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Perspective

The opportunity for an edge-native connectivity platform to support industrial transformation

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1. Executive summary

1.1 Industry 4.0 represents a monetization opportunity for CSPs

Four global megatrends are pushing industries to transform their outmoded approaches to automation by applying new technologies such as cloud, data/AI/analytics, IoT, digital twins and 5G networks to improve process efficiency and effectiveness. Global uncertainty, sustainability, ageing populations and government policies are driving industries to overhaul their manufacturing systems, production lines and logistics relationships. Enterprises want to build more flexibility, resilience and innovation into their industrial processes with the help of Industry 4.0 technologies.

Connectivity will be critical to emerging industrial transformation use cases. Reconfigurable manufacturing, digital twins and autonomous mobile systems will rely on ultra-low-latency networks for their operations. As the industrial world becomes highly instrumented, millions of sensors will need to be connected to an increasingly ubiquitous layer of AI/ML models and algorithms that industries will use for real-time insights. As a result, CSPs have an opportunity to provide the digital infrastructure that will underpin industrial transformation. They can supply zero-trust, cloud-native enterprise networks and the edge clouds that will not only run cloud-native network functions (CNFs) but also the industrial software that is being disaggregated from industry-specific operational equipment and refactored as cloud-native applications.

CSPs that build programmable digital infrastructure to support industrial transformation will be able to monetize the capabilities within it, including low-latency, deterministic routing, hyper-accurate positioning, support for massive numbers of sensors, security features, edge compute and the abstraction of different industrial network domains to provide end-to-end private network slices.

1.2 Industrial transformation will be supported by a new edge platform

This paper describes the industrial edge platform (IEP) that Analysys Mason believes CSPs will need to provide to fulfil Industry 4.0's compute and connectivity requirements. It expands on the capabilities of such a platform, including its ability to deliver software-defined, zero-trust connectivity that spans network domains and multi-access edge computing (MEC). The platform will feature open APIs and AI/ML-driven management and orchestration so that it can be extended to support network innovation in future and customised to support customers' required network experience.

This report points out that CSPs are already investing in the components of such a platform although they have not necessarily brought them together into a single solution yet. The cloud-native 5G network, particularly deployments that implement 5G Advanced features, will be a key component of an IEP solution, complemented by CSPs' edge cloud locations that support their 5G networks, security and the big data/AI/ML environments they are putting in place to analyse network telemetry data but which are also needed by industrial use cases.

1.3 CSPs must act quickly to assure themselves of a place in the Industry 4.0 value chain

CSPs will face competition for the IEP from established companies from different parts of the Industry 4.0 value chain which want to expand their service portfolios and influence. Systems integrators, industrial equipment and applications vendors and new entrant service providers will pursue this opportunity, often through partnerships.

To accelerate their market entry, CSPs will also need partnerships to help them to assemble and integrate multiple IEP components. CSPs will first need to decide which part of the Industry 4.0 value chain they wish to participate in and then develop an ecosystem accordingly. CSPs that wish to provide digital infrastructure will nevertheless need assistance to build a platform that can deliver cloud-based private 5G networks and automated network slices at attractive price points for enterprises. CSPs will need help from partners to master cloud-native software and skills and prepare their own organisations to work with cloud-native automation. If CSPs want to move further up the value chain so that they can deliver industrial use cases, they will need an expanded ecosystem that can supply them with industry-specific expertise and applications.

Selecting the right ecosystem partner(s) for the IEP will be critical to CSP speed and success in addressing the Industry 4.0 opportunity.

2. Global trends are driving Industry 4.0 transformation through the use of digital technologies

2.1 Industry 4.0 is harnessing digital technologies for the operational transformation of industrial processes and systems

Today's industrial transformation, often referred to as Industry 4.0, refers to the current trend for industries to apply information technologies (IT) associated with digital transformation to the automation and data exchange that improves the efficiency and effectiveness of industrial processes. Such technologies include big data/analytics, artificial intelligence (AI), cloud and edge computing, and more operationally-oriented technologies such as Internet of Things (IoT), digital twins and 3D CAD engines.

