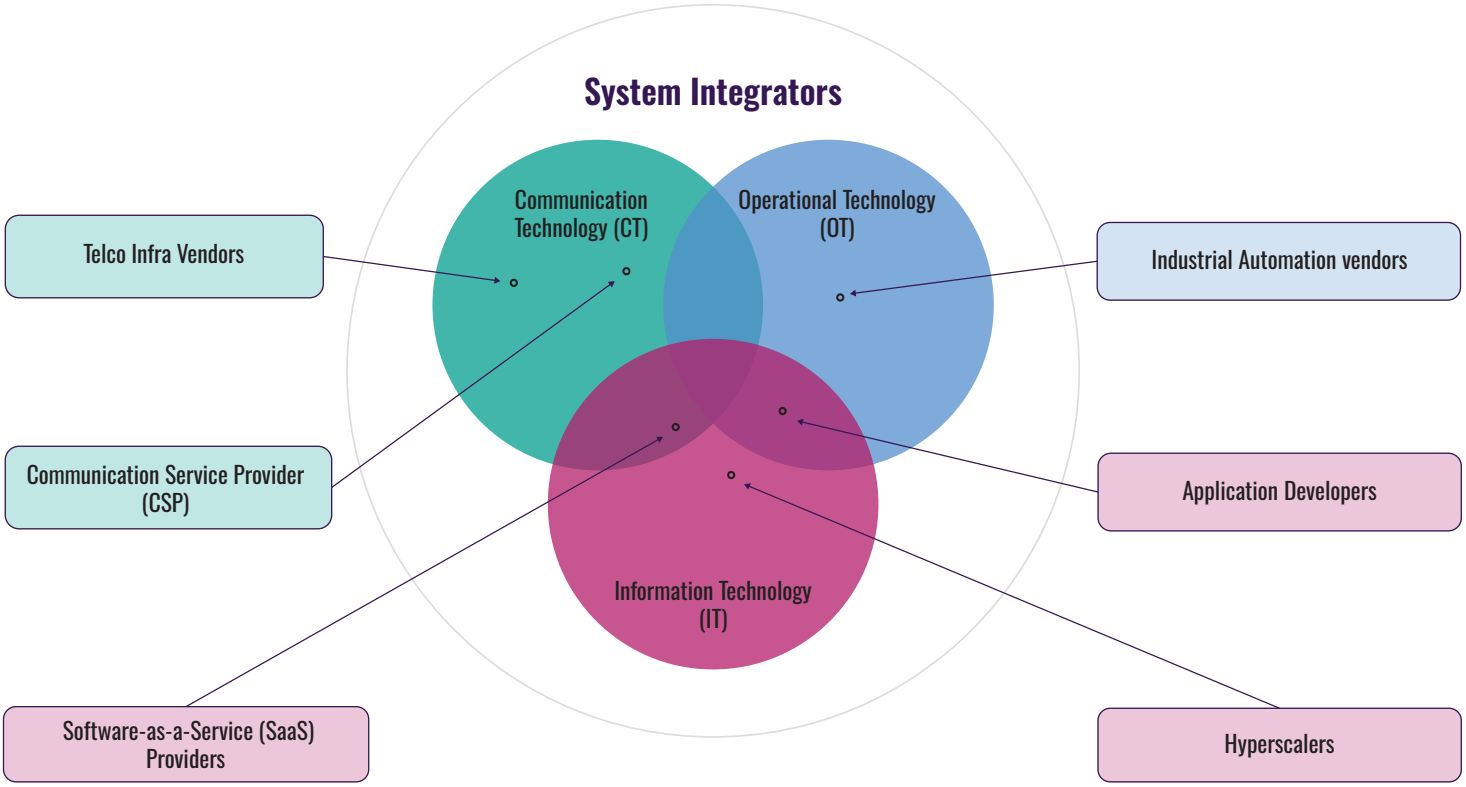


Table 1: Enterprise 5G Ecosystem Players: Key Characteristics

(Source: ABI Research)

PLAYER	KEY CHARACTERISTICS
Infrastructure Vendor	▪ Traditional supplier of connectivity devices for network deployment ▪ Radio Access Network (RAN) infrastructure for last-mile connectivity • Industrial automation vendors might jeopardize telco infra vendors' enterprise ambitions ▪ Different models to offer scalable "plug-and-play" deployments to enterprises
Communication Service Provider (CSP)	▪ Spectrum assets (99% of global mobile network spectrum still licensed to CSPs) ▪ Network management know-how ▪ Spectrum liberalization and unlicensed spectrum create the need for a new business model ▪ Initiatives to intensify ties with application developers (*e.g.*, DT with hubraum)
Software-as-a-Service (SaaS) Provider	▪ Network virtualization allows traditional SaaS companies to offer virtualized Core-as-a-Service to enterprises ▪ Access to enterprises through partnerships with CSPs (*e.g.*, Athonet core available through AWS Marketplace)

Hyperscalers	▪ Utilization of public cloud resources for Enterprise 5G deployments:
	  • AWS: Snow Product Family + Marketplace
	  • Microsoft: Azure Edge Zones
	▪ Two different strategies to push toward enterprise connectivity:
	  • Acquisitions (*e.g.*, Microsoft with Metaswitch and Affirmed Networks in 2020)
	  • Co-creation (*e.g.*, AWS with Orange or Vodafone)

PLAYER	KEY CHARACTERISTICS
Application Developers	▪ Providers of easy-to-use applications and interfaces for implementers ▪ Application developers will become key for enterprise 5G, as they need to ▪ Traditionally very strong ties with hyperscalers and System Integrators (SIs) ▪ Industrial automation vendors also take over application development for industrial manufacturing (*e.g.*, B&R Automation)
Industrial Automation Vendor	▪ Traditional partners to automate OT for enterprises -> excellent knowledge of operational concerns ▪ Adoption of industrial 5G into existing production portfolio: • Siemens announced its first industrial 5G router in November 2020 • Other industrial automation vendors (*e.g.*, Bosch Rexroth, Harting, Schneider Electric driving forward their 5G development projects
System Integrators	▪ Traditional strong and mature ecosystem partnerships ▪ Utilization of existing telco initiatives (*e.g.*, MobiledgeX) to provide End-to-End (E2E) connectivity to enterprises ▪ Accepted as primary partner for enterprise digitization projects

THE ROLE OF SYSTEM INTEGRATORS FOR ENTERPRISE 5G DEPLOYMENTS

To understand the role that SIs are playing for enterprise 5G deployments, this white paper examines three distinct verticals: 1) automotive & industrial manufacturing; 2) energy & utilities; and 3) logistics & ports. These were been chosen because they show the starkest immediate interest in private cellular connectivity and are, therefore, driving the market, at least in the immediate term.

AUTOMOTIVE & INDUSTRIAL MANUFACTURING

One of the most promising use cases for mobile cellular connectivity certainly is the industrial manufacturing domain. Looking at the factory floor of today, it becomes clear that fixed-line connections make up 90% of the total number of connections in industrial manufacturing, while the remaining 10% are made up of a mix of wireless technologies, depending on the use case. With production processes becoming more and more complex, the number of components requiring a connection is constantly increasing. Costs are around US$225 per cable drop, so this also increases the overall costs of wiring a factory floor to several US$100,000s. In addition, the costs of renewing fixed-line connections are significant, especially when it comes to equipment that needs to be reconfigured on the factory floor on a regular basis.

