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Transformative Enterprise 5G

# To Become an Attractive Enabler for DX

Three Proposals for CxOs Taking on the Challenge of Enterprise 5G

# Contents

# Transformative Enterprise 5G: To Become an Attractive Enabler for DX

## Three Proposals for CxOs Taking on the Challenge of Enterprise 5G

Due to the outbreak of COVID-19 pandemic, the spread of geopolitical risks, and the frequent occurrence of natural disasters such as earthquakes and heavy rains, the international community and business world have entered the era of VUCA, where it is difficult to predict the future. However, what is progressing in this VUCA era is deepening digitization, or digital transformation (DX) and the creation of innovation. On the other hand, the evolution of digitization is giving rise to contemporary issues, such as security in the virtual society and cybercrime.

In this way, new connectivity technologies are born along with the activation of DX and innovation creation. In addition, these connectivity technologies are required to evolve further as an infrastructure for DX and innovation activities. In short, it is the enabler for DX. 5G, the next-generation wireless technology, has high security, large capacity, low delay, and high reliability; 5G is a technology that matches the IoT era. These capabilities are driving expectations not only for digitized consumers as connectivity enablers, but also for vertical sectors such as manufacturing, logistics industry, medical health, education, and energy and utilities. Assuming that a set of private 5G systems will be installed at each vertical sector base, the potential market for enterprise 5G is expected to be larger than that for the public sector so far*1.

Players such as traditional telecom carriers, telecom equipment vendors, leading cloud vendors, enterprise network suppliers and connectivity startups have entered or are accelerating their preparations to enter the enterprise 5G market. However, 5G (for enterprise) adoption is still at a low level although 5G technology and standardization, the development of base stations and commercialization of devices for public 5G (for consumer), and the fixed wireless connectivity (FWA) of 5G have made steady progress.

This paper researches the latest development trends of 5G for enterprises including Private 5G (P5G) which is physically independently constructed and Dedicate 5G (D5G) which is logically independent by slicing public 5G. Based on the research, we will summarize insights and suggestions on how to form an attractive enterprise 5G for promoting DX.

*1 The term "enterprise" in this paper encompasses a large set of industrial and general service verticals. Examples of enterprise verticals include manufacturing, transportation, mining, oil & gas, utilities, healthcare, education, hospitality, venues, banking, public sector, and gaming.

# 1. Expansion of IoT Connections and Evolution of 5G Technology

Consumer connectivity is rapidly shifting from fixed broadband to wireless broadband due to advances in ICT technology. According to Ericsson's statistics and forecasts, fixed broadband subscribers were predicted to reach 1.45 billion in 2022, while mobile communication subscribers were predicted to reach 8.39 billion, about six times the number of fixed broadband subscribers[*2]. In the wireless field, subscribers are accelerating their shift to the new generation one after another as well.

Of the 6.6 billion total smartphone subscribers in 2022, LTE and 5G were predicted to account for 5.16 billion and 1.05 billion. By 2028, the numbers are expected to be 3.58 billion and 4.97 billion, respectively, and the shift to 5G will progress. This consumer shift to 5G is evidence that public 5G networks are well on their way.

On the other hand, there were predicted to be 13.2 billion IoT wireless connections in 2022, more than double the 6.6 billion subscribers. By 2028, IoT will be 34.7 billion compared to 7.79 billion of subscribers. Among IoT wireless connections, broadband IoT (4G/5G) achieved for over 1 billion in 2021, a small proportion of the total IoT but is estimated to account for 60% in 2028. In addition, most of the broadband IoT is based on 4G, but with the maturation of 5G technology and the ecosystem of equipment and devices, the expansion of frequency allocation to 5G (including both public and vertical) will provide an incentive to introduce 5G technology.

For example, 5G-related devices began with few announcements in 2019 and then picked up pace, with 1,798 products announced by the end of 2022, of which about 80% were commercially available devices (Figure 1-1). As Figure 1-2 shows (As of the end of November 2022), 5G devices are mostly consumer products, but vertical devices (enterprise products) are also increasing.