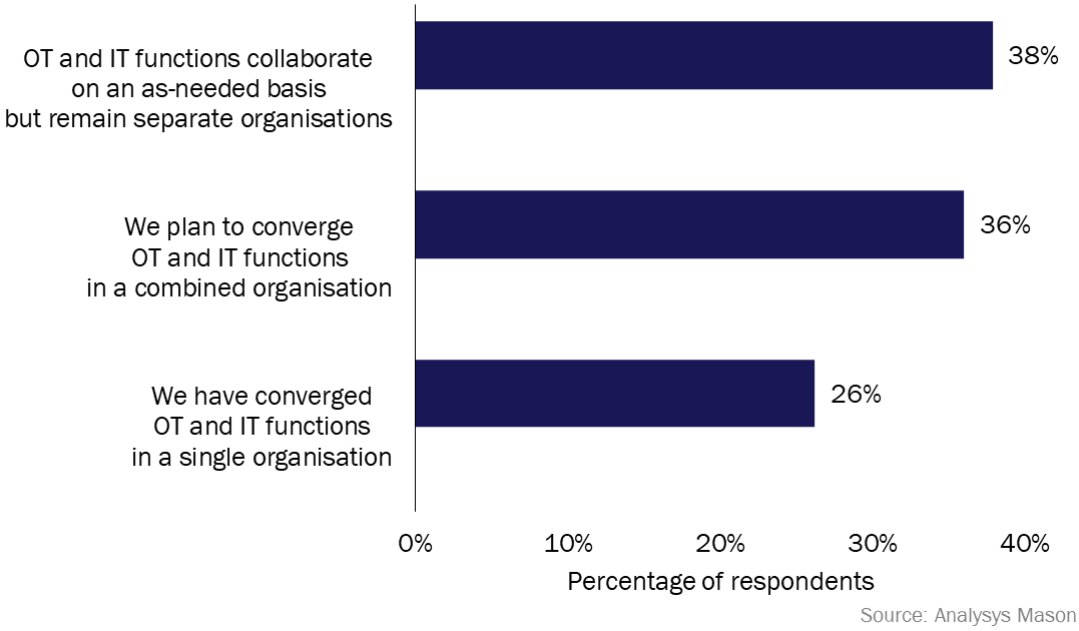
The application of IT makes possible a completely new set of industrial use cases because it replaces outmoded ways of automating industrial processes which use industry-specific operational technologies. To date, industrial automation has been achieved through the time-consuming integration of large, monolithic industrial systems from different vendors. Now, cloud and edge computing are enabling the disaggregation of embedded software from proprietary industrial appliances such as robots and programmable logic controllers, and the refactoring of monolithic systems into cloud-native microservices that can run on COTS hardware in highly automated, cloud-native environments.

There are clear parallels between Industry 4.0 and the softwareization journey that the telecoms industry has been on over the past decade as the latter has sought to increase agility and lower operational costs through digital means. In an industrial context, a horizontal cloud-based environment supports faster integration between multiple vendor solutions across production lines and supply chains, rapid feature development for continuous process improvement and enables the application of AI and analytics for real-time decision making that saves process cost and waste. Industries of all types are introducing digital twins, data-driven, virtual copies of

physical industrial environments that people can immersively enter and manipulate, with their actions fed back to the real world through robots, exoskeleton suits and/or programmable interactions. Digital twin deployments aim to improve the health and safety of working conditions and support the proactive and predictive management of physical environments.

Just as network and IT departments are converging in the telecoms sector, Industry 4.0 is driving manufacturing, logistics, energy and utilities and other industrial sectors to bring together their IT departments and their operational technology organizations (Figure 2.1).

Figure 2.1: Attitudes to the level of collaboration between IT and operational technology (OT) functions, Analysys Mason survey of enterprise attitudes to edge compute, Germany, Japan, UK and USA



Question: "Which statement best describes your attitude towards the level of collaboration between your organisation's IT and OT functions?"' n = 200.