To understand the importance of 5G for industrial manufacturing, taking a look at other wireless communication technologies can be helpful. A Wireless Local Area Network (WLAN) provides one of the possibilities for wireless connectivity on the factory floor, based on the Institute of Electrical and Electronics Engineers (IEEE) 802.11 standard. However, it uses frequencies in the Scientific, and Medical (ISM) bands, which are used by one-fourth of industrial devices, resulting in a high risk of interference. Devices using the ISM bands are required to employ what is often referred to as "listen before talk" (or "listen before transmit"), which introduces additional latency. Furthermore, a WLAN does not offer robust handovers of a signal from one access point to another. Therefore, mobile use cases (*e.g.*, the operation of Automated Guided Vehicles (AGVs)) suffer from signal loss between access points. This increases latency and, in specific case, requires operating AGVs at reduced speeds.

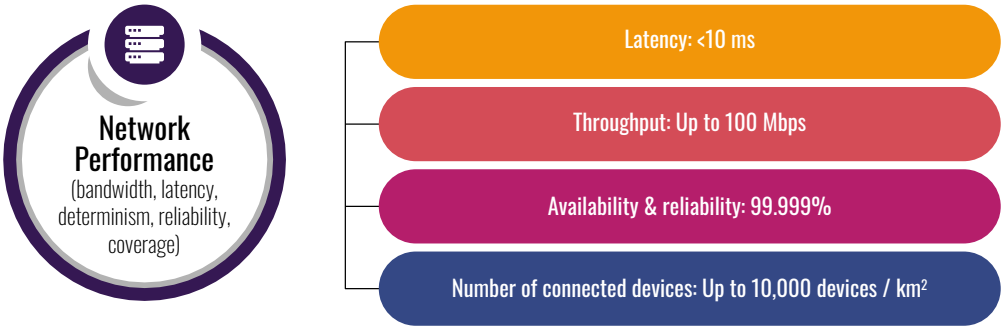
Looking at cellular connectivity, ABI Research estimates that 85% of today's use cases on the factory floor can be addressed with Long Term Evolution (LTE). Critically, with latency of around 50 ms, private LTE connectivity solutions can only be used to provide mobile control panels for 30% of production machines on a typical factory floor, due to external security regulations. By guaranteeing sub-10 ms latencies, industrial 5G can increase this so that 100% of a factory's machines can be fitted with mobile control planes, thereby offering considerable efficiency enhancements to the factory operator.

ENTERPRISE REQUIREMENTS AND TOTAL ADDRESSABLE MARKET

To connect production machines wirelessly, manufacturers require a deterministic and dedicated channel for machine communication, with frequencies that should not be used by anyone else around the factory. Figure 3 depicts the Key Performance Indicators (KPIs) for cellular connectivity to be deployed on the factory floor.

Figure 3: Key Requirements Industrial Manufacturing

(Source: ABI Research)



As networking requirements differ between use cases, Table 2 summarizes the key requirements for cellular connectivity on the factory floor by use case.

Table 2: Industrial 5G Use Cases Network Requirements

(Source: 5G-ACIA)

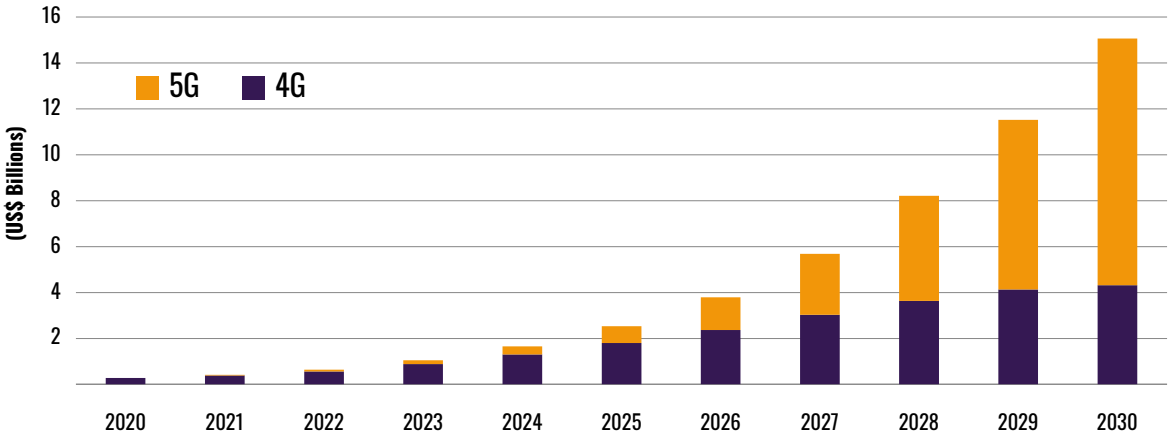
USE CASE		AVAILABILITY	CYCLE TIME (LATENCY)	TYPICAL PAYLOAD SIZE	NUMBER OF DEVICES
Motion Control	Printing Machine	>99.9999%	<2 ms	20 bytes	>100
	Tooling Machine	>99.9999%	<0.5 ms	50 bytes	~20
	Packaging Machine	>99.9999%	<1 ms	40 bytes	~50
Mobile Control Panels	Assembly Robots/ Milling Machines	>99.9999%	4-8 ms	40-250 bytes	4
	Mobile Cranes	>99.9999%	12 ms	40-250 bytes	2
Process Automation		>99.99%	>50 ms	Varies	10,000 devices per km²

To address these stringent requirements, private networks are seen as a key enabler for enterprise digitization on the factory floor: A recent survey among more than 600 manufacturers conducted by ABI Research revealed that more than 90% of manufacturers considering cellular connectivity as part of their digitization strategy are primarily looking toward private network deployments.

In terms of market sizing, ABI Research forecasts that the Total Addressable Market (TAM) for private network equipment in industrial manufacturing will grow from US$275.26 million in 2020 to more than US$15.06 billion by 2030. By 2030, 5G deployments in industrial manufacturing are forecast to generate revenue of US$10.74 billion (accounting for more than 70% of manufacturing private wireless revenue).

Chart 1: Industrial Manufacturing Private Network Revenue World Markets: 2020 to 2030

(Source: ABI Research)

