HUAWEI

Cross-Technology Collaboration (X-Tech) Enables Industry Digital Transformation

White Paper

STRATEGY ANALYTICS
Research, Experts, and Analytics

Contents

Executive Summary

The concept of industry digital transformation has been embraced by major economies since the early 2010s. The COVID-19 pandemic has led to new demands on the transformation. Leading-edge digital technologies are being introduced to help economy to recover from the pandemic. Both South Korea's Digital New Deal and China's New Infrastructure Plan aim to lay the foundations for a digital economy and boost sustainable growth. These strategic initiatives suggest that industry digital transformation is entering a new stage.

A comprehensive ICT service is required to implement the transformation. This is a great opportunity for communications service provides (CSPs) to scale up their businesses by promoting Cross-Technology Collaboration (X-Tech). X-Tech is the integration of ICT technologies including connectivity, computing, cloud and intelligence with Operational Technology (OT) to build an end-to-end digital transformation value chain.

The development of 5G and edge computing allows CSPs to provide an integrated infrastructure service for the digital transformation. The integrated connectivity and edge computing infrastructure is the backbone of the transformation. A strong infrastructure can help CSPs develop cloud and intelligence services for industrial applications. Either internal development or collaboration with specialists can help a CSP build a converged network, cloud and intelligence platform and evolve its role to a capability platform provider.

With the industry digital transformation, digital technologies and

connectivity are already at the core of an increasing number of assets, control devices and systems. Industries see the benefits of bringing ICT and OT closer together and even converging them. A CSP could leverage their experience in managing complex platforms and relationships with specialist vendors to connect ICT and OT silos. The CSP could further therefore shift its role towards being a Comprehensive ICT Service Provider.

The evolution from an infrastructure service provider to a capability platform provider to a Comprehensive ICT Service Provider can enable CSPs to move to the upstream of the value chain, develop a strong market position and expand the addressable market. X-Tech will play a key role in the journey. Collaboration between technologies and with partners can help CSPs expand their service portfolios to better respond to industrial market demands. The depth and breadth of its X-Tech strategy will determine how many opportunities a CSP can capture in the digital transformation market.

The whitepaper analyzes how a CSP can improve its infrastructure, platform, service and integration capabilities to seize the opportunities in the industrial digital transformation market. A few cases are discussed to demonstrate how a CSP can address customer demands in different vertical sectors. An estimate for the long-term market potential and a phased approach to developing the market are given at the end of the whitepaper.

01 Requirements and Vision

1.1 Industry Digital Transformation Calls for Cross-Technology Collaboration (X-Tech)

1.1.1 Industry Digital Transformation Entering a New Stage

Since the early 2010s, the concept of industry digital transformation has been embraced by the world's major economies. Various policy programs have been launched by governments around the world, such as the Industry 4.0 programs of European countries (see the Exhibit 1), the National Network for Manufacturing Innovation in the US and China's 'Made in China 2025' strategic plan.

The COVID-19 pandemic has led to new demands for industry digital transformation. Leading-edge digital technologies are being introduced to help economies recover from the pandemic. South Korea has initiated a 5-year New Deal plan to prepare the South Korean economy for the future. It is centred on two pillars: the Green New Deal and the Digital New Deal. While the Green New Deal is focused on transitioning South Korea to a net-zero emissions economy, the Digital New Deal lays the foundations for a digital economy that will spur economic growth and innovation. China's New Infrastructure Plan aims to build new digital infrastructure throughout the country – including building 5G networks, intelligent technology, Big Data, and Industrial IoT -- and setting up research and development institutions. The plan is intended to offset the economic impact of the coronavirus pandemic and boost sustainable growth.

These strategic initiatives suggest that industry digital transformation is entering a new stage and that Cross-Technology Collaboration (X-Tech) is at the heart of progress.

Exhibit 1: Key facts of Industry 4.0 policies of EU Countries

	Launch data	Target audience	Budget	Funding approach
France	2015	Industry & production base, SMEs & mid-caps	Approx. €10 billion	Mixed
Germany	2011	Manufacturers / producers, SMEs & policy-makers	€200 million	Mixed
Italy	2012	Large companies, SMEs, universities, research centres	€45 million	Public
Netherlands	2014	General business community	€25 million	Mixed
Spain	2016	Industry, above all SMEs & micro-enterprises	€97.5 million	Public
Sweden	2013	Research, academia & industrial & service SMEs	€50 million	Mixed
UK	2012	Business, industry & research organisations	€164 million	mixed
Czech Republic	2016	Industry & service sector companies, trade unions	Not yet defined	Public

Source: European Commission, 2017

1.1.2 Common Requirements of Industry Digital Transformation

A few design principles have been recognized in the practice of industry digital transformation, as a part of the vision and the guidelines for the transformation process. The principles generally include[1]:

- Interoperability, interconnection and connectivity
- Information transparency, virtualization and virtual entities
- Decentralization, autonomous decisions and autonomy
- Real-time processing
- Service orientation
- Modularity

The principles can be applicable to almost all digital transformation projects and raise common requirements for technology development and industry collaboration. A comprehensive solution covering all layers and technology domains is required to implement a digital transformation project. ICT technologies including connectivity, computing, cloud and intelligence should be integrated with operational technology (OT) to build an end-to-end digital transformation value chain. This Cross-Technology Collaboration (X-Tech) will be key to the journey.

Since the beginning of modern industrialization, ICT and OT have always existed separately. With industry digital transformation, digital technologies and connectivity are already at the core of an increasing number of assets and control devices and systems. Everything will be digital and connected. Many enterprises see the benefits of bringing ICT and OT closer together and ultimately converging them.

The convergence and integration of ICT and OT can help industrial players optimize business processes, make better decisions, reduce costs and risks, and accelerate time-to-market. The convergence requires a common platform and efficient collaboration between the ICT domain and the OT domain, which will bring challenges to hardware and software design, production and information process and data security. The X-Tech is crucial for the success of the convergence. Only when a close collaboration is built among all technology domains, can an effective convergence of ICT and OT be achieved that will be a key enabler of industry digital transformation.

[1] refer to i-scoop's Guide to Industrie 4.0

Connectivity, computing, cloud, intelligence technology, and industry applications all play an indispensable role in industry digital transformation.

- **Connectivity**

To enable the digital transformation, a ubiquitous network infrastructure should be available on industrial premises to seamlessly connect machines, sensors, people and data. Connectivity should provide sufficient bandwidth, particularly in uplink, because video monitoring, remote control and machine vision transmit large amounts of data over the uplink. Connectivity should also be ultra-reliable and low latency, because many industrial use cases such as automated guided vehicles (AGV), remotely operated robots and smart grid applications require these for guaranteed accuracy and safety,

Exhibit 2: 5G performance requirements for low latency and high reliability scenarios

Scenario	End-to-End Latency Communication	Service Availability	Reliability	User Experienced Data Rate	Connection Density	Service Area Dimension
Discrete automation – motion control	1 ms	99,9999%	99,9999%	1 Mbps to 10 Mbps	100 000/km²	100 × 100 × 30 m
Process automation – remote control	50 ms	99,9999%	99,9999%	1 Mbps to 100 Mbps	1000/km²	300 × 300 × 50 m
Process automation – monitoring	50 ms	99,9%	99,9%	1 Mbps	10 000/km²	300 × 300 × 50 m
Electricity distribution – medium voltage	25 ms	99,9%	99,9%	10 Mbps	1000/km²	100 km along power line
Electricity distribution – high voltage	5 ms	99,9999%	99,9999%	10 Mbps	1000/km²	200 km along power line
Intelligent transport – infrastructure backhaul	10 ms	99,9999%	99,9999%	10 Mbps	1000/km²	2 km along a road

Source: 3GPP

The connectivity solution must be able to be deployed and optimized in a flexible way to support the flexible manufacturing line. Cost is another factor influencing the adoption of the industry's digital transformation. As the backbone of the entire digital industrial system, the connectivity solution should be sufficiently cost-effective.

- **Computing Infrastructure**

Data is the lifeblood of a digital economy. The applications of big data and intelligence

technology raise the bar for high-performance computing. Cloud infrastructure has been broadly adopted by industrial customers for its flexibility and cost-effectiveness. Some industrial applications are based on real-time data analytics, which requires data to be stored and processed nearby its source. For these cases, the local computing platform can be integrated with the network infrastructure to guarantee the processing speed and reliability.

In modern industry, data has become one of the most valuable business assets. Ensuring data security is an important task of ICT infrastructure. Important data must be stored and processed on-premises to assure its security. Therefore, local computing platforms deployed on-premises becomes a key element in the digital industrial system to enable real-time data processing and guarantee data security.