Industry 4.0 transformation is expected to lead to more decentralized, flexible, and responsive systems that are able to adapt to changing market conditions and customer demands. Overall, the goal of Industry 4.0 is to create intelligent, interconnected, and integrated industrial systems that can produce industrial goods more sustainably while driving innovation and competition. The application of IT technologies to industrial use cases is creating new opportunities for suppliers in the Industry 4.0 value chain.

2.2 Industry 4.0 is gaining momentum as a result of global megatrends

Four worldwide trends are driving industries towards Industry 4.0 transformation.

- **Global uncertainty.** The trend towards globalization and the increasing interconnectivity and interdependence of global supply chains has been checked somewhat by the COVID pandemic and rising political tensions between nations. In a new era of post-globalization, however, the need for supply chain flexibility has never been more important. This is driving companies to overhaul their manufacturing

systems, production lines and logistics relationships, building more flexibility and resilience into their industrial processes with the help of Industry 4.0 technologies.

- **Sustainability**. The need to mitigate the potential effects of climate change is becoming a key business driver for industrial transformation. Sustainability is becoming a mantra across industries as shareholders and customers scrutinise companies' environmental, social and governance (ESG) credentials before investing in or buying from them. Companies want to reduce waste and gain early warning of potential supply chain problems through predictive monitoring and maintenance, harnessing Industry 4.0 technologies to power the smart automation and interconnectivity needed to achieve these goals. Such technologies have the potential to take productivity, the customization of production and materials/energy savings to new levels.

- **Ageing populations**. According to the World Health Organization, nearly 2 billion people across the world are expected to be over 60 years old by 2050, more than triple the number in 2000. Globally, the working-age population will decrease by 10% by 2060, with some European and Asian countries expecting a decrease of 35% or more. China's working age population will fall 23% by 2050. Many countries are already experiencing a decline in the availability of skilled labor. This is encouraging industries to increase their investment in new approaches to automation.

- **Government focus on competitiveness and economic growth.** Governments around the world are promoting the adoption of Industry 4.0 technologies as a key means of achieving their economic aspirations and maintaining or improving the competitiveness of their national industries. China has been especially vocal about Industry 4.0: its 'Made in China' vision is modelled on Germany's Industry 4.0 plan for innovation-driven manufacturing and increased industrial efficiency. In 2019, the UK government published a white paper on Regulation for the Fourth Industrial Revolution and the US has published a similar paper on the role that AI and automation will play in Industry 4.0. Other countries, including Australia, South Korea, Indonesia, Spain, Estonia and Uganda have set out national policies for Industry 4.0.

3. Industry 4.0 demands a new industrial edge platform that converges connectivity and compute

3.1 Industry 4.0 will drive changes in industrial compute and connectivity infrastructure

Industry 4.0 use cases will demand changes to the way that compute and connectivity is delivered in an industrial setting. As control software is disaggregated from industrial equipment to enable more flexible and configurable production lines, it will need an edge cloud environment to run in. Private edge clouds will be distributed across a factory floor or industrial campus and companies may choose to run some operational functions in shared, public edge clouds very close to their locations for cost/space reasons or to gain access to advanced AI tools and platforms. Edge clouds will need ultra-low-latency connections, for example, between software controllers running in the edge and the industrial equipment they are controlling.

Digital twins that are likely to run on edge clouds are fed by real-time streaming data from sensors within industrial environments. They will also rely on stringent, high-performance connectivity to deliver the real-time insights they need for predictive maintenance purposes.