**Figure 1 Current Status of 5G-Ecosystem (December 2022)**

**Figure 1-1 Growth of 5G devices**

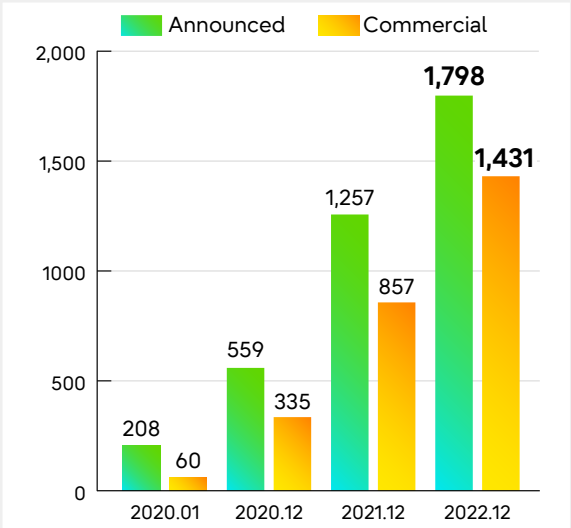
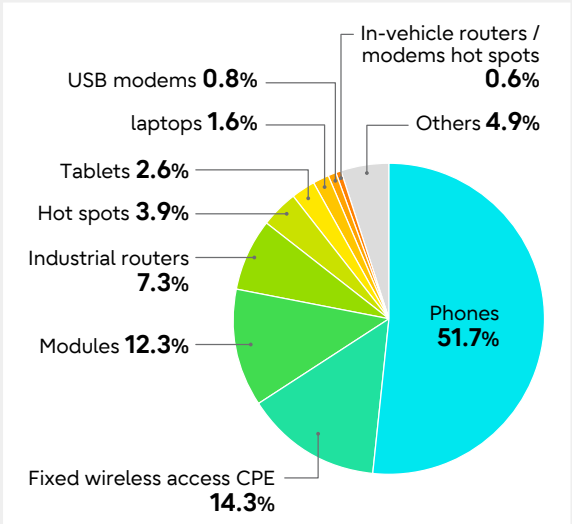



**Figure 1-2 Announced 5G devices, by form factor**




Data Source: GSA "5G Device Ecosystem" (Monthly)

*2 Ericsson (November 2022) "Mobility Report"

## 2. Expectations for Enterprise 5G as a Digital Infrastructure that Supports the Evolution of DX

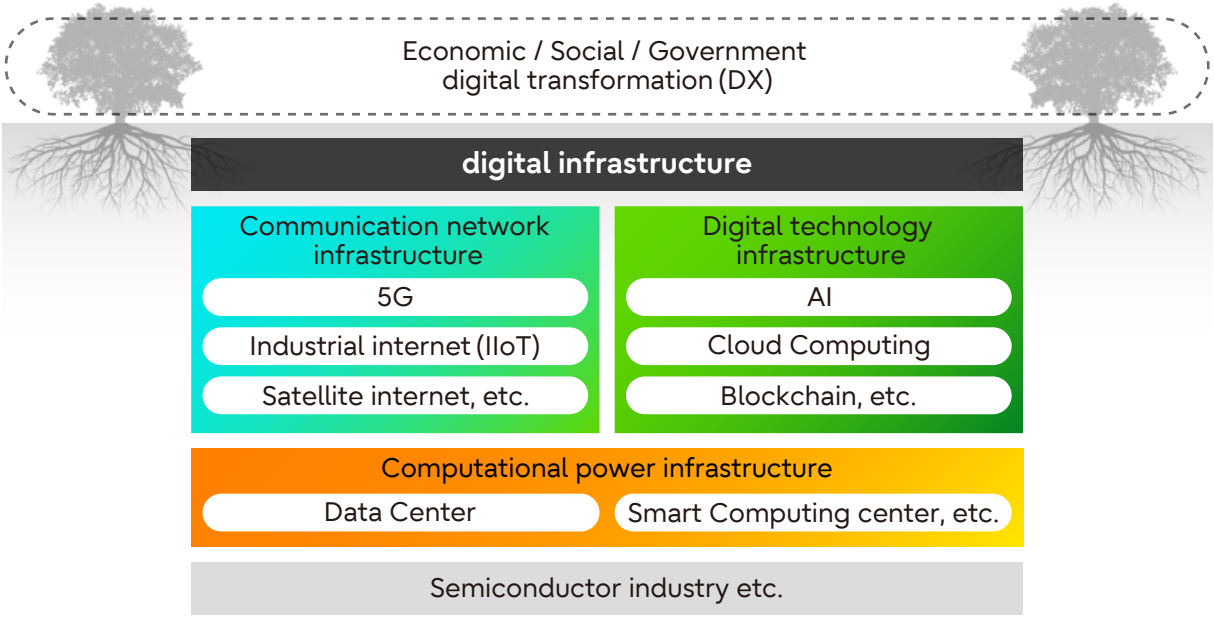
It is nearly a decade since industry efforts to address the proposed Fourth Industrial Revolution, which predates the commercialization of 5G. Efforts for digital transformation (DX) in each industry using digital technology are steadily spreading. At the implementation level, silos among departments have been broken down, and efforts have also begun across the organization. The commitment of major countries to carbon neutrality and the COVID-19 pandemic have further fueled expectations for DX. A compelling digital infrastructure, such as AI, cloud computing and connectivity, is essential to achieving the performance expected by this digital transformation (see Figure 2).

For example, since the 2010s, the World Economic Forum (WEF) has focused on transforming the manufacturing industry through next-generation digital technology (fourth industrial revolution technology). Considering the sluggish progress of DX in the manufacturing industry, WEF has been working with McKinsey since 2018 to select the world's leading DX companies (lighthouses). Using these lighthouses as role models for DX, the WEF is trying to scale up the DX activities of the manufacturing industry. As of January 2023, 132 global lighthouse companies have certified.