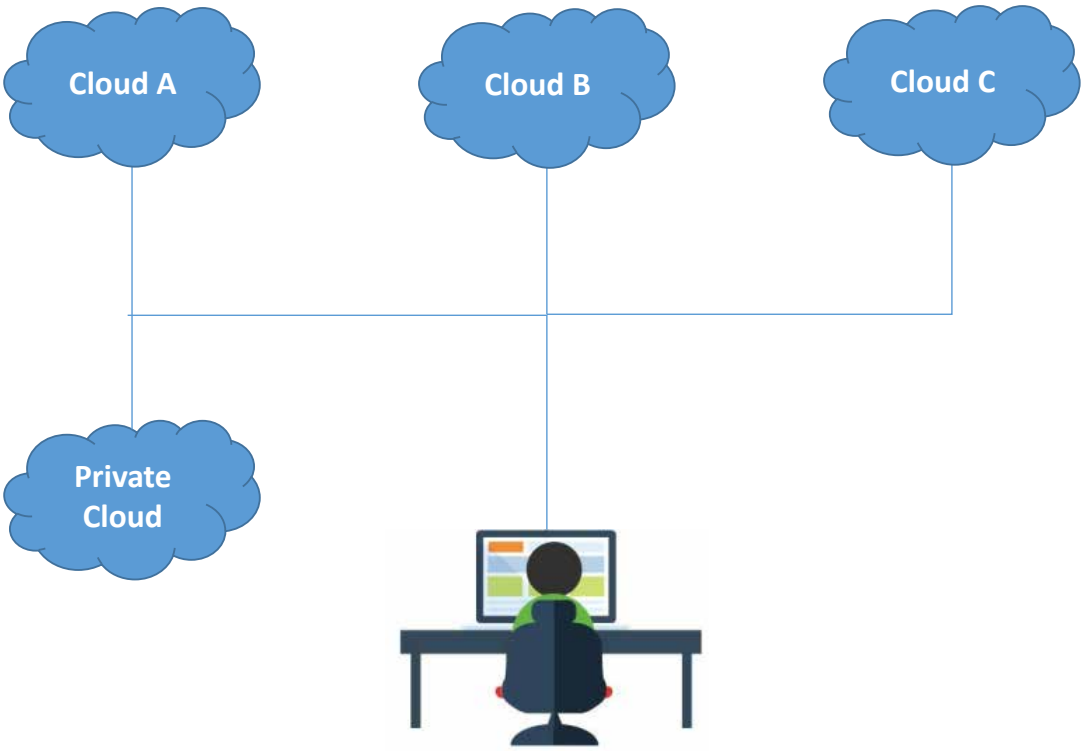
- **Cloud**

While some critical data must be stored and processed on-premises, cloud computing plays a central role in the digital transformation journey. Cloud computing can provide enterprises a flexible and on-demand processing and storage capability, without having to incur the costs of establishing and operating an internal data centre. The IT capital investment and deployment effort can therefore be significantly lowered, which can help the enterprise to accelerate its transformation process. When critical data must be kept on-premises, a hybrid cloud solution can provide an environment that allows the enterprise to deploy workloads in private or public clouds as needed and move between them as computing needs and costs change.

Cloud computing also means an ecosystem of service and innovation. Enterprises can leverage the ecosystem to reduce internal development needs and accelerate the transformation process. The Multi-Cloud approach has been broadly adopted by industrial players to manage their software and applications across multiple public cloud platforms, which can improve the flexibility of entire IT infrastructure, provide service redundancy and distribute the workloads to the most suitable platform.

Reliable and flexible network connectivity is needed to guarantee the quality of Hybrid Cloud or Multi-Cloud services.

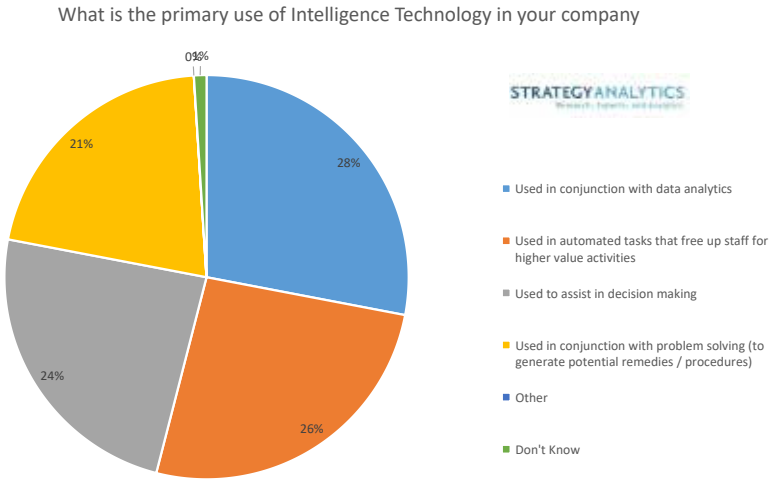
Exhibit 3: Illustration of Multi-Cloud and Hybrid Cloud



- **Intelligence technology**

Intelligence and automation have been recognized as major driving forces of the industry digital transformation. Intelligence not only can enable industrial automation but also open completely new avenues for industry transformation. Results from the Strategy Analytics Enterprise IoT Deployment Survey underline the assertion that intelligence technology and analytics are heavily intertwined. The most common uses of intelligence technology within the enterprise are in conjunction with data analytics. In all cases, intelligence technology is used by companies to assist in vital decision making and problem solving, as well as automating processes. These use cases can vary widely, from chat bots to reduce support costs, to understanding why a part or process is failing repeatedly-something that a company may not have the staff, the skills or the ability to support, but which may increasingly be able to extract the data from, through the implementation of IoT.

Exhibit 4: How Enterprises are Using Intelligence Technology



Base (US, UK, France, Germany, China): 2018 AI integrated in company - overall - 145, Energy/Utilities – 16, Telecom/Media/Technology – 12, Finance/Insurance/Real Estate – 21, Manufacturing – 19, Healthcare/ Pharmaceuticals – 16, Professional Services – 13, Fleet-Based Delivery or Transport of Goods – 11, Retail – 15, Education/Public Sector – 12, Agriculture - 10

A2: what is the primary use of AI in your company

Source: Strategy Analytics

The complexity of using intelligence technology in industry digital transformation requires enterprises to work with intelligence specialists to achieve customized solutions. Enterprises need to identify the business challenges that they face and work with relevant partners to develop specific solutions.

The intelligence capability should be integrated into the production chain seamlessly. Therefore, the partnership for intelligence capability should include cloud service provider, connectivity service provider and software integrator. A flexible and robust ICT infrastructure provides the basis for fully exploiting the potential of intelligence technology.

- **Enhancement of Operational Technology and Applications**

Operational technology (OT) comprises the hardware and software that monitors, actuates and manages industrial process assets and manufacturing/industrial equipment and keeps things, e.g., factories, power plants, facility equipment running. It is an essential part of industry digital transformation. While Information Technology (IT) is about business and enterprise systems that store, process and deliver information, OT is about control and safety systems and industrial process assets.

Operational technology is evolving in response to industry digital transformation. An important evolution is the ability to monitor and control physical devices remotely. The injection of information technologies such as big data and machine learning in OT, along with the evolution in communications technology (CT) and sensor technology, enables innovative operational applications, such as remote management of physical devices in industrial processes, remote diagnostics and predictive maintenance. These applications can greatly improve the industry productivity and also improve working conditions.

The convergence is also a matter of organization and corporate culture. The people in operational technology should know about IT in the same way that IT people now know about operational technology, and vice versa. A Comprehensive ICT Service Provider will be needed to coordinate all silos in ICT domain and OT domain to achieve an effective collaboration across technologies, organizations and people. People should be prepared to accept change. Human Relations (HR) is an indispensable partner for this part of the journey.

1.2 X-Tech Creates Opportunity for CSPs to Expand Business Boundaries

With the emergence of technical dividends such as 5G, edge computing, and multi-cloud, Cross-Technology Collaboration (X-Tech) will bring new opportunities for CSPs to expand their business boundaries.

The development of telecom technologies creates opportunities for communications service providers (CSPs) to support industry digital transformation and expand their role in the value chain.

5G is the first wireless technology that natively supports the ultra-reliable and low latency communications. Network launches have been much more concentrated for 5G compared to earlier generations of cellular technology. As of December 2020, 140 operators in 59 countries/territories have launched commercial 3GPP-compatible 5G services, according to GSA statistics. 61 operators are identified as investing in 5G standalone architecture (5G SA) that can better support industry digital transformation.

5G networks have the ability to manage end-to-end SLAs (Service Level Agreement), which could only be done by fixed networks in the past. Meanwhile, as a wireless technology, the deployment of 5G is significantly more flexible than that of fixed networks. The combination of E2E SLA capability and the deployment flexibility makes 5G the best communication solution for industry digital transformation.

Industrial digital transformation requires moving some computing resources as close as possible to the data source to enable real-time data processing and ensure data security. This is called Edge computing. Edge computing allows user workloads to use local infrastructure rather than a distant data center to store and process data, while it can leverage the mature software applications in the cloud ecosystem. Edge computing has been recognized as the focal point of interplay between Connectivity, Computing, Cloud and Intelligence, and thus is becoming a pillar for industry digitalization. Leading CSPs are actively trialling and deploying edge computing. Cloud-native applications, which are

composed of individual micro services, can run latency or security critical micro services locally, and more resource intensive micro services in a data center in the public cloud.

The cloud is becoming a unified platform and portal for enterprise IT services. More and more enterprises are choosing to transfer their IT system onto the cloud. Flexera's 2020 State of the Cloud Report found 96% of respondents utilize at least one public cloud service, executing 53% of their workloads in the public cloud. 93% of enterprises have a multi-cloud strategy and 87% have a hybrid cloud strategy.