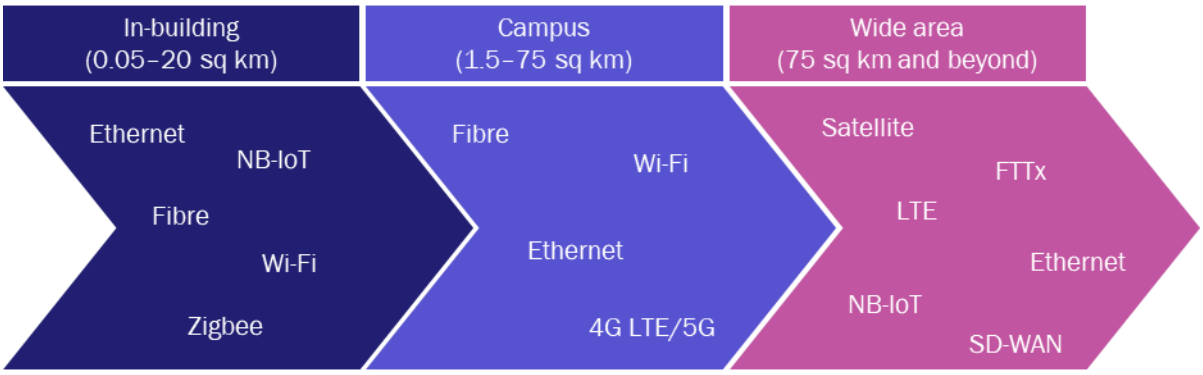
Companies will deploy more autonomous, mobile systems as part of their operations, such as autonomous guided vehicles (AGVs) and drones. These systems also depend on real-time data and will need to be supported by secure edge cloud infrastructure, AI/ML platforms and highly available and resilient networks.

Industrial use cases will increasingly rely on a distributed and collaborative understorey of AI/ML models and algorithms, realised as agents and 'bots' that support, for example, natural language and image processing, closed loop automation and complex, cross-domain decision-making. These models must run ubiquitously to support processes that span industrial domains – in-building, across campuses and in wide-area environments.

The private and public edge infrastructure to support Industry 4.0 use cases does not yet exist at scale. Edge compute is nascent and connectivity is fragmented. Industrial campuses and factory floors use a plethora of different fixed and wireless connectivity solutions (Figure 3.1), often operating in siloes to support individual use cases. Different types of connectivity are typically limited to specific industrial domains. Companies currently use different networking technologies to support their in-building, campus and wide-area connectivity needs and each technology has its drawbacks. Early generations of Wi-Fi are not deterministic, for example, so Wi-Fi is not suitable for mission-critical industrial use cases that require connectivity performance guarantees. Narrowband IoT networks are efficient for the transmission of small amounts of data but do not support streaming data at scale. Cabling between pieces of industrial equipment has an impact on the time and cost to change production lines.

Enterprises urgently need zero-trust networking that spans domains and hides the details of, and differences between, the connectivity protocols used in each. Such a networking approach should provide a protocol abstraction layer that hides the complexity of underlying industrial networks from application developers while still providing them with programmable control throughout the end-to-end networking experience.

Figure 3.1: Range of network technologies deployed in each of the three industrial domains today



Source: Analysys Mason

3.2 The industrial edge platform anticipates the demands of a broad range of industrial use cases today and in the future

If companies are to realize their Industry 4.0 ambitions, they need appropriate digital infrastructure to support them. They need a secure, distributed and AI-powered compute and connectivity platform that underpins operational processes wherever they are running: in their factories, across campus locations or out in the field. The platform should support zero-trust enterprise networking and the real-time delivery of data and insights. It should be built from open, cloud-native, container-based technologies such as Kubernetes and Linux and will need to provide the appropriate levels of scalability, resilience, automation and security to support Industry 4.0 workloads. The platform will be deployed across multiple physical cloud/edge locations, so it should be portable

and distributed, yet its governance and management will remain consistent, regardless of location and cloud environment.