Each of these lighthouses employs 20-40 use cases, with a total of 142 original use cases (excluding duplicate use cases)[*3]. Use cases such as flexible automation, process control, AI inspection, digital twins, supply chain visualization, and predictive maintenance will have a significant impact. To be effective, these use cases must be supported by a good network infrastructure. The main features of 5G: "high speed and large capacity", "multiple simultaneous connections", and "ultra-Reliable and low latency" are highly anticipated.

*3 WEF (January 2023) "Global Lighthouse Network: Shaping the Next Chapter of the Fourth Industrial Revolution"

**Figure 2 Digital Infrastructure Supporting Social Implementation of DX**




Source: Author's summary

In fact, with the evolution of DX, as enterprise networks, several important requirements (examples in the United States) for Enterprise 5G have been confirmed as follows*4.

1. **Suitable Radio Frequency (RF) Spectrum**
   Adequate and cost-effective spectrum availability is a top requirement for enterprise wireless use cases. This is because the cost of using spectrum in some countries is high, and there is a possibility that companies will shy away from adopting it.

2. **Ensure system for higher quality connections**
   For the most advanced use cases, such as industrial automation like the "factory of the future", we need to ensure the deterministic nature.

3. **Coverage ability**
   A considerable number of companies may require collaboration between indoors and outdoors, between domestic cities, and even international bases.

4. **Security**
   A company's unique security requirements are a priority consideration.

5. **Availability and reliability**
   Companies considering adopting P5G will continue production or service 24/7, requiring high availability and reliability.

6. **Operability**
   It is required to reduce the complexity of P5G so as to maintain the same operability as the traditional enterprise network system.

*4 5G Americas (January 2023) "Enterprise Evolution with 5G Adoption"

These requirements are not limited to the United States but can be seen in surveys of companies around the world. In fact, with the evolution of DX, after each government, mainly in Japan, the United States and Europe, has started commercial use of public 5G, they will soon approve dedicated spectrum in the vertical field for companies and use it for corporate DX. Emerging countries like China and India have also licensed[*5] or are considering[*6] the possibility of licensing dedicated spectrum for P5G applications. Overall, interest in P5G is growing.

The contents of Figure 3 are the results of a survey of 400 companies that have already adopted or are planning to adopt P5G in the United States. The spread of industries interested in P5G can be seen, with the top four being tech companies, manufacturing, distribution, and Healthcare. On the other hand, applications implementing P5G are concentrated (see Figure 3-2). The top 4 were overall corporate premises rather than indoors, IoT sensor data response, remote asset control, and edge computing. We believe that all of these are applications that take advantage of the superiority of 5G.

**Figure 3 Private 5G Trends in the US (As of April 2022)**

**Figure 3-1 Top 10 Industries Interested in Private 5G**

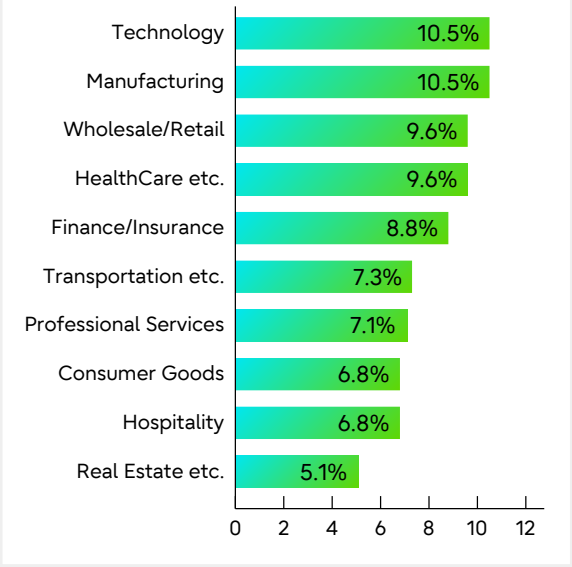
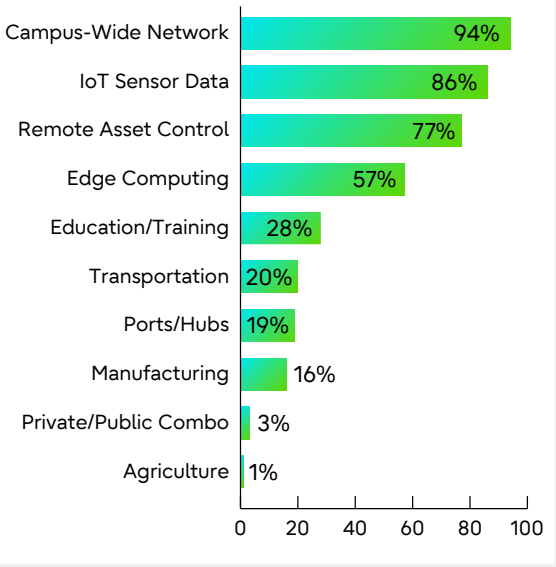