The adoption of multi-cloud and hybrid cloud increases demand for reliable, flexible high-speed network connections. To meet these needs, CSPs have introduced Software Defined Network (SDN) technology to provide network agility while maintaining five-nine reliability. Complete Service Lifecycle Automation can be ensured by networks that integrate management, SDN control and analytics systems. The architecture creates a synergy between the cloud and the network. The Cloud-Network synergy offers enterprises necessary flexibility and agility and will also allow growth of new B2B service offerings by CSPs.

An increasing number of organizations are looking to tap intelligence technologies to streamline day-to-day operations and revolutionize their business models. According to Deloitte's third annual "State of AI in the Enterprise" survey report, 67% of respondents are using machine learning today and 97% are using or planning to use it in the next year; 58% of global respondents have adopted Natural Language Processing (NLP) and 94% are using or planning to use it in the next year; and 56% are using computer vision and 94% are using or planning to use it in the next year.

To deploy an intelligence solution, enterprises often need to upgrade their connectivity infrastructure, which creates an opportunity for CSPs. At the same time, Intelligence can

also power up CSPs network management and operation to improve efficiency and lower cost.

The development of these new technologies allows CSPs to transform their networks and introduce new services. Most of the leading CSPs have provided cloud and intelligence services through internal development or partnership with specialist companies. The transformation of network and services forces CSPs to improve their in-house R&D capability and also to transform their organization, culture and processes. Telecom networks have connected billions of people and millions of enterprises. CSPs have extensive experience in managing complex ICT systems and integrating equipment from diverse suppliers. CSPs can leverage these technologies, capabilities and experience to expand their service portfolio and play a greater role in industrial markets.

1.3 From Infrastructure Service Provider to Comprehensive ICT service Provider

In the digital transformation value chain, the primary role of CSPs is to provide infrastructure services. While 5G is the best connectivity solution for industrial transformation, CSPs can also provide a broad connectivity portfolio, including 4G/5G, cellular IoT, fixed network services and Wi-Fi, to serve for the diversity of industrial use cases. CSPs can also provide local edge computing infrastructure and management. The integrated connectivity and edge computing infrastructure is the backbone of industry digital transformation.

As of November 2020, there were already over 1100 5G industrial projects deployed in China, according to a Chinese media report. In Europe, Asia and North America, leading CSPs have also deployed 5G industrial projects, including Vodafone in the UK and Germany, Deutsche Telekom in Germany, Hungary, Czech and Austria, Telefonica in Spain and Germany, SK Telecom in South Korea, AIS in Thailand, and Verizon and AT&T in the US.

A strong infrastructure can help CSPs to develop cloud and intelligence services for

industrial applications. In parallel with the 5G rollout in China, China Telecom launched a Cloud-Network Integration strategy that leverages its Number1 hybrid cloud provider position in China to develop 5G industrial IoT business. China Telecom recently showcased around 20 cases of 5G and cloud serving industrial IoT, and also revealed a 5G edge computing based machine vision application platform that can provide automatic detection service for industrial customers.

Exhibit 5: China Telecom's Cloud-Network Integration Strategy

Target	• To strengthen cloud-network capabilities • To build a digitalized platform based on cloud-network integration • To open up ecosystems • To empower customers
Unified cloud-network strategy	• **Unified infrastructure** – 'Cloud-as-the-core' to leverage IDC / DC to build a sturdy core of cloud-network integration and 5G deployment • **Unified product / application** – 'Digitalized platform' to integrate cloud and network capabilities and proprietary research + ecological cooperation for DICT solutions and applications • **Unified operating system** - "Operation maintenance, service support, security safeguarding and API exposure" of cloud, network and terminals to satisfy customer demands.
Technology capabilities	Proprietary research and control on key core capabilities such as IaaS / PaaS, MEC, cloud-network operating system, digitalized API enablement platform, etc.
Cloud-led network	Optimize the network to enhance efficiency and reduce latency for cloud-network services
Ubiquitous accesses	• Cellular networks – 4G, 5G, NB-IoT • Fixed broadband • Leased line • Satellite

Source: China Telecom, summarized by Strategy Analytics

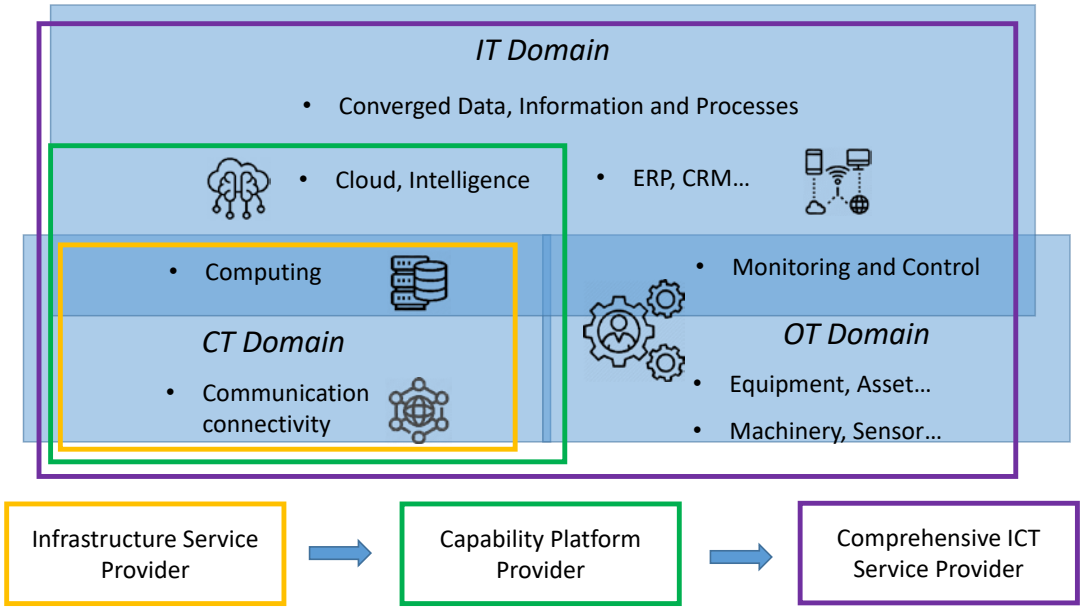
In addition to the development of internal cloud and intelligence capabilities, CSPs can also partner with cloud and intelligence technology specialists. Some of the leading 5G service providers have launched the collaboration with IT and public cloud giants to provide industrial customers hybrid cloud and edge cloud services. For example, AT&T has worked with IBM to bring open hybrid cloud services to enterprise clients for the 5G Era and Verizon, Vodafone, SK Telecom and KDDI have collaborated with AWS for edge computing. These partnerships bring with them micro services, software libraries, application program interfaces (APIs) and a developer ecosystem. Either internal development or collaboration with specialists can help a CSP build a converged network, cloud and intelligence platform and evolve its role to a capability platform provider. When working with hyperscalers, CSPs should continually evaluate the impacts of the partnership to protect their position in the industry value chain.

Industry digital transformation requires the traditionally separated ICT and OT value chains merged to form a unified end-to-end value chain. All elements in the value chain will be impacted: supply chain, production, planning, information flow, IT systems, distribution channels and ultimately customers. This will require a primary integration that integrates ICT systems for and across the various production and business planning processes. Primary integration, which impacts on the various systems employed in the enterprise, is in the end all about data and information flow.

In addition to providing ICT infrastructure services and cloud/intelligence platforms a CSP can further shift their role towards a Comprehensive ICT Service Provider. The CSP could leverage their experience in managing complex platforms and relationships with various vendors to connect ICT and OT silos to form an end-to-end value chain.

The evolution from an infrastructure service provider to a capability platform provider and further to a Comprehensive ICT Service Provider can enable CSPs to move upstream in the value chain, build a strong market position and expand the addressable market. However, this role evolution will raise high requirements on CSP capabilities in terms of software development, system integration, vertical knowledge and, particularly, the X-Tech. The exhibit below summarizes the evolution.