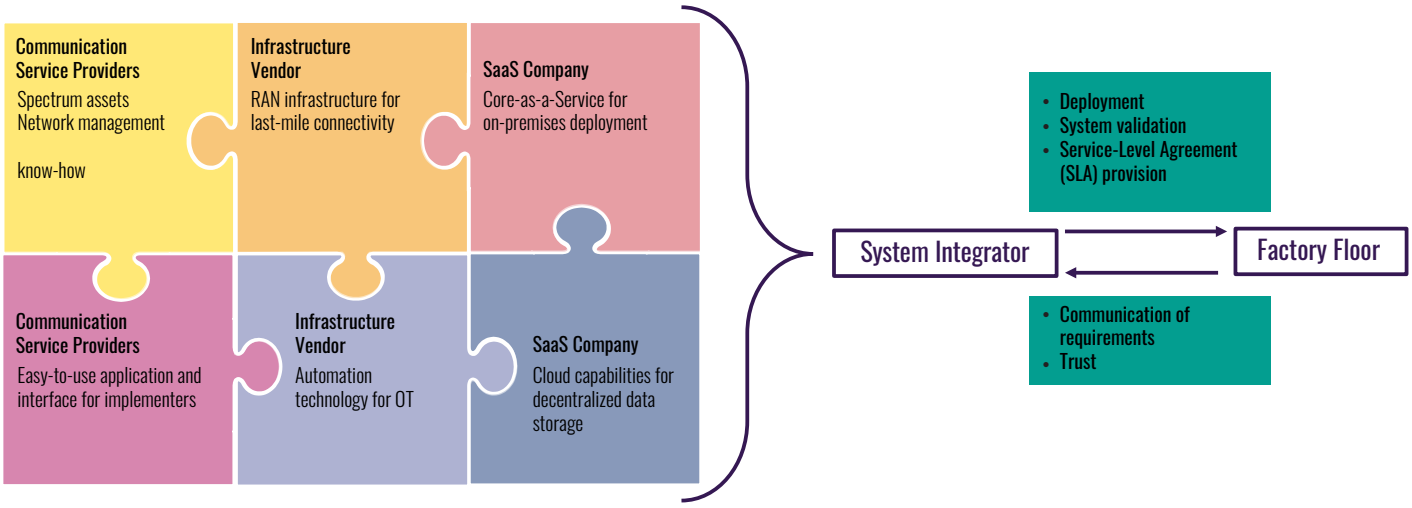


VALUE AND SUPPLY CHAIN ANALYSIS

The value and supply chain for 5G deployments in industrial manufacturing needs to address two important considerations. Firstly, successful deployments in the manufacturing domain require the telco industry to offer complete E2E connectivity solutions that are easy to deploy on the factory floor. Secondly, providing a networking solution that fulfills all the stringent requirements on the factory floor needs specialist expertise from different domains. The combination of these two considerations leads to a value chain that can be split into two parts, as Figure 4 shows.

Figure 4: Enterprise Cellular Value Chain Industrial Manufacturing

(Source: ABI Research)



Taking all of this into account, there needs to be a single entity to integrate all these capabilities that ultimately deploys the complete connectivity solution on the factory floor. Furthermore, there needs to be a central partner for manufacturers that is responsible for system validation, as well as Service-Level Agreements (SLAs). Most importantly, this company also needs to demonstrate profound knowledge of the requirements on the factory floor, as well as the operational constraints. This puts SIs in a key position for 5G deployments.

ANALYSIS OF THE COMPETITIVE LANDSCAPE

The subsequent question to ask is: who will be able to fill in for this central integrating and coordinating role? To answer this, ABI Research has undertaken a systematic analysis of each player's Strengths, Weaknesses, Opportunities, and Threats (SWOT), as outlined in Table 3.

Table 3: SWOT Analysis of Hyperscalers Industrial Manufacturing

(Source: ABI Research)

CAPABILITIES	CSPS	INFRASTRUCTURE VENDORS	HYPERSCALERS
Strengths	▪ Legacy and expertise network operation ▪ Spectrum assets for last-mile connectivity ▪ Know-how in dealing with CT and IT data	▪ Necessary infrastructure for last-mile connectivity ▪ Capability to translate manufacturing requirements into technology specifications	▪ Cloud computing systems ▪ Ability to deploy large-scale systems to process large amounts of data ▪ Excellent ties with developer communities
Weaknesses	▪ Limited experience with OT data management and orchestration ▪ No experience with industrial automation interfaces (*i.e.*, fieldbuses) ▪ Missing link to software and app developers	▪ No understanding of industrial manufacturing pain points ▪ Focus on telco market priorities ▪ Small and Medium Enterprise (SME) market suitable to smaller vendors	▪ Limited experience with OT and CT on the factory floor ▪ Lack of last-mile connectivity knowledge ▪ Inability to orchestrate across all domains

CAPABILITIES	CSPS	INFRASTRUCTURE VENDORS	HYPERSCALERS
Opportunities	▪ Partnerships with hyperscalers for data management know-how and deploying directly to enterprises ▪ Offer network operation as a managed service to enterprises/SIs	▪ Direct to enterprise (Nokia) or through CSP channel (Ericsson) ▪ Provide equipment for deployments using shared spectrum	▪ Offer scalable connectivity to small and medium-sized manufacturers ▪ Combine with cloud resources to allow decentralized data storage on the factory floor
Threats	▪ Increasing competition from hyperscalers and SIs targeting factory floor deployments ▪ Providing access connectivity might lose its power in the wake of spectrum liberalization arrangements	▪ Industrial automation vendors will add 5G to their product portfolio. ▪ SIs have a much better position to target industrial manufacturers directly	▪ SIs have an incumbent advantage to initiate digitization projects on the factory floor ▪ Regulation and security threats

Industrial Automation Vendors: Another player to consider in this context are industrial automation companies that focus on providing a portfolio of their automation solutions to industrial manufacturers. Currently, their portfolios consist of automation technologies based on OPC Unified Architecture (UA) (*i.e.*, proprietary fieldbuses like PROFINET or MODBUS) using fixed-line connectivity or industrial wireless Local Area Networks (LANs) (industrial WLAN). Automation specialists are beginning to extend their reach to include industrial 5G in their product portfolios as well.

In contrast to SIs, industrial automation providers are focused on selling their own products, rather than integrating partner components. Another aspect to consider is that the solution of automation suppliers centers around automating Operational Technology (OT). As production processes are becoming more complex and the integration of OT in Information Technology (IT) is becoming more important, automation suppliers will need to find a way to gain experience in the IT domain to successfully present this to manufacturers.

IMPLICATIONS FOR SYSTEM INTEGRATORS

Based on analysis of the competitive landscape, it becomes clear that SIs are in a vital position for 5G deployments. On one hand, their *raison d'être* is the integration of specific know-how and components from individual sources. Therefore, SIs have an excellent partnership network at hand that would make providing an E2E connectivity solution easily feasible. On the other hand, SIs are a well-trusted channel partners for manufacturers to introduce new technology to the factory floor. Furthermore, their experience in both OT and IT adds to this incumbent advantage and underlines their importance as transformation partners. However, this does not mean that SIs will automatically take on the position for enterprise 5G. On the contrary, there are fundamental implications for SIs and their business models that will be important for successful 5G deployments on the factory floor.

5G DEPLOYMENT OPTIONS IN AUTOMOTIVE & INDUSTRIAL MANUFACTURING

When looking at the different deployment options for a private wireless network on a factory floor, there are two important considerations from an enterprise point of view to consider:

- Manufacturers want the **highest possible degree of control over the complete network**. On one hand, this refers to controlling and adjusting the network performance to each specific use case. On the other hand, manufacturers want to be able to address any network issue immediately without having to wait for a CSP or infrastructure vendor, as every minute of network downtime results in immediate production losses.
- Manufacturing enterprises require full integrity of the network data. Specifically, this applies to any kind of data on the number and the condition of production assets within the factory. Critically, manufacturers always require all of these data to be on their own premises.

Based on these two considerations, the most prominent deployment option for cellular connectivity is to deploy all network components (both the RAN and the core network with user plane and control function) on the implementer's premises. However, a full on-premises deployment requires a high amount of upfront investment (therefore, it is rather Capital Expenditure (CAPEX)-intensive) and might not be realizable for SMEs. To minimize the Total Cost of Ownership (TCO) for medium-sized enterprises, a second deployment option is emerging that uses off-premises resources to run services and applications in the public cloud, while connectivity infrastructure and the platform for applications would reside on-premises. As this allows monetizing models to pivot from CAPEX-intensive to an Operational Expenditure (OPEX)-focused, subscription-based model, this will be more appealing to medium-sized manufacturers facing tight budgetary controls that would prevent large upfront investments.