**Figure 3-2 Top Applications Expected for Private 5G**




Data Source: technalysis RESEARCH (July 2022) "Private 5G Networks: Defying Expectations: a survey Report"

*5 China grants first 5G private license to COMAC. State-owned COMAC is the first non-telco to receive a private 5G license in China. https://www.chinadaily.com.cn/a/202211/21/WS637b33aea31049175432afed.html

*6 Over 20 Indian firms show interest in setting up 5G private networks. https://www.rcrwireless.com/20221118/private-networks/over-20-indian-firms-show-interest-set-up-5g-private-networks.

# 3. Enterprise 5G Deployment Models Are Diverse and Evolving

Public 5G network services are conducted by a small number of licensed telecom network service providers. As mentioned at the beginning, in enterprise 5G, cloud service vendors, communication equipment manufacturers, and start-up companies are entering along with conventional communication carriers, and service providers are diverse. In fact, enterprise 5G network deployment models are also diversifying.

As a result of researching the definition of the wireless communication standardization organization 3GPP and the practical report on the adoption of 5G (including P5G and D5G) by enterprises in the vertical field, the 5G deployment model for major enterprises is summarized as shown in Table 1. According to 3GPP Release -16, there are two types of networks for enterprises: SNPN Model (where the network is physically independent, referred to as P5G in this paper) and PNI-NPN Model (Model to share public 5G physically, referred to as D5G in this paper)*7. In addition, Table 1 divides the SNPN model into a Full P5G model and a Cloud Hosted P5G model in which some functions are cloud hosted. In addition, the PNI-NPN model is classified into a full shared model and a partially shared model. Further variants (sub-models) can be considered from these four Deployment models*8.

**Table 1 Major Deployment Models of 5G for Enterprise**

| Deployment Model | | Spectrum | Enterprise Premises | Cloud Service Provider | Public Network Service Provider |
|---|---|---|---|---|---|
| **SNPN Model (P5G)** | Full Private Deployment | Dedicated Spectrum | Building all network functions | – | – |
| | Cloud Hosted Private Deployment | Dedicated Spectrum | Building all or part of network functions | Virtually build some functions of the network | – |
| **PNI-NPN Model (D5G)** | Macros Slice Private Deployment (Partially Shared) | Public Network Spectrum | Partially Shared With Public Network | – | Build all 5G network |
| | Macros Slice Private Deployment By the Public Network (Fully Shared) | Public Network Spectrum | Fully Shared With Public Network | – | Build all 5G network |

* This article considers private 5G when spectrum is leased from a carrier to deploy an enterprise 5G network.
Source: Created by the author

*7 SNPN: "Standalone Non-Public Network", PNI-NPN: "Public Network Integrated - Non-Public Network".
*8 Jianmin Jin (2021) "Transformative 5G in the IoT Era: how to realize its potential, from verification to implementation" https://www.fujitsu.com/global/vision/insights/21-5g-business-of-the-iot-era/

Enterprise 5G deployment models in each country differ considerably depending on the country's radio regulatory policy (whether there is spectrum allocation for enterprises), the state of public 5G network development (coverage), and the availability of 5G services for enterprises. Countries such as the US, Germany, UK, Japan, Finland, France, and Spain (as of September 2022) that have licensed enterprise-only spectrum along with the rollout of public 5G networks are using P5G Deployment as their preferred model[*9]. For example, Germany has licensed spectrum for P5G, which is the earliest in the world. It has approved 293 P5G users by January 15, 2023, after initiating P5G applications in November 2019[*10]. Japan has also licensed 126 users as of November 30, 2022, starting March 2020 to license the P5G spectrum (referred to as "local 5G" in Japan)[*11].

On the other hand, around 2020, there were some case where D5G, which shares public 5G using Slicing technology, was also adopted in the United States and Europe[*12]. Since then, a lot of company in Japan, Germany and other countries have adopted P5G because of the availability of corporate-dedicated spectrum, delays in the development of public 5G networks, and the prioritization of ensuring corporate data security. However, in the United States, where public 5G development is progressing, it seems that the Shared model that utilizes slicing technology is being re-evaluated. Because "This Macro Slice model is very exciting as it can open the vast resources of cellular providers: spectrum, footprint, coverage, expertise, to enterprises"[*13].

China, which had prioritized effective use of spectrum, will not approve spectrum for corporate use until the second half of 2022, prioritizing the development of public 5G networks. However, as mentioned above, in November 2022, large companies with particularly high requirements for security, reliability, and autonomy were authorized for enterprise-only spectrum, and the P5G model was launched.