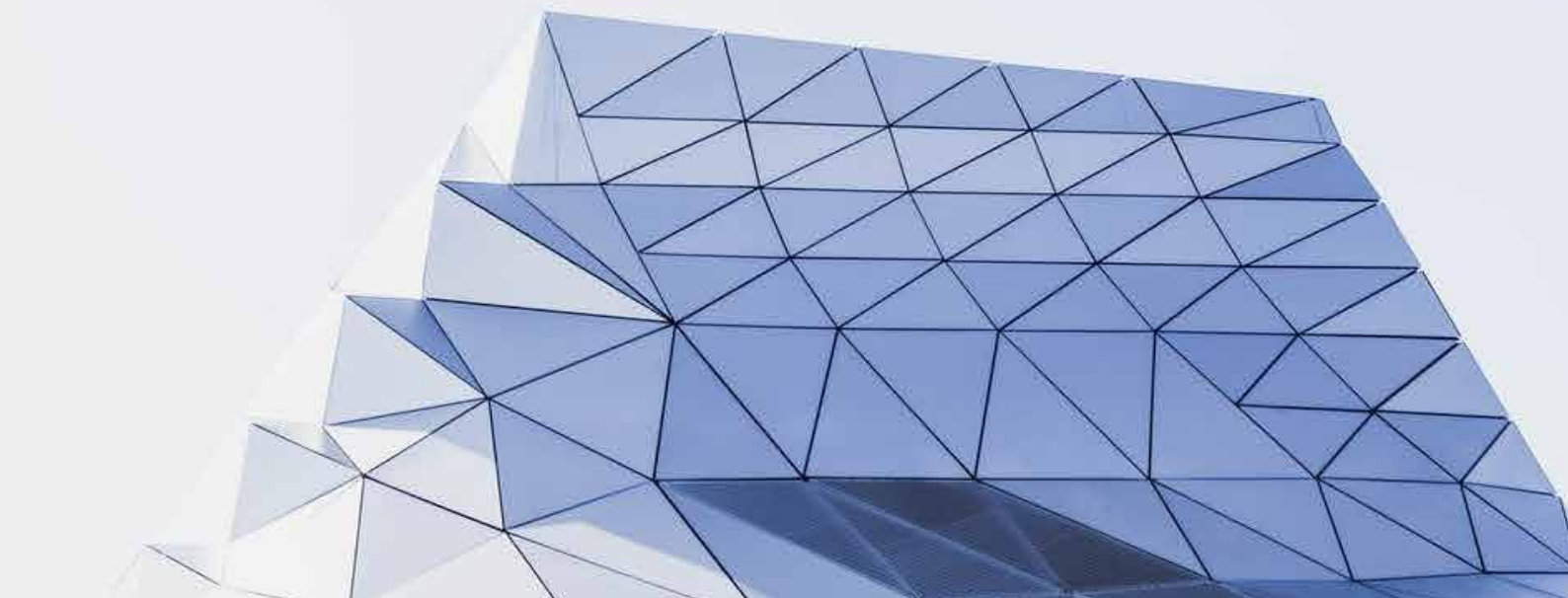
Exhibit 6: Communications Service Provider's Role in Industry Digital Transformation



Source: Huawei and Strategy Analytics

02

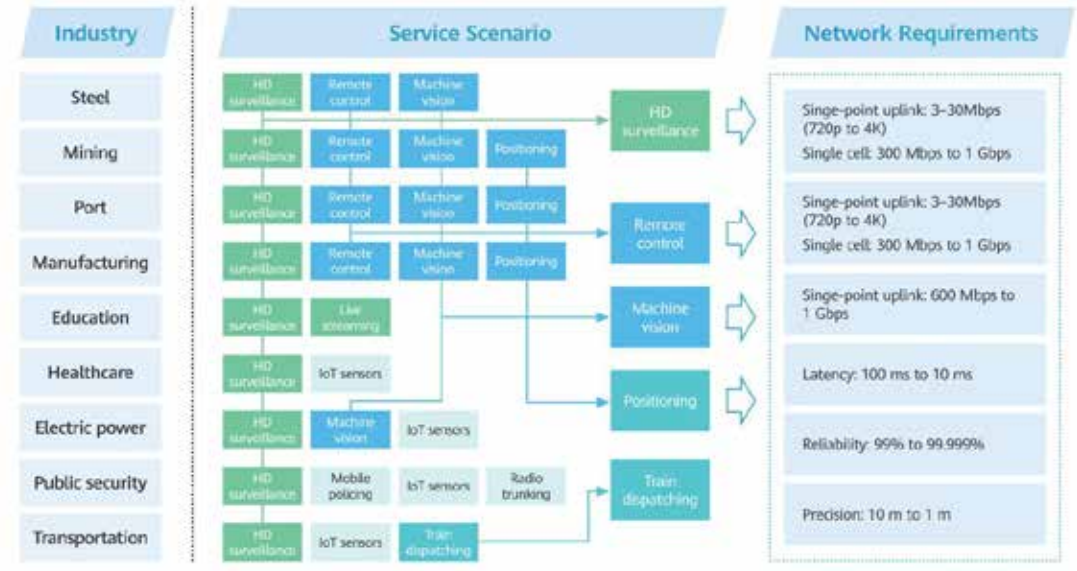
Improving CSPs' Capabilities to Seize the Opportunity



2.1 Infrastructure Solution

The telecommunications network was initially designed for consumer and business applications. Network features primarily target consumer usage patterns. Industrial applications have very different requirements. The exhibit below summarizes the requirements on the uplink bandwidth, reliability, latency, etc. of typical industrial use cases.

Exhibit 7: Typical uplink-demanding industries and scenarios, and their capability requirements



Source: Huawei and China Mobile

CSPs need to improve their network solutions to meet all these requirements. Specific technical solution will be needed. For example, China Telecom Anhui has teamed up with Huawei to successfully provide 5G Super Uplink services to Conch Group, one of China's largest building material corporate groups. The solution enhances the uplink bandwidth to enable smart factory industrial.

High-precision positioning is another specific requirement of some industrial use cases, as shown in the exhibit above. CSPs need to work with partners to improve their positioning service. Recently China Mobile announced its high-precision positioning service that uses the 5G network to enhance the BeiDou satellite navigation system. We believe the high-precision positioning capability will become a standard requirement for CSP networks that serve industrial customers.

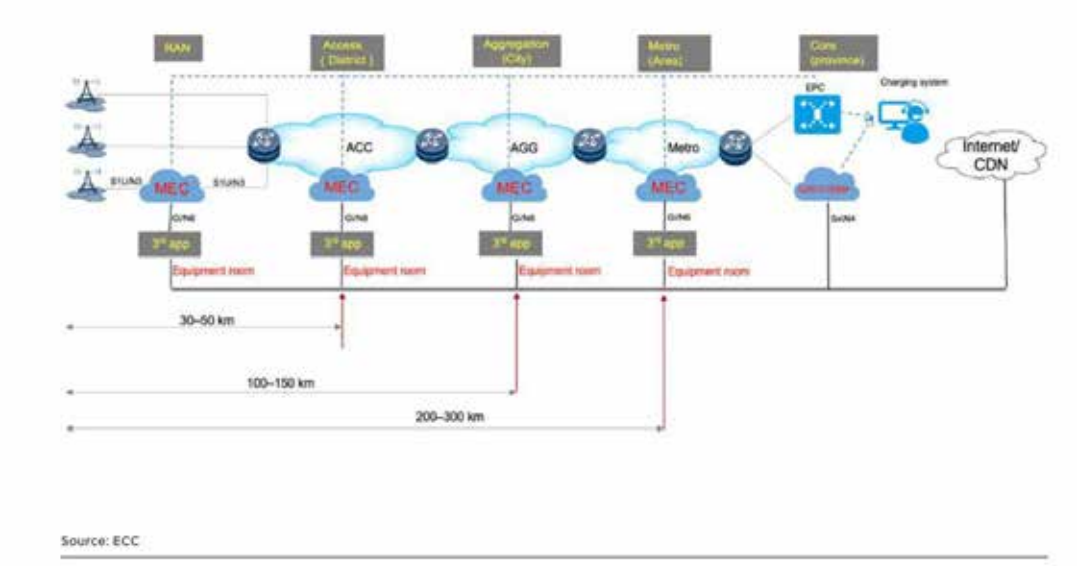
The cost of 5G industrial deployment is an important factor that will influence the decisions of industrial players. CSPs should work with suppliers to continuously optimize the cost structure of 5G industrial solutions and provide a broad product portfolio to make sure the range of solutions can best fit the technical and business needs of industrial customers.

2.2 Platform Capability

The adoption of Multi-Cloud and Hybrid Cloud places new demands on CSP networks for flexibility and agility. Increasing network scale and complexity make it increasingly difficult for CSPs to manage network operation costs and guarantee user experience. Network automation solutions are becoming a must-have for CSPs to manage the convergence of network and cloud. Huawei's Autonomous Driving Network (ADN) is such a solution. It provides intelligence for networks management and enables end-to-end lifecycle automation across multiple domains.

With the autonomous network, CSPs can fully leverage their infrastructure assets and partnerships to develop a comprehensive cloud service platform. Furthermore, by leveraging buildings and support infrastructure in the access network, aggregation network and metro network, CSPs can deploy their own edge cloud service, which could become an important platform for them to develop enterprise services. According to a Chinese media report, China Mobile has deployed 156 edge computing nodes in 22 provinces, and China Telecom is also beginning to provide edge cloud trial service based on its platform.

Exhibit 8: Edge Computing Deployment Scenarios



Partnership and application ecosystem are important for the sustainable development of edge cloud service. Leading CSPs, including China Unicom, Deutsche Telekom, EE, KDDI, Orange, Singtel, SK Telecom, Telefonica and TIM, have joined forces, with the support of the GSMA, to develop an interoperable platform to make edge compute capabilities widely and easily available. The collaboration will help CSPs to develop edge computing ecosystem and extend market presence.

2.3 Service and Integration

Along with network and platform improvements, CSPs need to improve their service capabilities, particularly with regard to how to respond quickly to customer demand. When ICT solutions are integrated into the industrial core production process, the ability to quickly respond will be essential to maintain the trust relationship between the CSP and the industrial customer. To improve rapid response capability, a CSP first needs to transform its operations systems. Intelligence and automation technologies can be leveraged to transform the traditional network operation to a data-driven, customer centric and zero touch operation.