SIs have the required ties with cloud service providers and infrastructure vendors, so they can become the central interface for manufacturers for both deployment options.

BUSINESS MODELS AND MONETIZING STRATEGIES

In the wake of global spectrum liberalization initiatives (allowing enterprises to acquire mobile network spectrum without having to involve a network operator), connectivity may lose its asset. Therefore, a business model purely focused on connectivity (even an OPEX-based Connectivity-as-a-Service (CaaS) model) will not be appropriate to realize the opportunity for private network deployments.

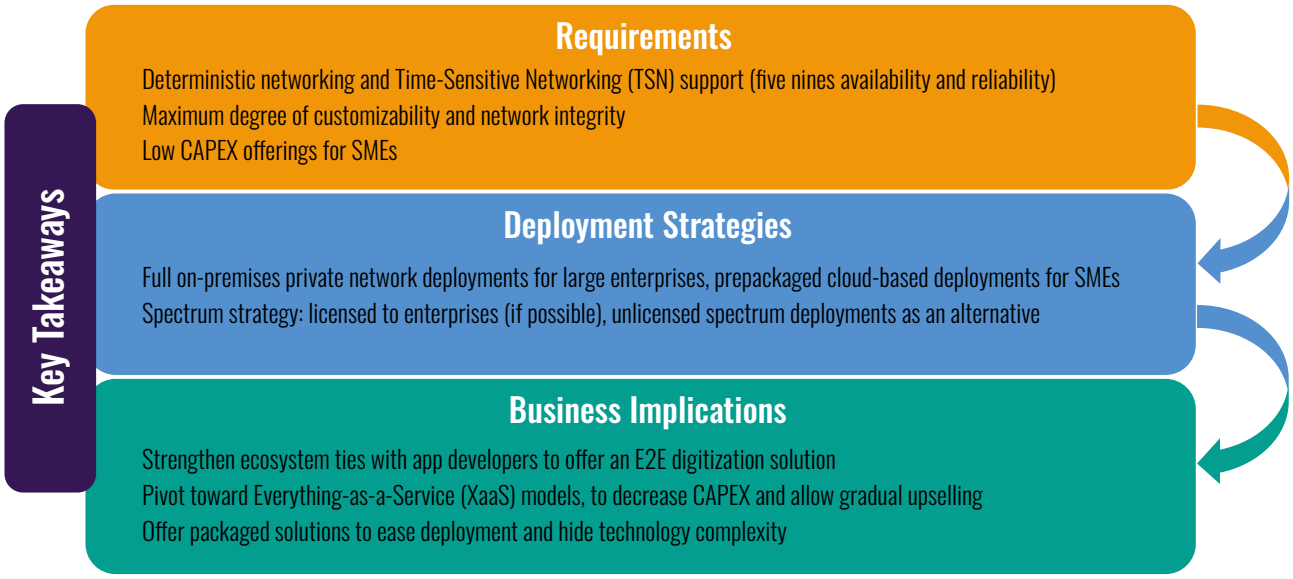
Enterprise 5G should be deployed as a platform that allows specialist developer communities to write vertical-specific applications. Monetization should center around vertical-specific requirements for a service-based offering. For SMEs, providing Infrastructure-as-a-Service (IaaS) could be an alternative model that would erase any CAPEX component and, therefore, lift financial entry barriers completely.

To achieve this, SIs need to engage with the entire telco ecosystem to negotiate an appropriate monetization strategy. This could either center around revenue sharing arrangements (which would not require any advance payments from SIs) or could also include SIs purchasing components from respective partners and then offer the integrated system to enterprises on an OPEX-based subscription model. This approach would require advance payments from SIs, so they would carry the entire risk of successfully monetizing the system on the factory floor.

Figure 5 presents the most important takeaways from this focused view on industrial manufacturing environments.

Figure 5: Key Takeaways Industrial Manufacturing

(Source: ABI Research)



ENERGY & UTILITIES

Energy resourcing sites (*e.g.*, power plants, oil fields, or mines) and power plants are characterized by two main aspects that carry important implications: hazardous environments and a multitude of concurrent processes. While the hazardous environment means that site operators do not want to send people in unless necessary (because of security concerns), the multitude of concurrent processes means that beneficial effects from automating these processes are comparatively large. Use cases for 5G in the energy production center around enabling remote operations of production assets (minimizing the number of workers who need to be sent into a particularly hazardous environment) and constant condition monitoring within a mine, oil field, or power station to prevent accidents.

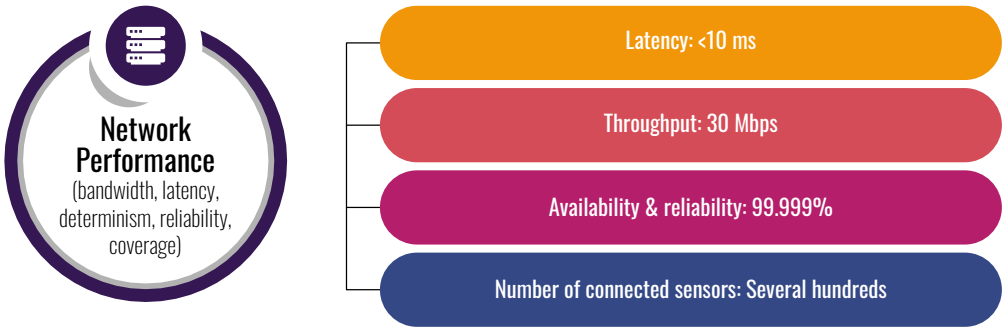
Furthermore, the energy sector has been built to guarantee profitability in situations of high energy demand. As the global response to the outbreak of COVID-19 has shown, exorbitantly high OPEX prevents profitability in scenarios of low energy demand.

ENTERPRISE REQUIREMENTS AND TOTAL ADDRESSABLE MARKET

Resulting from the complexity of workflows in the energy sector, automating these workflows puts stringent requirements on the capabilities of a cellular network. Because the cellular network is used primarily for mission-critical applications, network reliability and availability are pivotally important. Figure 6 highlights the KPIs that 5G will need to fulfill to be deployed in mines or oil & gas fields.

Figure 6: Key Takeaways Energy & Utilities

(Source: ABI Research)



When considering the geography of the typical energy production site, two challenges arise for a wireless connectivity solution: While in a mine propagation of radiofrequency waves through different kinds of stone is difficult, oil and coal fields cover particularly large areas (up to several 1,000s of km2), requiring a particularly wide coverage area. Furthermore, the energy production sector often is highly prone to explosions. This raises requirements towards network deployments also in terms of the network infrastructure, that needs to be certified as explosion proof (APEX).

To increase transparency across the entire energy supply chain, allowing energy producers to adjust their production instantly to demand fluctuations, 5G connectivity can also be used in the utility network. Table 4 summarizes the performance requirements for different smart grid use cases.