### Example 1 Physically independent P5G models, based on frequency range acquisition - Fujitsu Shin-Kawasaki Technology Square and Oyama Plant

In February 2020, Fujitsu obtained Japan's first P5G license (using a dedicated 5G frequency range allocated to each qualifying enterprise) and built the NSA network (5G wireless system that realizes 5G data communications in conjunction with LTE equipment) within its Shin-Kawasaki Technology Square. In March of the same year, Fujitsu began operating a security system, which is the first commercial operation of a private 5G network in Japan. It realizes high-capacity/high-speed transmission of high-definition image data collected by multiple cameras, as well as the operation of a security system for the early detection of suspicious behavior based on video analysis.

*9 According to GSA (December 2022) "Private Mobile Networks", as of September 2022, China, Russia, Austria, Canada, Belgium, Mexico, etc. have not approved Spectrum for enterprise use only.

*10 https://www.bundesnetzagentur.de/SharedDocs/Downloads/DE/Sachgebiete/Telekommunikation/Unternehmen_Institutionen/Frequenzen/OffentlicheNetze/LokaleNetze/Zuteilungsinhaber3,7GHz.pdf?__blob=publicationFile&v=9

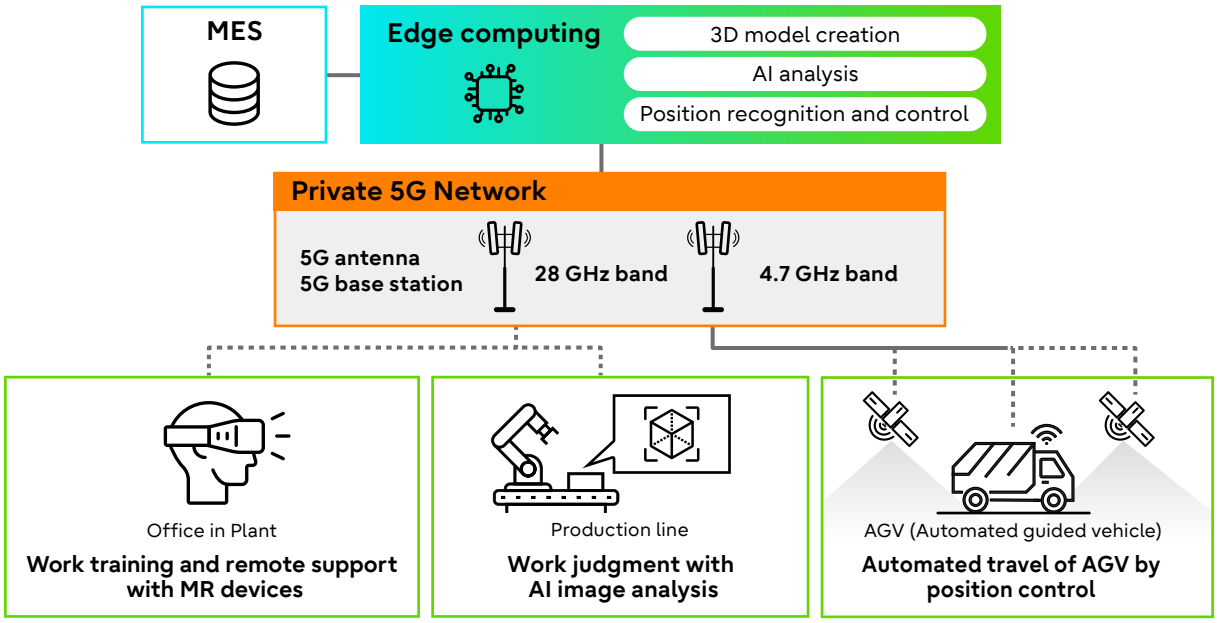
*11 https://go5g.go.jp/sitemanager/wp-content/uploads/2020/10/221130-ローカル5G免許人等一覧.pdf

*12 GSMA (October 2020) "5G IoT Private & Dedicated Networks for Industry 4.0"

*13 5G Americas (January 2023) "Enterprise Evolution with 5G Adoption"

In March 2021, we began commercial operation of a P5G system at our Oyama Plant to automate on-site operations and provide remote support. As shown in Figure 4, the P5G system comprises two parts: a middle-band SA (Stand Alone: 5G wireless system including the core network implemented only by 5G technology), which enables the automated movement of an unmanned vehicle (AGV = automated guided vehicle) via position control. The second part involves a high-band NSA (Non-Stand Alone: system consisting of a 4G LTE core network and 5G base station), which is used for work training facilitated by MR (mixed reality) functionality, and remote support through high-capacity/high speed data transmission, and work assessment by AI image analysis.

**Figure 4 Private 5G Utilization at Fujitsu Oyama Plant**




Source: Author's summary based on Fujitsu news release

The Oyama Plant's private 5G solution, based on the locally built Enterprise 5G communications network, was verified to realize a smart factory, utilizing advanced technologies such as AI, IoT, AR/VR/MR (see Figure 4). The plan is to offer this to other companies as a service in the future. This example from the Japanese manufacturing industry, ranked as one of the world's leaders, has proved the viability of an P5G. It was realized by overcoming the challenges of a manufacturing system to ensure data security, network availability, production system resilience, etc. even in situations where the deployment of public 5G networks is not particularly widespread.