CSPs also need to optimize their organization, culture and processes to effectively integrate connectivity, cloud, security, payment, video, big data, intelligence and other capabilities to provide industrial customers a single service portal. A dedicated Industrial Markets organization should be put in place to develop industrial expertise and coordinate internal and external resources.

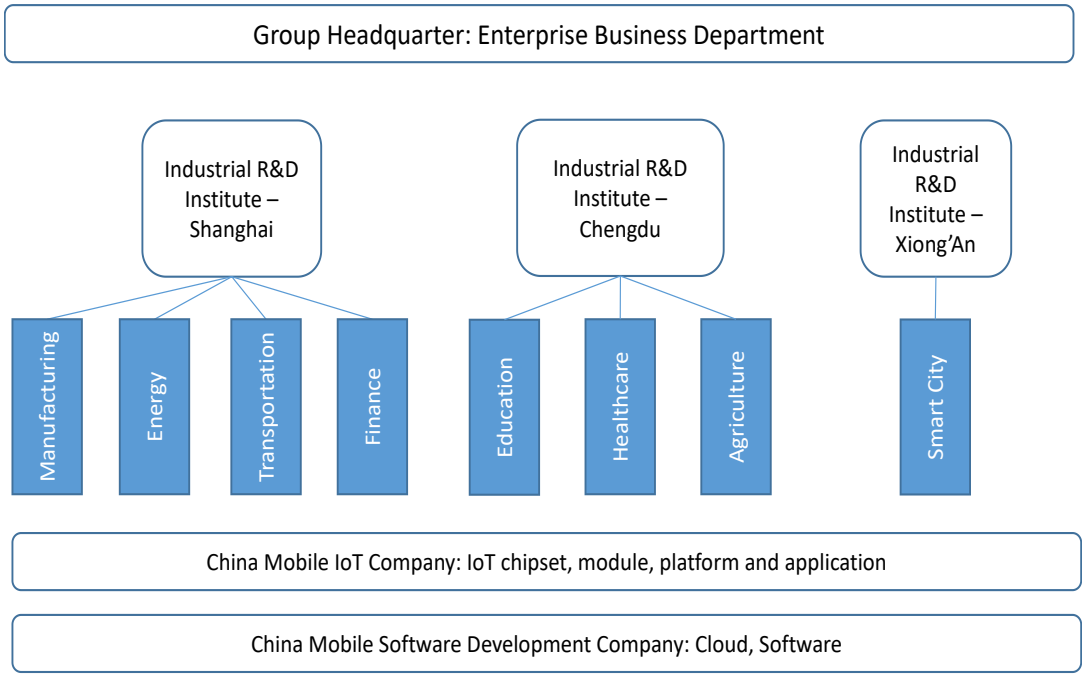
When moving to Comprehensive ICT Service Provider role, CSPs need to improve their system integration capability. This includes hiring professionals from targeted industry verticals and investing in in-house R&D resources, particularly software development.

Leading CSPs have started the transformation. In its "Tech2025" strategic framework, Vodafone aims to be "Digital First". Vodafone will insource much of the IT that it outsourced in 2006 and focus on transforming the customer experience. Vodafone has been developing its own in-house capabilities by developing toolsets using agile development and big data analytics.[2]

China Mobile has synergized business development organizations and R&D resources for the industrial market, according to a Chinese media report. The new organizational structure allows China Mobile to dive deeply into specific industries and coordinate business and technology development efficiently.

[2] For more details, please see Strategy Analytics' report Vodafone Stands Tall as a Digital Transformation Partner to Enterprises.

Exhibit 9: China Mobile's Organization for Industrial Market



Source: Media Reports and Strategy Analytics

An extensive network of partnerships with key players in the value chain is crucial for CSPs to improve their service and integration capabilities. Potential partners include the leading cloud and software companies and also industrial solutions specialists. Vodafone has established a broad partnership with leading companies, such as IBM, AWS, and Google, to leverage complementary expertise to deliver better business outcomes. While building its partnership with Microsoft to "help customers of all sizes accelerate their cloud transformation initiatives," Deutsche Telekom also partners with industrial specialists including EK Automation, Konica Minolta and Endress+Hauser, to expand its ecosystem for smart factory.

2.4 X-Tech is Key for CSPs Evolution

The evolution of a CSP from an infrastructure service provider to a Comprehensive ICT Service Provider is actually a process to improve the X-Tech.

As an infrastructure service provider, the CSP must coordinate and integrate all available connectivity technologies into a service portfolio to deliver the solution best suited to the industrial use case. The CSP also needs to build the collaboration between edge computing infrastructure and connectivity infrastructure to lay out a solid ICT infrastructure for industry digital transformation.

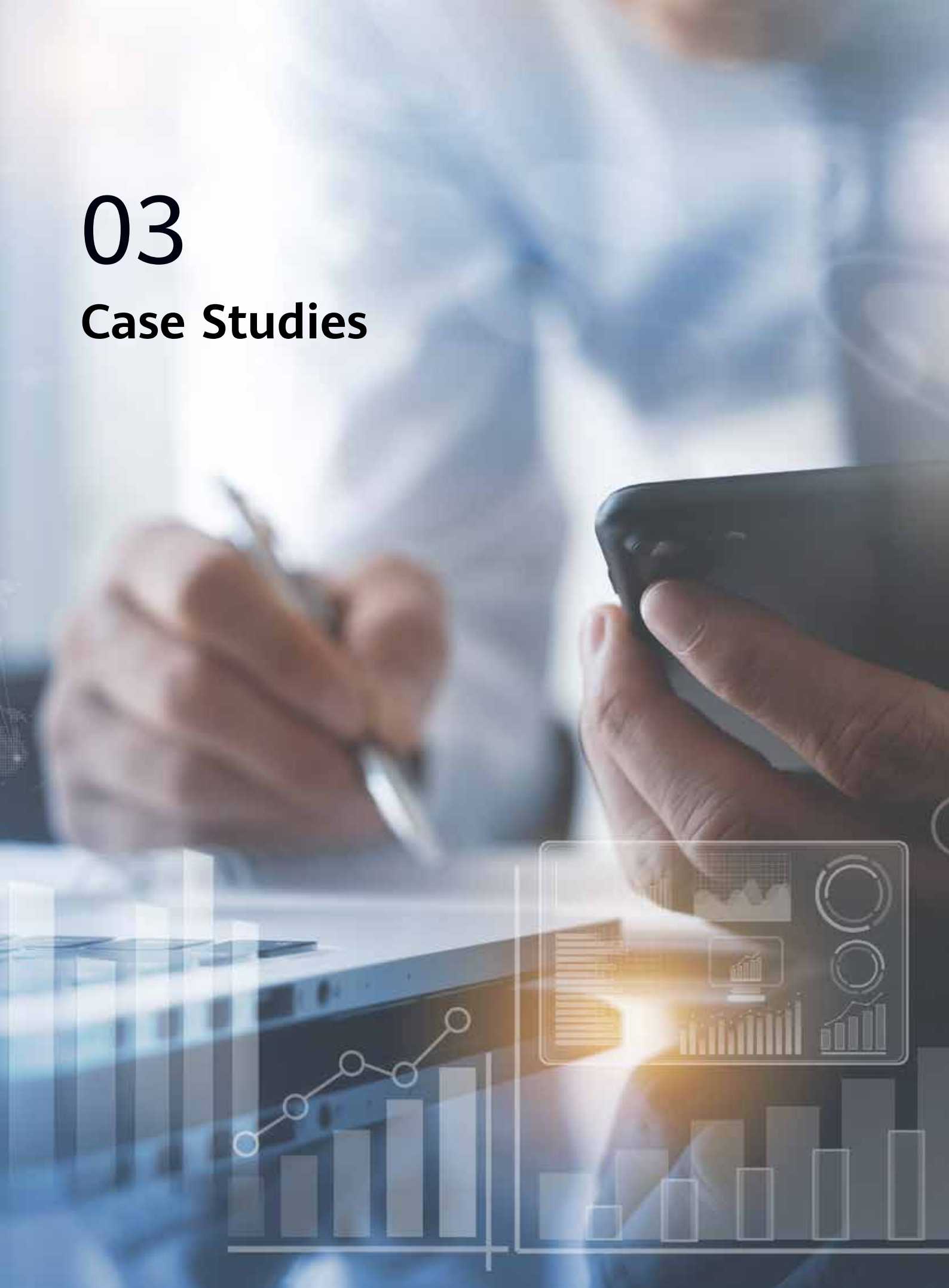
When a CSP evolves from an infrastructure service provider to a capability platform provider, the collaboration must be broadened. Cloud, Intelligence, and other common software applications should be integrated with the infrastructure layer. Cross-layer and cross-platform collaboration is required to build a unified capability platform for industry digital transformation.

To be a Comprehensive ICT Service Provider, CSP needs to further improve the X-Tech, not only for the collaboration inside the ICT domain, but also collaboration across the ICT and OT domains. The CSP could become an end-to-end enabler for the digital transformation value chain.

To promote the X-Tech, CSPs can fully leverage their experience of managing complex ICT systems and dealing with diverse suppliers, while improving in-house software development and system integration capabilities by hiring professionals and/or acquiring specialist companies. The process will be a long journey for CSPs. However, the result will decide whether a CSP can move upstream in the value chain and achieve a long-term business growth.