Table 4: Smart Grid Use Case Requirements

(Source: ABI Research)

USE CASE	END-TO-END LATENCY	RELIABILITY	NUMBER OF TERMINALS
Intelligent distributed feeder automation	Millisecond level	99.999%	Low
Precise load control	Millisecond level	99.999%	Low
Information acquirement of low voltage distribution systems	Millisecond level	<99%	>10 mio
Distributed power supplies	Millisecond level	99.999%	>10 mio

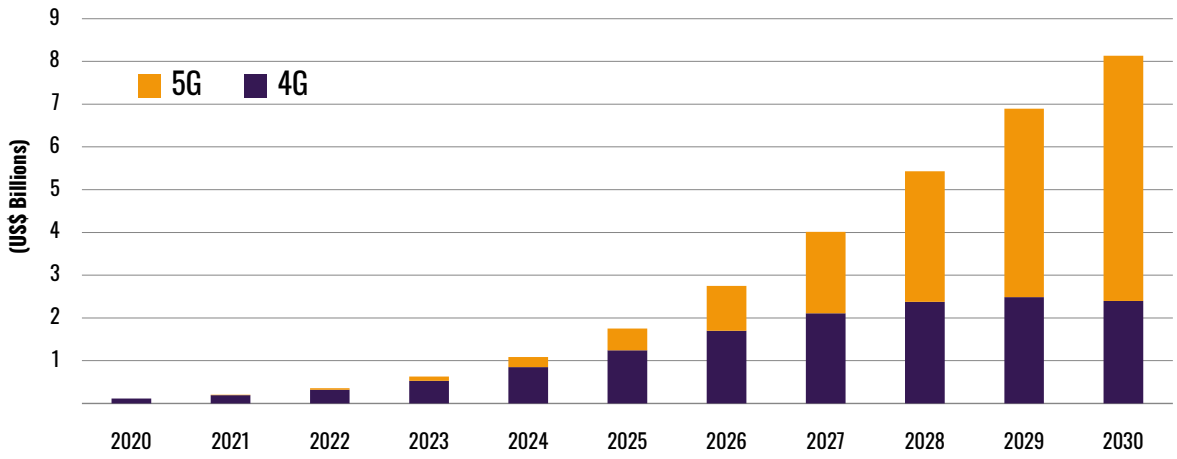
The global shift toward renewable energy sources (*i.e.*, solar energy, wind, or hydropower) makes 5G deployments for smart grid use cases even more important in order to guarantee a constant level of energy supply. While traditional means of energy production guarantee a reliable level of power yield, this will not be the case with renewable energy sources. The sun shines more intensely in summer than in winter months, and the wind does not blow with the same constant intensity, which also impacts hydropower generation. In short, renewable energy production is much more volatile than relying on fossil energy sources. In order to guarantee a constant level of electricity supply in light of these anticipated production fluctuations, constant

and automated monitoring of the energy grid is necessary to prevent power outages that could result in a production standstill or the loss of a patient's life if hospitals are affected. Furthermore, 5G can be deployed for automated condition monitoring of renewable energy production sites to enable preventative maintenance and avoid unexpected equipment failure.

When it comes to looking at the market size for private networks in the energy & utilities domain, ABI Research sees a similar picture in terms of 4G and 5G deployments. While the overall addressable market is expected to increase from US$116.86 million in 2020 to US$8.13 billion in 2030, 4G deployments will drive the market until 2027. By 2030, 5G deployments are projected to account for revenue of US$5.74 billion, while 4G deployments will generate US$2.40 billion by 2030.

Chart 2: Energy & Utilities Private Network Revenue World Markets: 2020 to 2030

(Source: ABI Research)



VALUE AND SUPPLY CHAIN ANALYSIS

Similar to manufacturing enterprises, operators of mines, oil fields, and power plants are looking for connectivity solutions that are easy to deploy. Therefore, plant operators require one key interface. However, because digitization initiatives are not as widespread in the energy sector, there are no firm go-to-market channels, which is why the value chain is more fluid than for verticals like industrial manufacturing. Therefore, operators are receptive to a rage of different partners to deploy cellular connectivity on their premises. Given the technology complexity associated with network management, operators of mines, oil fields, and power plants require additional third-party capabilities to address these issues. Because of their legacy network management and operation, CSPs will be important partners to consider in this domain.

CSPs' value proposition is also strengthened by the fact that WAN coverage is necessary for deployments in oil & gas fields, as well as mining and smart grid use cases. Using low-band spectrum (sub-1 Gigahertz (GHz)) allows for a much more economical and, therefore, affordable way to deploy a WAN. Across the globe, low-band spectrum is exclusively licensed to CSPs. Even in countries with spectrum liberalization initiatives in place, these usually apply to mid-band spectrum (*e.g.*, 2.6 GHz in France or 3.7 GHz in Germany). Therefore, CSPs will continue to play a crucial role for 5G WAN deployments in mines, oil & gas fields, and smart utility

grid use cases. Similar to the industrial manufacturing domain, energy & utility operators will require SLAs and system validation to remain in the same hands, as this provides clear accountability for network performance. Unlike in the industrial manufacturing domain, these considerations are not based on distrust toward the traditional telco domain.

ANALYSIS OF THE COMPETITIVE LANDSCAPE

Table 5 reports the analysis of strengths, weaknesses, opportunities and threats of each supplier of cellular connectivity to the energy & utilities sector.

Table 5: SWOT Analysis
Energy & Utilities
(Source: ABI Research)

CAPABILITIES	CSPS	INFRASTRUCTURE VENDORS	HYPERSCALERS
Strengths	▪ Legacy and expertise network operation ▪ Low-band spectrum assets particularly interesting for economical WAN deployments	▪ Last-mile connectivity for mines and oil & gas fields ▪ Expertise in network planning in harsh environments	▪ Ability to deploy large-scale systems ▪ Redundancy and reliable deployments, addressing industrial requirements
Weaknesses	▪ Limited experience with OT data management and orchestration ▪ No experience with industrial automation interfaces	▪ Limited understanding of pain points and key market dynamics ▪ Focus on telco market priorities	▪ Limited experience with OT within mines, oil & gas fields, and power plants ▪ No understanding of utility networks and associated workflows
Opportunities	▪ Partnerships with hyperscalers ▪ Offer network operation as a managed service to enterprises/SIs	▪ Direct to enterprise (Nokia) or through CSP channel (Ericsson) ▪ Provide equipment for deployments using shared spectrum	▪ Combine 5G with cloud storage to support massive wireless sensor networks ▪ Public cloud resources can be used for smart grid applications
Threats	▪ Increasing competition from hyperscalers and SIs to target energy & utility deployments ▪ No recognition of energy-specific requirements	▪ Safety regulations might require additional (CAPEX) certifications for networking infrastructure ▪ SIs have a much broader partner network	▪ SIs for specific enterprise verticals ▪ No understanding of security procedures in explosion-prone environments ▪ Safety regulations for energy production sites

IMPLICATIONS FOR SYSTEM INTEGRATORS

SIs will need to establish business workflows that support digitization initiatives. As a result, successful digitization efforts will consist of two components that will not only focus on deploying and tailoring technology, but that will also entail a consulting component, adjusting enterprise workflows to embrace the efficiency enhancements of digitization in the energy sector.