# 4. Enterprise 5G Adoption Still in Early Stage, Challenges to Scaling Up

As mentioned above, there are growing expectations for the vertical application of 5G in the IoT era. How many companies in the world are using 5G? No exact statistics exist, but the Global mobile Suppliers Association (GSA) has put together a Monthly report called "Private Mobile Networks". According to the latest report, as of September 2022, 955 companies have deployed in seventy-two countries/regions*14. However, GSA report excluded D5G deployed with Slicing technology but included the number of networks with LTE technology; thus, the number of P5G networks will decrease.

**Figure 5 Deployment Status of Private Mobile Networks (As of September 2022)**

**Figure 5-1 Private mobile network customers by year announced**

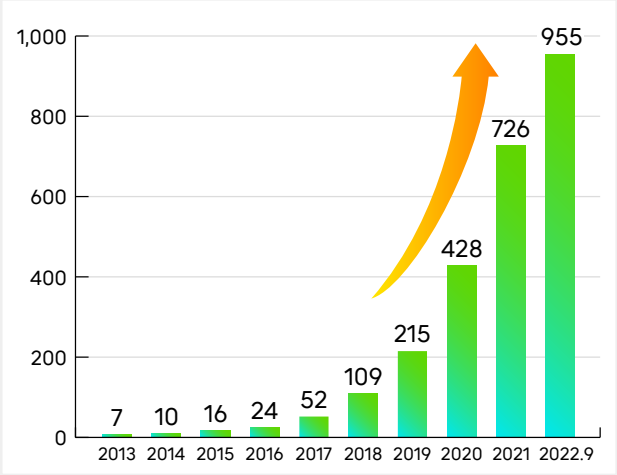
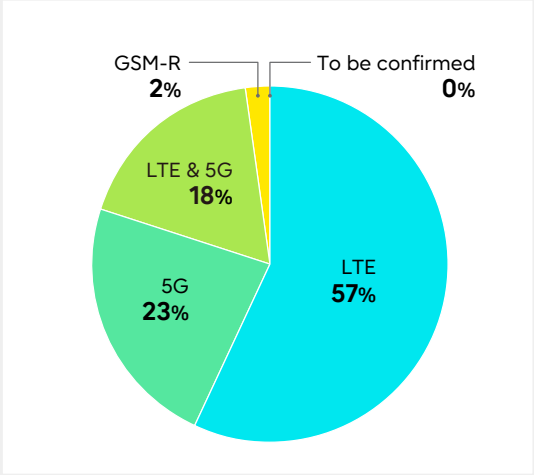



**Figure 5-2 Deployment of Private mobile networks by technology**




Created by the author based on data from GSA (December 2022) "Private Mobile Networks"

As shown in Figure 5, private mobile networks expanded more than fourfold in the three years from 2019 to September 2022. LTE technology is the leader, with 5G and LTE/5G combinations accounting for 42%. Also, according to GSA, the number of companies that have specifically deployed P5G networks has increased from 296 in March 2022 to 391 in September 2022. However, it should be noted that many of these P5G networks are for education and testbeds or verification purposes, and only a limited number of them are operating in industrial activities. This could be said that the commercial use of P5G networks is still in its preliminary stages.

Also, according to research by the European 5G Observatory, which is supported by the EU Commission, 64 companies (only cases where information is disclosed) have deployed P5G networks in EU countries between 2018 and 2022, the number has been declining since peaking in 2020*15.

*14 GSA (December 2022) "Private Mobile Networks"
*15 the European 5G Observatory "5G private networks" https://5gobservatory.eu/5g-private-networks/#

Various issues have been raised regarding the sluggish growth of P5G Deployment, but three important challenges can be sorted out*16.

1) **Technical complexity and lack of technical talent**
   Most companies have IT personnel but not many communication engineers. Enterprise 5G is the new world in wireless technology, and Private 5G also presents a steep learning curve.

2) **Financial Challenges: Difficulty Determining Investment Returns**
   It is difficult to strike a balance between the TCO (Total Cost of Ownership), including the initial investment amount and operating costs for maintenance, and the profit from the introduction of the P5G network.

3) **Difficulties in integrating existing networks with P5G**
   Every company has an existing fixed line or wireless system such as ethernet and WiFi, and integration with P5G takes time and cost. It is difficult to obtain investment budget from management.

Fortunately, we are developing various business models and technological innovations, including Private-Networks-as-a-Service (PNaaS), to overcome the above challenges. In fact, in the United States and Germany, customers already have the choices of truly private5G or a semi-P5G variation of a managed service or a fully managed service from a carrier.