03

Case Studies



3.1 Xiangtan Iron & Steel's 5G Smart Plant

3.1.1 Requirements

Valin Xiangtan Iron & Steel is the largest state-owned enterprise in Hunan Province and is a fine steel producer based in South China. It has an annual production capacity of 12 million tons of steel. Products include more than 400 varieties of wide and heavy plates, wire rods and bars.

The production processes in the factory generate about 1 TB data per day that can be used to optimize production in real-time. However, collecting data from sensors in production lines is always challenging, because it is difficult and expensive to deploy fixed networks to connect all the sensors in the dusty, hot and hazardous environment. Wi-Fi is prone to interference and lacks both stability and capacity. The challenging environment also impacts staff morale and results in low working efficiency.

Thus, the plant wants an advanced ICT solution to connect all equipment flexibly, to perform data analytics in real-time and to enable remote control of its production processes.

3.1.2 Solution

In July 2019, China Mobile Hunan Branch and Huawei kicked off the smart 5G steel plant project for Xiangtan Iron & Steel. A pilot deployment was carried out at the five-meters-width thick plate plant, one of the subsidiary plants. In 2020, the pilot project was gradually expanded to other production lines and facilities, such as metals bars production facilities, the wharf, the thick and wide metal plate facilities, and wiring.

When the 5G system was deployed for the project, specific solutions were taken to meet special requirements of iron & steel production operations:

- Uplink bandwidth – the plant planned to deploy more than 300 HD video surveillance cameras that need to transmit massive data over uplink.
- Low latency – 20 – 50 millisecond end-to-end latency is required to enable the remote control of cranes and robots.
- High reliability – 99.99% reliability is required.

- Industrial grade terminals
- Network slicing – to isolate production-oriented services from general business services.
- Fault management – automatic fault location, isolation and recovery

China Mobile has signed a commercial contract with the Xiangtan Iron & Steel to deploy a private 5G network and a converged terminal, connectivity and cloud platform. By September 2020, more than 150 5G base stations and a set of edge computing platforms have been deployed that achieve 450 Mbps uplink data throughput and 20 millisecond end-to-end latency.

China Mobile provides an annual subscription plan and is responsible for the commercial operations of public/private cloud services. In the first pilot deployment, four use cases were tested:

- Centralized remote control of four overhead scrap steel cranes; accurate real-time remote control with eight-channel HD video streaming
- One unmanned crane in the slag bay, equipped with eleven cameras, two scanners, one rangefinder, and one encoder
- One remotely controlled robotic arm in the steelmaking zone
- HD video surveillance in hazardous areas

More use cases have been deployed since, such as production process orchestration based on data analytics, smart inspection, and AR assisted production line assembly. The

Exhibit 10: Crane Remote Control

converged terminal, connectivity and cloud platform will connect, manage and control all plant equipment to achieve a fully autonomous factory.

3.1.3 Results

The 5G-based remote control application allows semi-automatic crane control. An operator is able to manage three cranes at a time remotely (see Exhibit 10). With the remote control, operators are no longer required to work in hot and dusty areas. The overall working efficiency is improved by 20%.

Compared to the fixed network connectivity, the 5G solution significantly reduces the crane control system downtime. The cost of a crane being out of service for one hour is about RMB 2,000. 5G connectivity can reduce failure hours by 2 hours per month on average, resulting in RMB 48,000 savings per crane per year. There are about 400 cranes in the factory. Once all control systems are upgraded to 5G connectivity, the overall savings will be considerable. Reduced downtime can also save the labor cost of maintenance. In the first pilot deployment, only 4 cranes were upgraded to 5G connectivity, RMB 300,000 labor cost savings were achieved within a year. Significant savings are expected when 5G connectivity is widely adopted within the factory.

The remote-control application is also deployed to operate continuous casting and

Exhibit 11: Remote Control of Robotic Arm for Slagging

slagging. 12 robotic arms were upgraded to enable the remote-control operation, which saves 5% of slag and significantly improves the working condition of workers.

Based on the enhanced 5G uplink and edge computing platform, over 10,000 inspection points were deployed at the plant to monitor more than 1,700 pieces of equipment in real-time. High-resolution images are sent to the central analytics platform. Big data analytics enables predictive maintenance that shortens maintenance hours and reduces cost.

Since the smart 5G steel plant project was kicked off in July 2019, the overall efficiency of Xiangtan Iron & Steel has been improved by 30%, according to the factory. Productivity has increased from 920 tons of steel per man year to 1,300 tons of steel per man year. Direct profit increased by RMB 100 million, according to a Chinese media report.

In the next step, Xiangtan Iron & Steel will leverage the connectivity and computing infrastructure to further improve production efficiency through data analytics. Meanwhile, the factory will work with China Mobile and Huawei to continuously optimize the 5G coverage in the production area.

3.2 Smart Campus for Guangdong Industry Design City

3.2.1 Requirements

Guangdong Industry Design City (GIDC) is located in Shunde, Guangdong province which is a "national industrial design demonstration base." The core area of the campus is 70,000 square meters. The campus is already home to some 300 companies with over 8,000 designers and developers. These companies have formed an integrated end-to-end industrial design service chain, including functions such as market research, innovative design, R&D pilot (R&D center, pilot workshop), manufacturing, trading, exhibition, communication, training, incubation, and public services.

With increased numbers of companies and designers on the campus, the campus operator realized that the campus' management system was out of date and limited business growth. The main issues included:

- Weak security system – there were fewer than 100 CCTV cameras in the large campus. Most of cameras had no intelligence functionality and had not been maintained.
- No unified management system – different subsystems on the campus were isolated without a unified operations, administration and maintenance (OA&M) platform. Coordination between subsystems was manual, which impacted efficiency and customer response time.
- Daily management was manual Activities such as the utility metering and visitor management, were performed by human staff, while labor cost was increasing rapidly.
- Lack of value-added services – the campus had few value-added services to offer to enterprises and designers, which would impact the long-term growth of the business.

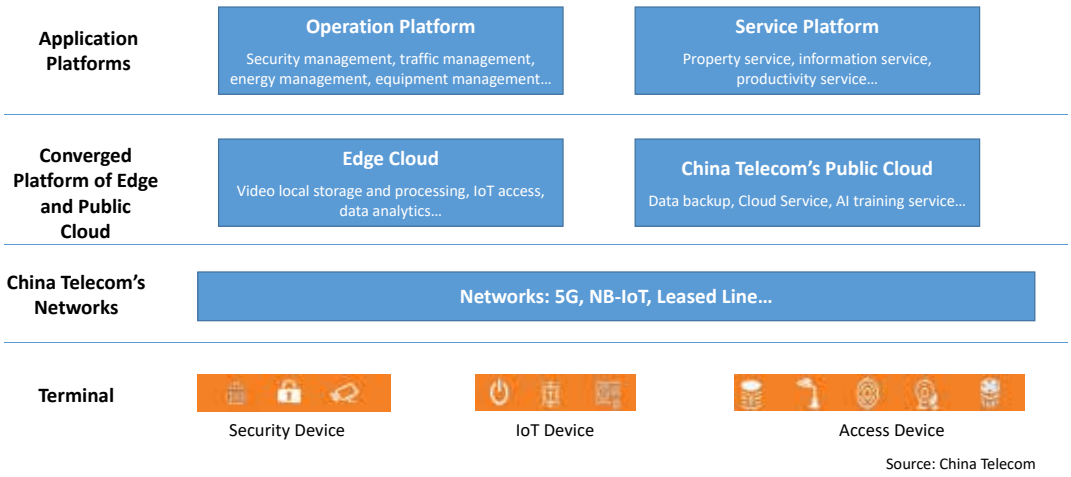
As a result, the campus operator hoped to introduce leading-edge digital technologies to improve operational efficiency and also create new revenue opportunities.

3.2.2 Solution

China Telecom Foshan Branch and Huawei launched the smart campus project for GIDC in July 2020. The first phase of the project was completed and placed into commercial operation in December 2020.

Given the requirements of the campus operator, China Telecom fully leverages its network and cloud capabilities to provide the campus with a comprehensive solution. The architecture is as the exhibit below.

Exhibit 12: Smart Campus Solution Architecture



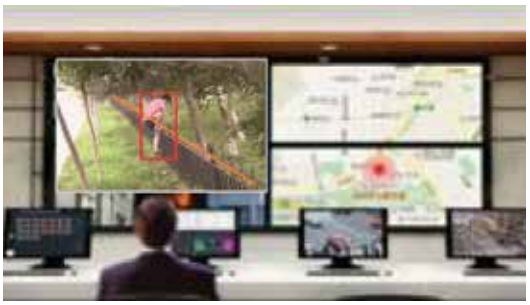
Source: China Telecom

As the foundation layer, China Telecom provides a broad connectivity portfolio to address various campus requirements. The connectivity solutions include not only wireless technologies such as 5G and NB-IoT, but also wireline technologies to provide the best performance and cost effectiveness.

Since China Telecom is a leading provider of public cloud services in China, it naturally integrates its own public cloud service with the edge computing platform deployed within the campus. The converged cloud service platform provides the campus operator, as well as the companies in the campus, a unified software and application ecosystem and enables them to seamlessly manage the workload between edge cloud and public cloud.