5G DEPLOYMENT OPTIONS IN ENERGY & UTILITIES

The energy domain is characterized by a high degree of mission-critical use cases, so any form of interference with the cellular networks used to automate these mission-critical or even life-critical use cases could have detrimental effects. Therefore, network availability and reliability, as well as deterministic networking, are particularly important for 5G deployments in mines, oil & gas fields, and power plants. Furthermore, data on the condition of production assets within a mine or an oil & gas field are highly

sensitive and are, in most cases, areas of national security. Considering all these aspects and stringent requirements, a fully isolated private network, with no (or very limited) interoperability with any public network will be required to fulfill these requirements. From a deployment architecture point of view, this means that all network components will need to be deployed under the implementer's control (ideally within the implementer's premises). As for full on-premises deployments, additional aspects (*e.g.*, explosion-proof equipment) might be important for SIs to consider.

Even though, at first sight, the requirements of utility deployments look radically different from deployments within energy production sites, there are important similarities. On one hand, a municipal electricity or (waste) water grid typically spans a larger area than an energy production site. Furthermore, the energy production site has much more clearly-defined boundaries, while a utility grid is much more dispersed. This implies that the typical distinction between an "on-premises" and an "off-premises" network deployment does not immediately apply.

On the other hand, utility grids require a similar degree of security as energy production sites. Denial of service or damage to the infrastructure could have detrimental effects to several thousand or even millions of people, depending on the respective utility infrastructure. Therefore, deterministic networking is important, and the deployment of a private network will be an integral part to protecting the network (and, therefore, the utility grid) from any unauthorized interference.

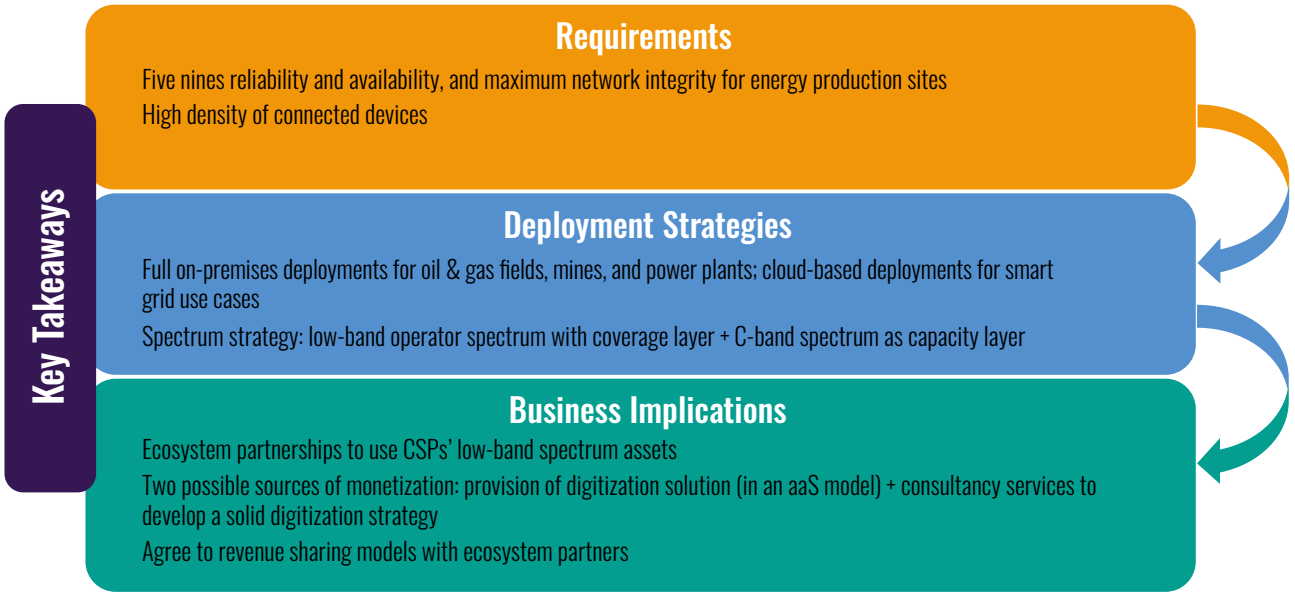
BUSINESS MODELS AND MONETIZING STRATEGIES

SIs can monetize energy & utilities networks, similar to deployments in other verticals. Making deployments appealing even to medium-sized enterprises (with limited means for upfront financial investments) can be provided in an OPEX-based model with recurring subscription fees. To maximize the revenue opportunity, provisioning of each feature could be offered as an add-on, charging enterprises for exactly the services required. The design of these offerings should follow key performance requirements. In that way, SIs could offer low latency, high reliability, and network availability as a service or provide high bandwidth on demand. Theoretically, even the network infrastructure could be provided on a monthly subscription basis (in an IaaS model), which would remove the necessity for any upfront CAPEX from enterprises. Infrastructure will not belong to the implementing enterprise in an IaaS model, which might be appealing for SMEs with particularly tight budgetary controls that are willing to compromise on network integrity. In order to address the entire community of energy & utility companies, SIs need to provide different business models with varying CAPEX components.

Figure 7 presents the key takeaways from this closer look into the energy & utilities vertical.

Figure 7: Key Takeaways Energy & Utilities

(Source: ABI Research)



LOGISTICS & PORTS

Both shipping environments and airports, as well as logistic environments, are very complex and characterized by multiple concurrently running processes. This carries two important implications: 1) the requirements toward automating these processes are particularly stringent; and 2) the operational benefits gained from automating these workflows are particularly large.

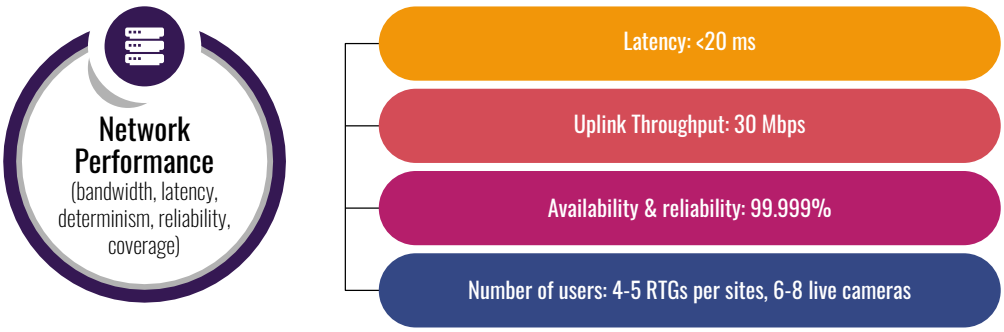
The use of cellular connectivity for logistics and ports centers around remote operations and the automated control of logistics operations. 5G can be used for remotely operating Rubber Tired Gantries (RTGs) within a port, increasing efficiency of shipping port workflows, while decreasing cabling and wiring costs. Furthermore, 5G can also be deployed to automatically control the accuracy of logistics operations, while massive wireless sensor networks can be deployed to monitor the condition of ships and cargo. 5G can be used to provide an E2E transparent supply chain through active traceability and condition monitoring. This allows production facilities to react instantly to supply chain disruptions or demand fluctuations. This can ensure successful transportation of particularly perishable goods that require constant conditions (*e.g.*, a constantly low temperature) throughout the entire supply chain. Looking at airport deployments, 5G can be deployed to provide enhanced connectivity for passengers (both inside aircraft and in terminal buildings) and a higher degree of automation for ground operations to increase efficiency and reduce airplane ground times.

ENTERPRISE REQUIREMENTS AND TOTAL ADDRESSABLE MARKET

As the ports & logistics environment is characterized by a high degree of mission-critical use cases, requirements for cellular connectivity are particularly stringent. Figure 8 highlights the KPIs that 5G deployments will need to address.