However, the majority of P5G adoptions so far are confined to company campuses. Use cases such as connected cars, power transmission networks, and wide area/multi-site factory networks require seamless private and public access.

In addition, the expensive and technically complex P5G network is adopted by some large companies, and it is difficult to spread it to small and medium-sized enterprises and start-ups*17. This is one of the reasons why the number of P5G adoption cases is decreasing. For example, about 300,000 factories in the United States are said to benefit from 5G, but at present (see GSA data), only over a hundred large companies have adopted it.

Therefore, it is necessary to scale up and popularize enterprise 5G. European and American industry associations are already having lively discussions. One argument is the utilization of the PNI-NPN Model defined by 3GPP, that is, the D5G mentioned in Chapter 3. For example, at the "Private Networks European Forum (PNEF)" held in October 2022, 'private 5G to the masses' was taken up, and the possibility of expanding P5G not only to large companies but also to small and medium-sized enterprises was discussed*18. In addition, the focus of discussion is on the coordination and liberalization of spectrum regulations, the integration of ecosystems, and the utilization of public 5G networks using slicing technology (deployment of D5G networks).

*16 TECHnalysis Research (July 2022) "Private 5G Networks: Defying Expectations: a survey Report"; Michael Cooney (May 2022) "Private 5G: Its use in enterprises faces challenges"; Ann Heyse(September 2022) "Deploying private networks: 3 challenges for enterprises)

*17 In Germany, there are also cases of SMEs deploying P5G.

*18 James Blackman (November 2022) "Spectrum, systems, slicing – five key challenges to bring private 5G to the masses".

As mentioned above, in China, the utilization of enterprise 5G is basically a D5G model that shares the developed public 5G. The Shared model's D5G (called "virtual 5G dedicated network" in China) have reached 800 in 2020, 2,300 in 2021, and 14,000+ by the end of 2022[*19]. Based on PoC and trial implementation (0 to 1) from 2019 to 2021, China's D5G model is expected to scale up and enter the diffusion stage (1 to N) from 2022.

China is prioritizing the D5G model based on public 5G because, in addition to focusing on frequency efficiency as mentioned above, carriers are trying to secure the enterprise 5G market in the absence of killer applications in the public 5G market. The three major state-owned carriers China Mobile, China Telecom and China Unicom each offer three models to meet the diverse requirements of enterprises. This refers to Full-Slicing D5G, Partial-Slicing D5G (UPF dedicated to enterprises and on-campus installation of MEC), and Full-D5G/P5G that leases frequencies to enterprises.

However, the number of deployments is rapidly increasing due to the promotion of corporate 5G market entrants such as carriers and equipment manufacturers and the preferential policies of the government. There are also many challenges in the deployment of D5G in China. The main points are as follows.

1) The excessive cost of introducing and operating enterprise 5G networks
2) Lack of human resources related to communication technology in companies
3) Enterprise 5G supply chain is not yet mature, and performance stability remains an issue
4) Acceleration of innovation in business models that meet corporate objectives and needs is required

We believe that the above D5G challenges will not be significantly different from P5G, and will be concentrated in technology, human resources, and costs.

Overall, it is estimated that the development of D5G will be further accelerated in China due to economies of scale, accumulation of technology, know-how, and human resources, in addition to the expansion of coverage through the development of public 5G infrastructure.

*19 Ministry of Industry and Information Technology (MIIT) of China "2022 Communication Industry Statistical Bulletin". Communication information "my country has built more than 2,300 5G private networks, and it is expected to move from pilot to promotion in 2022" https://finance.sina.com.cn/tech/2022-01-13/doc-ikyamrmz4987142.shtml

# 5. Three Proposals for the Spread of Enterprise 5G

As made clear by the above research and insights, expectations for enterprise 5G are increasing due to the progress of 5G technology and standardization, the expansion of the ecosystem including devices and applications, and the evolution of DX activities in the economy and society. However, various challenges lie ahead, and there is also a gap between higher expectations for 5G in the enterprise and actual adoption. We will summarize proposals for scaling up the adoption of 5G by companies, which is in the preliminary stages, and promoting its spread.

### (1) DX needs driving enterprise 5G deployment thinking

Enterprise 5G itself does not directly create value for companies independently, but it creates value only when combined with applications. Enterprise customers must plan their enterprise 5G network as part of their enterprise-wide DX solution based on their own DX promotion needs. Therefore, enterprise 5G must not be an independent plan that simply realizes corporate connectivity but must be a "corporate DX + 5G" plan that is integrated into the corporate DX plan.

Such enterprise 5G thinking is required not only by client companies but also by enterprise 5G vendors as partners.

### (2) Choose the best enterprise 5G model based on functionality, security and cost performance

Select the enterprise 5G Deployment model after the upper DX strategy/plan is created. Based on the premise of security, large capacity, low latency, high reliability, and mobility of 5G and evolving 5G-Advanced technology, the following main points raised by customers through the implementation of enterprise 5G including P5G and D5G mentioned above must meet requirements.