Based on the converged cloud platform, China Telecom can provide or integrate software and applications for campus operations and enterprise services. For example, the machine vision solution enables the automatic visitor and traffic management and also greatly improve the efficiency of security management. China Telecom also provides featured SaaS services to the companies in the campus, such as high-quality video conferencing, and cloud-based video processing applications.

Exhibit 13: Applications Examples of Smart Campus for GIDC



Security Management

Energy Management

Video Conference

Video Processing

Source: China Telecom

3.2.3 Outlook

Because the first phase of the smart campus project was delivered in December 2020, it is still too soon to get a full view of the value of the project. However, a number of clear indicators have been observed. For example, when a visitor drove into the campus, the traditional process of manually registering was often lengthy. The new machine vision based automatic solution can handle it in 2 seconds. Visitor and traffic management efficiency has been considerably improved.

It is expected that the overall operational efficiency of the campus will be significantly improved. Meanwhile, the companies in the campus can also benefit from the project, as the converged cloud platform and featured SaaS applications can help them improve their productivity. For example, the high-performance cloud computing platform could shorten image rendering time from 300 minutes to 5 minutes, and the cloud workstation could lower energy cost by 70%.

3.3 Digital Transformation in Oil and Gas Industry

As an asset-heavy industry, the oil and gas sector has been pursuing digital operations for decades. Although it is always challenging to implement a digital transformation in such a hardware-intensive environment, an increasing number of oil and gas companies are joining the transformation journey to address the challenges, such as the prolonged low price of oil and global attitude changes towards climate change. Accenture's Upstream Oil and Gas Digital Trends Survey 2019 found that 72% of survey respondents plan to invest "more or significantly more" in digital technologies. The global COVID-19 pandemic — leading to a historic drop in crude prices - increased the sense of urgency about digital transformation. The Ernst & Young Oil and Gas Digital Transformation and Workforce Survey in June 2020 indicated that 'oil and gas executives recognize the value in digital technologies and anticipate significant investment in them,' and 80% survey respondents 'are investing at least a moderate amount in digital technology today, relative to their budget.'

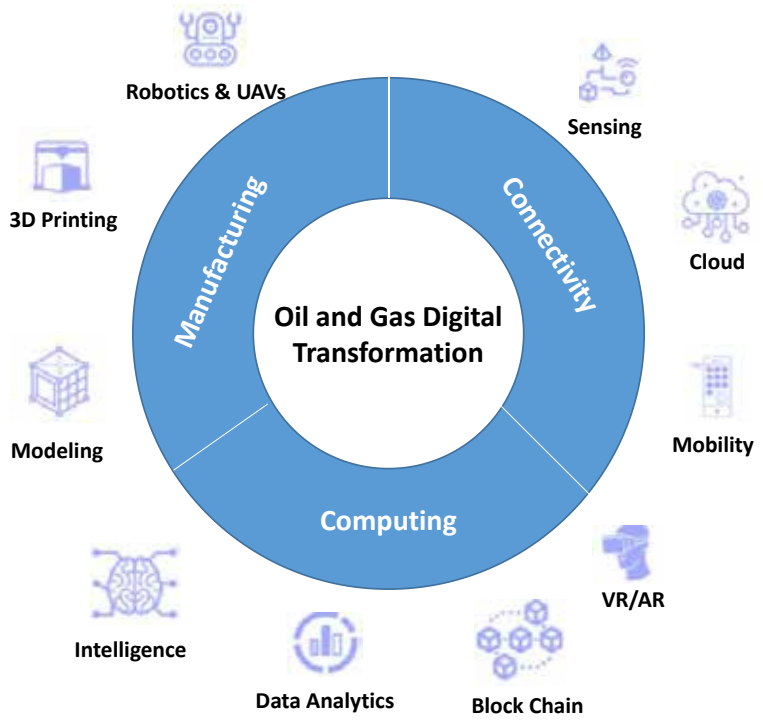
More and more oil and gas companies are realizing that cross-technology collaboration can drive their digital transformation. Recently, Huawei and a CSP partner launched a digital transformation project for an integrated oil and gas company. According to an executive of the oil and gas giant, the company has recognized that 5G is one of the major enabling technologies for digital transformation, and therefore it would like to collaborate with local service providers and their partners for new digital use cases over 5G networks at its facilities. Some use cases have been identified by the company, including:

- AR mobile operation and predictive maintenance – to improve device inspection and operation efficiency and reduce maintenance costs by using AR glasses for object recognition and collaboration between remote workers.
- Detect Personal Protective Equipment (PPE) wear violations - Detect in real-time video streams to improve operation safety and reduce security incidents.
- Smart Site Security – high resolution CCTV for Real-time monitoring, facial recognition, etc.
- Remote controlled drones – remote inspection for equipment and pipe, emergency response, etc.

Exhibit 14: PPE Detection

In addition to these new use cases, other operational use cases will be addressed, such as production dispatching, gas detection & inspection, process monitoring, and leak detection. A wide range of digital technologies must be deployed for these applications. Huawei and its partners have identified ten technology domains, as the exhibit below.

Exhibit 15: 10 Technology Domains for Digital Transformation of Oil and Gas Industry



Source: Huawei

All of these applications place various demands on the connectivity infrastructure. The exhibit below summarizes the requirements.

Exhibit 16: Oil and Gas Applications' Requirements on Connectivity

Use Case	Catalog	Wireless	Mobility	Bandwidth	Latency	Number of Connections	LTE/5G
Production dispatching	Voice	★★★★★	★★★★☆	★☆☆☆☆	★★☆☆☆	★★★☆☆	
Gas detection & inspection	Data	★★★★★	★★★☆☆	★☆☆☆☆	★★☆☆☆	★★☆☆☆	
Process monitoring	Data	★★★★☆	★☆☆☆☆	★☆☆☆☆	★★☆☆☆	★★★★☆	
Video surveillance	Video	★★★☆☆	★☆☆☆☆	★★★★☆	★★☆☆☆	★★☆☆☆	
Facial recognition	Video	★★★☆☆	★☆☆☆☆	★★★★☆	★★★☆☆	★★☆☆☆	
Object recognition and image processing	Video	★★★☆☆	★☆☆☆☆	★★★★☆	★★★☆☆	★★☆☆☆	
Thermal image processing	Video	★★★★☆	★☆☆☆☆	★★★★★	★★★☆☆	★★☆☆☆	
Immersive experience	AR/VR	★★★★☆	★★★☆☆	★★★★★	★★★★★	★★★☆☆	
Augmented reality	AR/VR	★★★★★	★★★★☆	★★★★★	★★★★★	★★★☆☆	
Robots communication and remote control	Unmanned	★★★★☆	★★★☆☆	★★★★★	★★★★★	★★★☆☆	
Drones for plant inspection	Unmanned	★★★★★	★★★★★	★★★★★	★★★★★	★★★☆☆	

Even though the ambitious plan is still at its initial phase, all members of the project team have reached consensus that X-Tech is key for the digital transformation in oil and gas industry. In the next few years, all parties will jointly explore the fast deployment of X-Tech with 5G enterprise-dedicated networks for the oil and gas industry and study the feasibility of relevant applications in order to establish industry digitization standards for the sector.

3.4 X-Tech Leads to a Successful Digital Transformation

All these deployment cases illustrate the importance of X-Tech for a successful industry digital transformation.