Figure 8: Key Requirements Ports & Logistics

(Source: ABI Research)

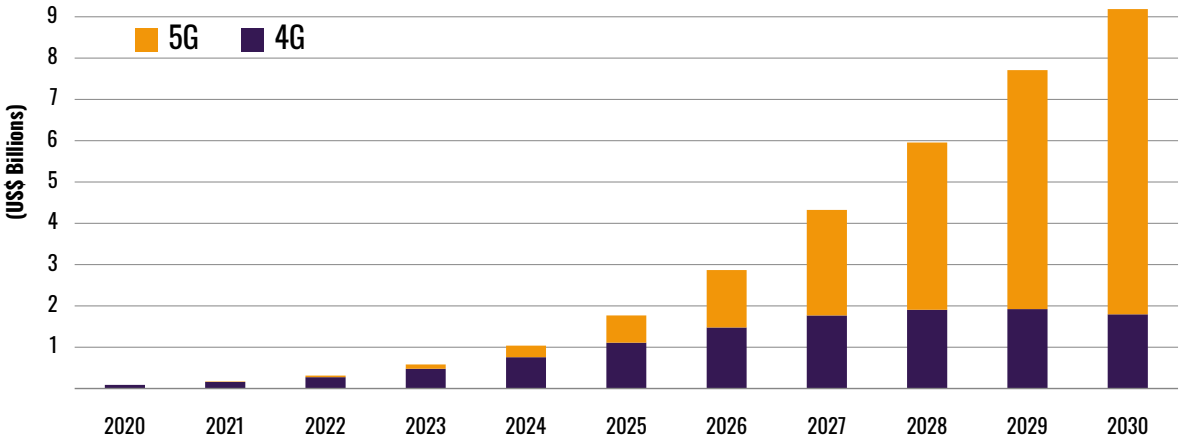


Network slicing allows both mission-critical and non-mission-critical use cases to be addressed within the same physical infrastructure, creating further efficiency enhancements for the respective operator.

In terms of market sizing, ABI Research forecasts that the TAM for private networks will increase from US$91.45 million in 2020 to US$9.18 billion by 2030. While 4G deployments will drive the market until 2026, 5G deployments will account for more than 80% of private network revenue by 2030 (translating to US$7.39 billion).

Chart 3: Ports & Logistics Private Network Revenue World Markets: 2020 to 2030

(Source: ABI Research)



VALUE AND SUPPLY CHAIN ANALYSIS

The logistics sector is very similar in terms of mission-critical use cases, and the requirements for availability, reliability, and network performance, as well as business relationships and buying patterns to realize digitization projects. Consequently, the composition and the shape of the value and supply chain for 5G deployments means that provisioning full E2E connectivity solutions requires integrating different domains (*e.g.*, cloud storage capabilities, RAN infrastructure, and specialized applications), so ports and warehouse operators require a single clearly identifiable partner to interact with for successful deployments and ongoing support.

Enterprises do not have the financial or the personnel resources to approach each of these different domains individually to integrate solutions on their own. Not only would this incur additional costs, but it would also require enterprises to move away from their key competency, essentially becoming a network operator or an SI.

A clearly identifiable point of contact is required in order to provide instant support in case of a network breakdown or similar technical issue. Given that these industrial (or "non-carpeted") verticals are characterized by highly mission- or even life-critical use cases, it is important that any potential network breakdown or technical issue can be addressed instantly without having to find the right point of contact. Therefore, careful design and concentration of SLAs within either the implementer or the SI will be necessary to ensure optimal Quality of Service (QoS).

ANALYSIS OF THE COMPETITIVE LANDSCAPE

Table 6 reports the results of the SWOT analysis of each telco industry player for ports & logistics deployments.

Table 6: SWOT Analysis
Ports & Logistics

(Source: ABI Research)

CAPABILITIES	CSPS	INFRASTRUCTURE VENDORS	HYPERSCALERS
Strengths	▪ Legacy and expertise network operation ▪ Public and private network interaction required to provide fully E2E transparent supply chain ▪ Spectrum assets for nationwide coverage	▪ Necessary infrastructure for last-mile connectivity ▪ Technology expertise to address complex requirements regarding interworking of private and macro networks	▪ Ability to deploy large-scale systems to process large amounts of data ▪ Redundancy and reliable deployments, addressing logistic requirements
Weaknesses	▪ Limited experience in the nature of OT data on port premises and supply chain dynamics ▪ Missing experience in integrating legacy technology	▪ Limited understanding of pain points and key market dynamics ▪ Focus on telco market priorities	▪ Limited experience with workflows in ports ▪ Lack of last-mile connectivity for warehouses ▪ No nationwide cellular coverage
Opportunities	▪ Provide access to spectrum to SIs to provide full E2E solutions to enterprises ▪ Provide network operation as a managed service to warehouse operators and ports with private spectrum	▪ Partnerships with market leaders (Port of Hamburg, Brussels Airport) to build up necessary expertise ▪ Partner with SIs for access to their partner ecosystems	▪ Combine on-premises 5G with cloud resources to allow decentralized data storage ▪ Partnership with SIs for better access to warehouse operators
Threats	▪ Increasing competition from hyperscalers and SIs ▪ No recognition of energy specific requirements (mission-criticality and explosion-proof equipment) will impede successful deployments	▪ New entrants with innovative ideas ▪ SIs and hyperscalers are in a much better position to target logistics environments directly	▪ SIs have an incumbent advantage for initiating digitization projects ▪ Safety regulations might impede hyperscalers' ambitions

IMPLICATIONS FOR SYSTEM INTEGRATORS

Looking at the complicated competitive landscape, ports operators and logistics companies wishing to deploy cellular connectivity on their premises require a strong digitization partner that is capable of navigating the multitude of different deployment opportunities. On one hand, CSPs will be needed as they can provide nationwide coverage for seamless E2E connectivity along the entire supply chain. On the other hand, similar to industrial manufacturing, there is a significant trust gap between port/warehousing operators and the telco industry (namely, CSPs), that needs to be overcome. In addition to being a key partner for digitization projects within ports & logistics environments, SIs can bridge this gap of trust and bring the telco industry together with logistics enterprises.

5G DEPLOYMENT OPTIONS FOR PORTS & LOGISTICS

Being able to use cellular connectivity for real-time applications require latencies of no more than 30 ms. From a network architecture point of view, this requires edge cloud facilities to be deployed on-site. Furthermore, implementers will be very hesitant to see sensitive data leaving their premises, so a large proportion of network traffic would need to remain on-site to attract interest. To maximize addressable use cases for airport deployments, the implementer (*i.e.*, the airport or terminal operator) will require its own network slicing capabilities.

To provide connectivity for goods across their entire supply chain, a private network deployment in ports, warehouses, or manufacturing sites would need interoperate with a public network provided by a network operator, which can be guaranteed in two ways. Firstly, a private network deployment within a warehouse or port could share the RAN with a public network. This still constitutes a full on-premises private network deployment, so it would allow all sensitive production data to remain within the private network on the implementer's premises. Interaction with any public part of a network would need to be safeguarded by firewalls and other comparable safety measures, as traffic would be separated at the RAN level. Secondly, warehouse or port operators could also rent a slice from a public network, which would provide dedicated connectivity to their respective premises. While this presents a much more economical deployment option (as it does not require deploying an on-premises core), it also requires enterprises to compromise on data integrity and customizability of the network.