1) Meet the different needs of each use case for 5G capabilities (versatility and flexibility)
2) Ensuring data security
3) Possibility of self-definition, self-design, and self-management (network agility)

However, when considering a particular use case, each of these requirements need not be met to the same extent at the same time but should be prioritized. This is because even though many companies recognize the business value of enterprise 5G networks, they may be hesitant to introduce them due to tradeoffs between network security and deployment costs.
In addition, enterprise 5G should not only be focused on large companies but should be inclusive, in other words, the need to develop technologies and environments that are easy for small and medium-sized companies to use.

**Table 2 Features of Enterprise Dedicated 5G Networks**

| Implementation Model | SNPN Model (Independent model) | | PNI-NPN Model (Network sharing model) | |
|---|---|---|---|---|
| | Full P5G | Cloud Hosted | Partially Shared | Fully Shared |
| **Degree of isolation from public 5G** | High | Relatively High | Medium-High | Relatively Low |
| **Degree of delay** | Small | Small | Small | Depends on the distance from MEC installation point |
| **Complexity of building** | Complex | Relatively Complex | Relatively simple | Simplest |
| **Building/ Operational costs** | High | Relatively high | Medium | Relatively Low |
| **Required skills** | High | Relatively high | Medium | Relatively Low |
| **Target companies** | Industries and large companies that require independence | Industries and large companies that require independence | General companies | Companies operating in a wide area / Small and medium enterprises |

Source: Author's summary

Table 2 summarizes the features, strengths, and weaknesses of the key models for deploying enterprise 5G networks discussed so far. In contrast to P5G, a company-specific model aimed at ensuring greater security, autonomy, and ultra-low latency. The shared public network model (D5G) focuses on efficient spectrum utilization, security, ultra-low latency, and it is a model for utilizing technology, know-how, and assets for the purpose of ensuring high-cost performance and simplifying the introduction and operation of systems.

However, regarding the P5G model as well, technology and know-how are shared, and cost performance is improved through third-party management services and system simplification according to purpose. Conversely, in the D5G model, 5G technology has increased the encryption level from 4G's 128-bit to 256-bit. Data and system security can be improved using more advanced encryption technology and the exclusive use (in-house installation) of some functions (for example, UPF and MEC).

As a result, companies need to evaluate the optimal combination of implementation methods, system functionality, security, and cost performance to maximize value creation, depending on their objectives. Customers and vendors need to design enterprise 5G network deployment plans based on objectives, expertise, public 5G coverage and availability, and requirements to acquire dedicated spectrum or own their own network assets, and TCO.

In the future, enterprise 5G technology will follow the same direction as cloud technology, which manages on-premises and public cloud systems, and that system will eventually take a hybrid form, depending on enterprise objectives, productivity, and cloud technology maturity. It is conceivable that it will converge to in other words, a hybrid enterprise 5G that mixes P5G and D5G will appear.

### (3) Proposal of Cloud-native enterprise 5G to fit for purpose

Unlike public 5G networks for consumers, enterprise 5G must meet the diverse needs of different industries and types of businesses. If specific hardware and software are used to realize connectivity, it will not be possible to achieve economies of scale that bring about high-cost performance.

Fortunately, with the fusion of communication technology and cloud computing technology, physical network functions (PNFs) in which hardware and software are tightly coupled, are replaced by virtualized network functions (VNFs) in which hardware and software are separated[*20]. In fact, the disaggregation and openness of the telecom sector will progress from the core network to the radio access network (RAN), leading to increased innovation, competitive functions, and off-the-shelf hardware and software (COTS) procurement. As a result, benefits such as performance improvement, deployment flexibility, and cost reduction are being realized.

Furthermore, about 10 years ago, container technology that further decomposes software functions began to spread and containerized network functions (CNFs) were realized by decomposing VNFs into small functions (small programs). CNFs can not only realize fit for purpose enterprise 5G but also reduce operating costs and has the advantage of enhancing security with automated zero trust functions. CNFs can also automatically perform container management and orchestration functions. In addition, CNFs can also support a hybrid deployment environment consisting of a center and edge to realize corporate 5G functions.

The containerized architecture is in line with the composable architecture[*21] in the application field and is expected to improve the efficiency and flexibility of the entire corporate DX system.

As the CNFs architecture becomes more widespread, it will create a new enterprise 5G model that incorporates the advantages of both P5G and D5G. Regardless of the size of the company, it is expected to become an inclusive enterprise 5G like cloud technology and an attractive enabler of corporate DX.

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- Digital Transformation in Manufacturing: Top Challenges CxOs Face and Proven Solutions(2022)
- Transformative 5G in the IoT Era: how to realize its potential, from verification to implementation(2021)
- Achieving Efficiency and Resilience Across Global Supply Chains with Digital Technology(2020)

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