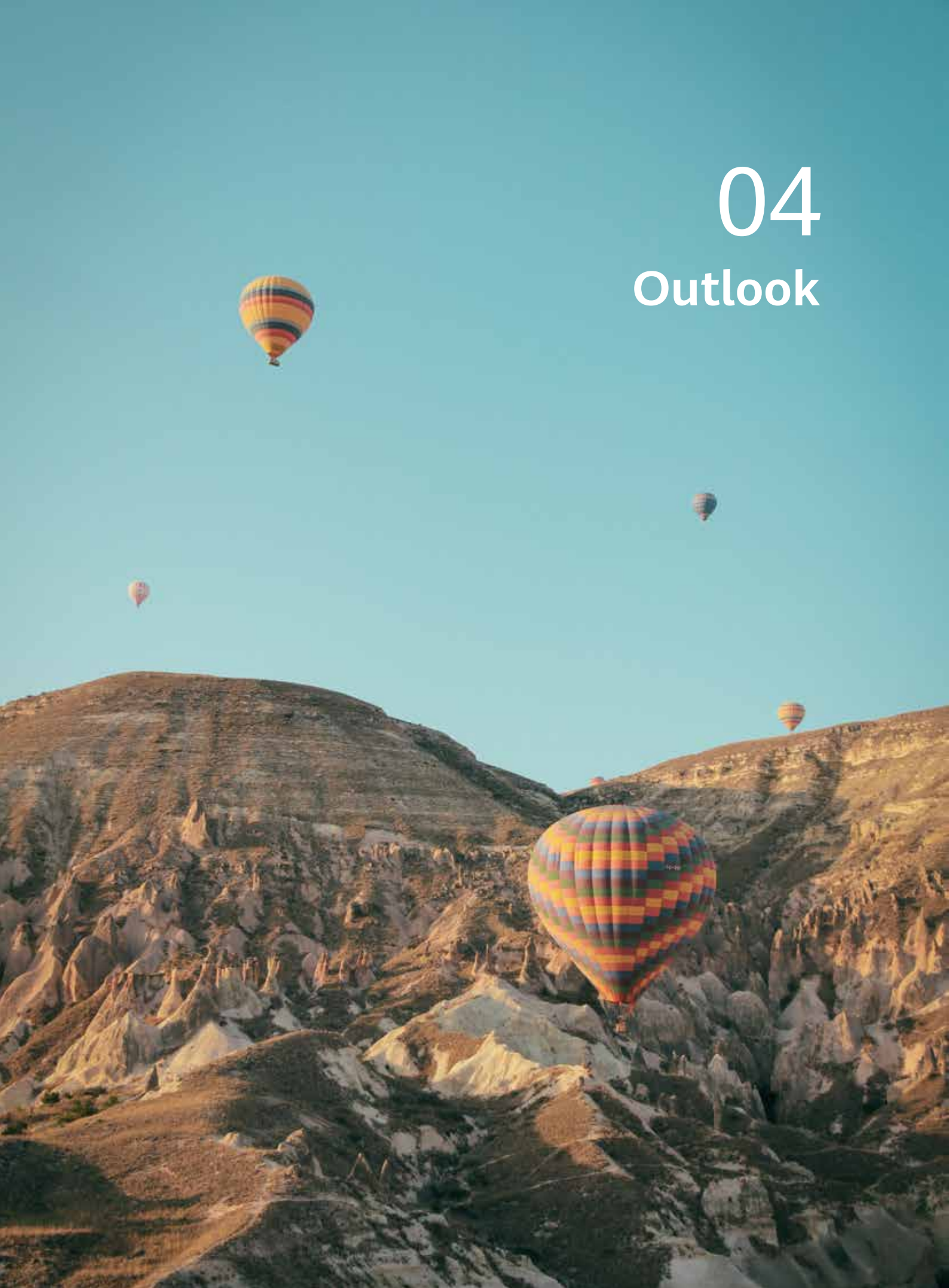
Some of the X-Tech cases demonstrate the diverse requirements of an industry digital transformation project on connectivity infrastructure that must be built with the collaboration between multiple connectivity technologies -- not just LTE and 5G but also cellular IoT, Wi-Fi and fixed network technologies. This kind of collaboration can offer industrial customers a good balance between performance and cost, while it can also be a great opportunity for CSPs. CSPs can leverage their broad connectivity portfolio to address various requirements, which will result in a competitive advantage and can help them effectively manage project costs and margins.

The smart steel plant case and the smart campus case show the value of a converged platform with an edge cloud and a public cloud. China Mobile and China Telecom took the same strategy in the two projects, with a unified cloud platform at the core of their comprehensive solution. Only when it provides a unified cloud platform, can a CSP have sufficient influence on the industrial market.

All the cases indicate the need for the collaboration between the ICT domain and the OT domain. Without operational expertise and know-how, an ICT player will not be able to design and deploy an effective solution for continuous casting and slagging or the detection of PPE wear violations. When a CSP has its in-house industrial expertise or partners with industrial specialists, it can play a Comprehensive ICT Service Provider role in the industrial market, such as what China Telecom did in the smart campus project. Meanwhile, it should be noted that China Telecom has a large R&D base in Guangdong province that can provide close R&D support for the project. This indicates that internal R&D capability is a key factor that allows a CSP to enhance the X-Tech.

These cases demonstrate that X-Tech is crucial to the success of an industry digital transformation project. The collaboration can also create opportunities for CSPs to scale up their businesses.

04
Outlook



Industrial digital transformation is entering a new stage with 5G being rolled out in global market. Policymakers and industry leaders are defining the vision for the next decade. The German Federal Ministry for Economic Affairs and Energy published- a 2030 Vision for Industrie 4.0 paper in 2019. Three closely interlinked strategic fields of action are identified: autonomy, interoperability and sustainability. These are crucial for a successful implementation of Industrie 4.0.

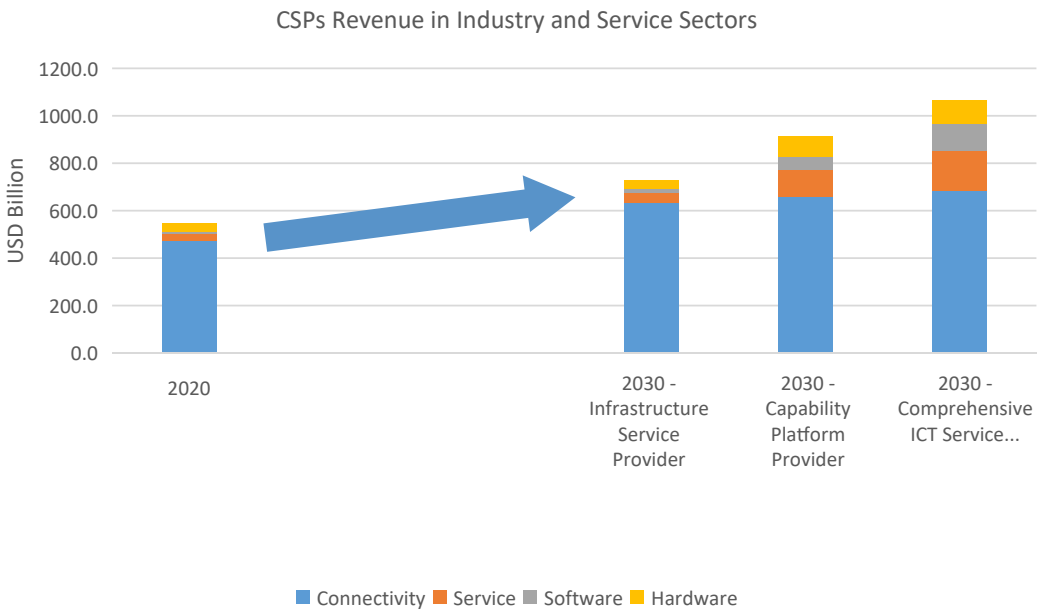
Exhibit 17: 2030 VISION FOR INDUSTRIE 4.0

In its 14th Five-Year Plan (2021-2025) for National Economic and Social Development and the Long-Range Objectives through the Year 2035, China intends to achieve new industrialization and a digital economy. China will 'promote digital industrialization and industrial digitization,' and 'strengthen the construction of digital society and digital government.'

The digital transformation roadmap towards 2030 leads to a great market potential for CSPs, particularly when CSPs move upstream in the value chain by strengthening their platform and integration capabilities. Huawei and Strategy Analytics project three scenarios for potential CSP revenue in the global industry and service sectors in 2030.

- Infrastructure Service Provider – CSPs focus on the connectivity and infrastructure services that will increase revenue by about 33% over 2020.
- Capability Platform Provider – CSPs can deliver cloud and intelligence service platforms based on their network infrastructure, through internal development or partnerships with specialist companies. This will expand CSPs' markets and boost revenue by around 67% over 2020.
- Comprehensive ICT Service Provider – CSPs can play an active role in promoting X-Tech and integrating components across the industrial digital transformation value chain. This will further expand CSPs' markets and will result in a revenue increase of approximately 95% over 2020.

Exhibit 18: Market Potential for CSPs in Global Industry and Service Sectors [3]



Source: Huawei and Strategy Analytics

[3] The scope of industry and service sectors refer to the World Bank's categories.

Since the first telecom operator was established in the late 1800s, CSPs have been used to serving mass-market customers with standard products and services. However, industry digital transformation is a diverse market. As a result, CSPs should take a phased approach to improving their capabilities.

In the short term, CSPs should focus on the industries that they know relatively well and where their existing technologies and skills can be leveraged. Once CSPs have the necessary experience and skills, they can reach out to the more challenging industries to expand their market.

Leading CSPs have identified some industries as their short-term target. Healthcare, Finance, Digital government, Smart city, Industrial Internet, data center partnership with cloud service providers, SME, Education, Transportation and Logistics have been selected by China Telecom as the focuses of its industrial market business. Vodafone's vertical focuses are similar to China Telecom. The verticals targeted for co-creation partnerships and platform-based development are: manufacturing, insurance, retail, energy/utilities, automotive and transport/logistics.

Transport, logistics and manufacturing/industrial internet are the common targets of Vodafone and China Telecom. These two leading CSPs also chose the sectors that mainly serve the public, such as smart city and digital government, education, retail, utilities, etc. In these public-facing sectors, consumers are end customers, and the services/products can be standardized to a certain extent. CSPs can leverage their experience in the consumer market to get used to these verticals. These vertical industries can be a good steppingstone for CSPs to get experience and develop expertise about industry digital transformation. It is expected that more CSPs will start their adventure in the industrial market from these verticals.

Looking toward 2030, the global industry digital transformation will create a great opportunity for CSPs to scale up their businesses. The depth and breadth of the X-Tech will determine how many opportunities a CSP can capture in the digital transformation market. We expect that CSPs can work together to promote the X-Tech in order to achieve long-term growth.

HUAWEI TECHNOLOGIES CO.,LTD.
Huawei Industrial Base
Bantian Longgang
Shenzhen 518129,P.R.China
Tel: +86 755 28780808

www.huawei.com