BUSINESS MODELS AND MONETIZING STRATEGIES

Similar to monetizing aspects in the industrial manufacturing domain, the deployment of a private network would need to distinguish between providing connectivity infrastructure *versus* professional services and network operation. Network operation would ideally be provided to enterprises as-a-Service, monetized through subscriptions to minimize the amount of upfront investment. The necessary infrastructure could be purchased by the enterprise through an SI (which would require upfront CAPEX investment). Alternatively, SIs could also provide the networking equipment in an IaaS model, which would be monetized through recurring subscription fees. From an enterprise perspective, this means that connectivity infrastructure would never be fully owned. Therefore, SLAs would need to be designed in a way to allow enterprises to attend to network performance issues immediately, without having to rely on CSPs or infrastructure vendors. Again, SIs could play an important mitigating role.

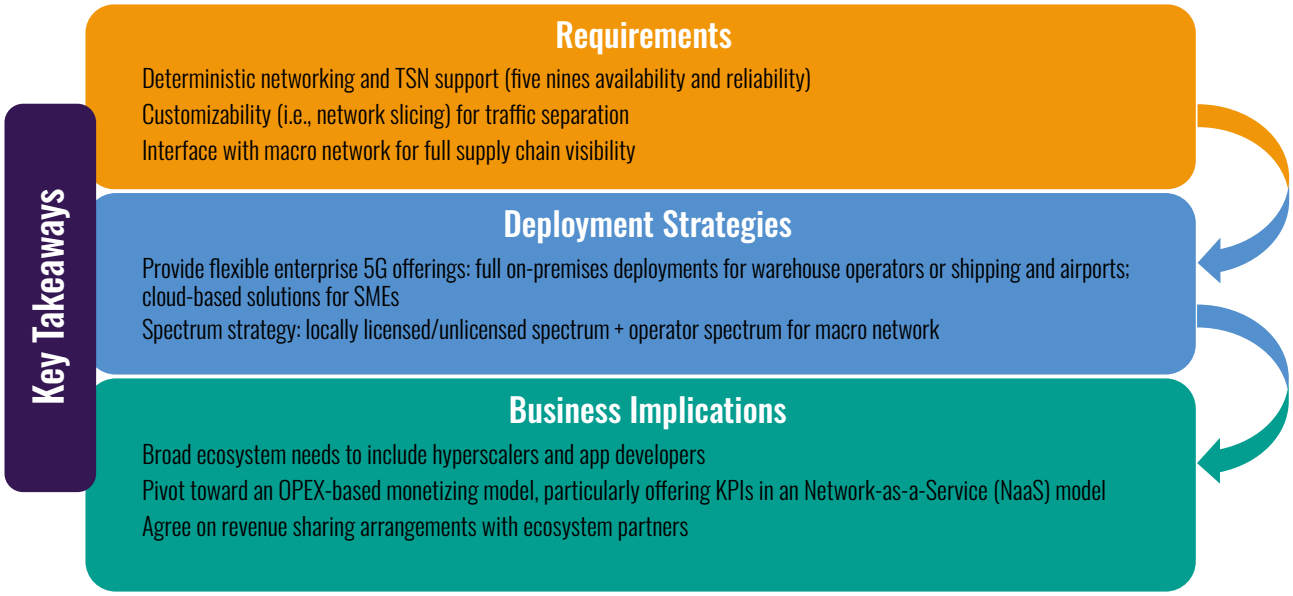
From an SI's point of view, an IaaS business model requires additional consideration about how to refinance these offerings. Either SIs would need agree on revenue sharing arrangements with their partners or purchase necessary equipment from respective vendors, subsequently leasing it to enterprises. The second option incurs a substantial economic risk to SIs, so a revenue sharing model will be the most sensible choice for providing IaaS.

When it comes to renting out a separate slice of a public network, this could be provided to logistics companies and port operators in an OPEX-based as-a-Service model that would not require any upfront CAPEX from the enterprise. Ideally, renting a dedicated slice from a public network would also include using the public network infrastructure, needing no additional equipment. However, the stringent enterprise requirements for reliability and infrastructure redundancy could make deploying additional equipment (*e.g.*, small cells) necessary. This additional infrastructure would need to be provided in an IaaS model, as no enterprise would purchase their own network infrastructure if the network itself is only rented. Even though in this scenario, the CSP would rent out its public network resources to the enterprise, an SI could assist the enterprise in making optimal use of the network slice.

Figure 9 presents the key takeaways from the closer look into the ports & logistics domain.

Figure 9: Key Takeaways Ports & Logistics

(Source: ABI Research)



CONCLUSIONS AND RECOMMENDATIONS

5G for the enterprise domain is really much more than a linear continuation of previous generations of cellular connectivity. Given its key characteristics of eMBB, Ultra-Reliable Low-Latency Communication (URLLC), and Massive Machine-Type Communications (mMTC), 5G will be a crucial enabler for large-scale adoption of key emerging technologies, such as Artificial Intelligence (AI) and Machine Learning (ML), Augmented Reality (AR) and Virtual Reality (VR), or the inclusion of edge computing into

cellular connectivity infrastructure. Consequentially, 5G cellular connectivity will be an important building block for full E2E enterprise digitization. Enterprise 5G will be one building block, among many others, to support enterprises with transforming their operations to take full advantage of what is often referred to as the **Industry 4.0**. This carries several implications on the work and role of SIs as Figure 10 illustrates.

Figure 10: Key Recommendations for System integrators

(Source: ABI Research)

Design flexible enterprise offerings

In order to address heterogenous enterprise verticals with different requirements, SIs need to provide a diversified solution portfolio for different verticals.

To address different enterprise sizes, these offerings should be designed with enough flexibility to enable easy up- or down-scaling depending on the size of the operation.

While the enterprise offerings should be flexible in size, there needs to be a standardized scope in terms of architecture and KPIs that allows for easy scalability and, therefore, guarantees profitability for SIs.

To enable this flexibility from a business model point of view, enterprise 5G deployments should be offered in an XaaS business model that allows for effortless upselling.

Provide strong ecosystem partnerships

To drive the adoption of 5G in the enterprise verticals, SIs need to understand cellular connectivity as one building block to enterprise digitization and embed it into an all-encompassing strategy.

To provide this digitization strategy, SIs need to understand enterprise pain points and be able to integrate a range of different technologies into a full digitization solution.

In order to be actionable for enterprises, this strategy needs to take into account different enterprise constraints (e.g., budgetary limits, legacy technology landscape, or retrofitting of existing infrastructure).

Most importantly, SIs need to develop their own frameworks on how to integrate IT and OT domains with CT.

Be a reliable digitization partner

To be able to deploy a full E2E connectivity solution for enterprises efficiently, telco suppliers need to engage in partnerships with different stakeholders to leverage synergy effects and avoid duplicating efforts.

Particularly important in this context are strong ties to hyperscalers and application developers with the necessary expertise to design vertical-specific applications. While this is a common weakness for the traditional telco industry, SIs already have these cross-domain partnerships in place.

SIs have a key incumbent advantage, as they have both the technical experience in integrating components from different domains and the ecosystem partnerships in place that are needed to provide a full E2E 5G deployment for enterprises.

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