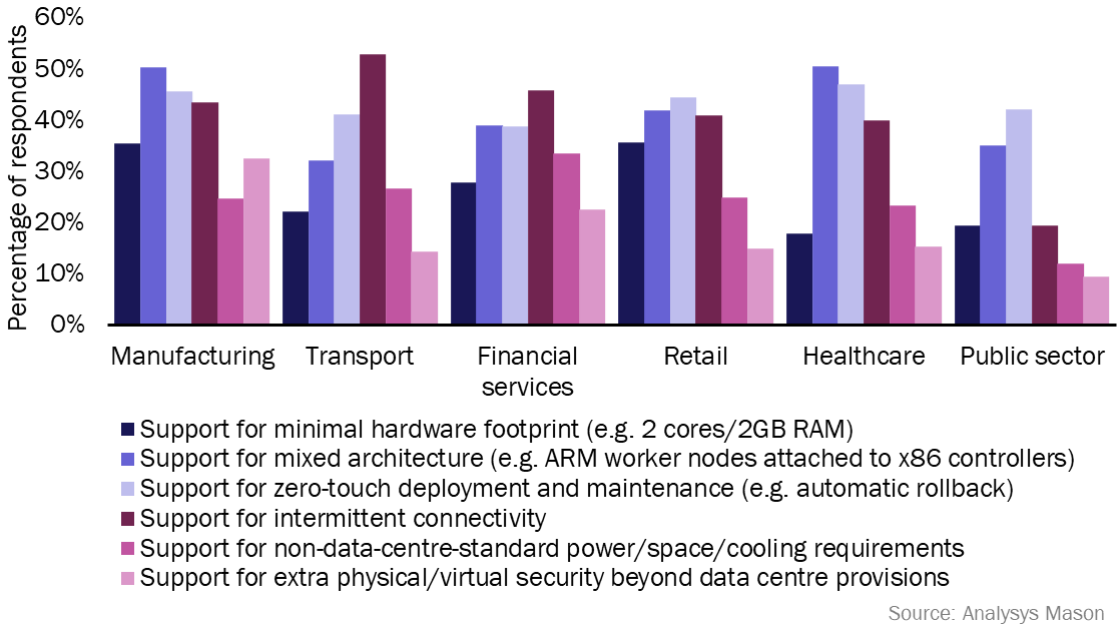
Analysys Mason calls this digital infrastructure an industrial edge platform (IEP). We believe the IEP will need to provide the following capabilities to support industrial transformation:

- **Integrated, software-defined connectivity that spans network domains**. The IEP is the first step towards a 6G platform, a broad architectural transformation of the network based on the cloud, in which the evolution of radio standards from 5G to 6G will be one enabler. Looking forward, 6G offers the promise of a converged, homogenous, cloud-based network that will be able to meet Industry 4.0 resilience, coverage, mobility and latency requirements across a wide range of industrial use cases. The starting point for the IEP, however, is the cloud-native 5G network, implemented initially in local, private campus architecture but increasingly converging with fixed, mobile, Wi-Fi, and specialist connectivity. The platform will integrate and manage this connectivity holistically, end to end, as zero-trust enterprise networking.

  From a 5G perspective, the IEP will draw on the work of the next three Releases of 3GPP standards, collectively called 5G Advanced, which build on Releases 15–17 but have a stronger focus on industrial applications and their diverse requirements. The IEP will need to provide the capabilities that are defined within 5G Advanced, including: simplified and more cost-effective implementations of ultra-low-latency communications; guaranteed reliability and deterministic connectivity to match the capabilities of networks based on fiber or proprietary protocols; hyper-accurate positioning to support advanced vehicular and robotics applications; seamless integration with Wi-Fi and non-terrestrial industrial networks; the ability to connect, provision and manage hundreds of thousands of devices and sensors; and AI-driven dynamic optimisation of the network so that it adapts to changing latency and traffic requirements.

- **Multi-access edge (MEC) support.** The IEP should provide a distributed, connected edge compute fabric. In the first instance, this will run the IEP's cloud-native network functions (CNFs), which themselves will be increasingly distributed as a result of the control/user plane separation (CUPS) architectures being applied to the 5G core and RAN. However, the IEP's edge fabric can also be used to host industrial applications. A survey conducted by Analysys Mason of 200 enterprises in 4 advanced markets across 6 verticals found that enterprise requirements for edge clouds expected to run operational use cases closely mirror CSP requirements for edge environments that can support virtualised RAN functions (Figure 3.2). The co-location of CNFs and applications can reduce infrastructure cost and support the orchestration of network features and applications together in the same pipelines to support industrial use cases.

Figure 3.2: Enterprise requirements for emerging use cases running at the edge are closely aligned with CSP edge requirements for virtualised RAN, Analysys Mason survey of enterprise attitudes to edge compute, Germany, Japan, UK and USA



Source: Analysys Mason

Question: "Please identify which of the following capabilities are/would be critically important requirements for your organisation."; *n* = 200.

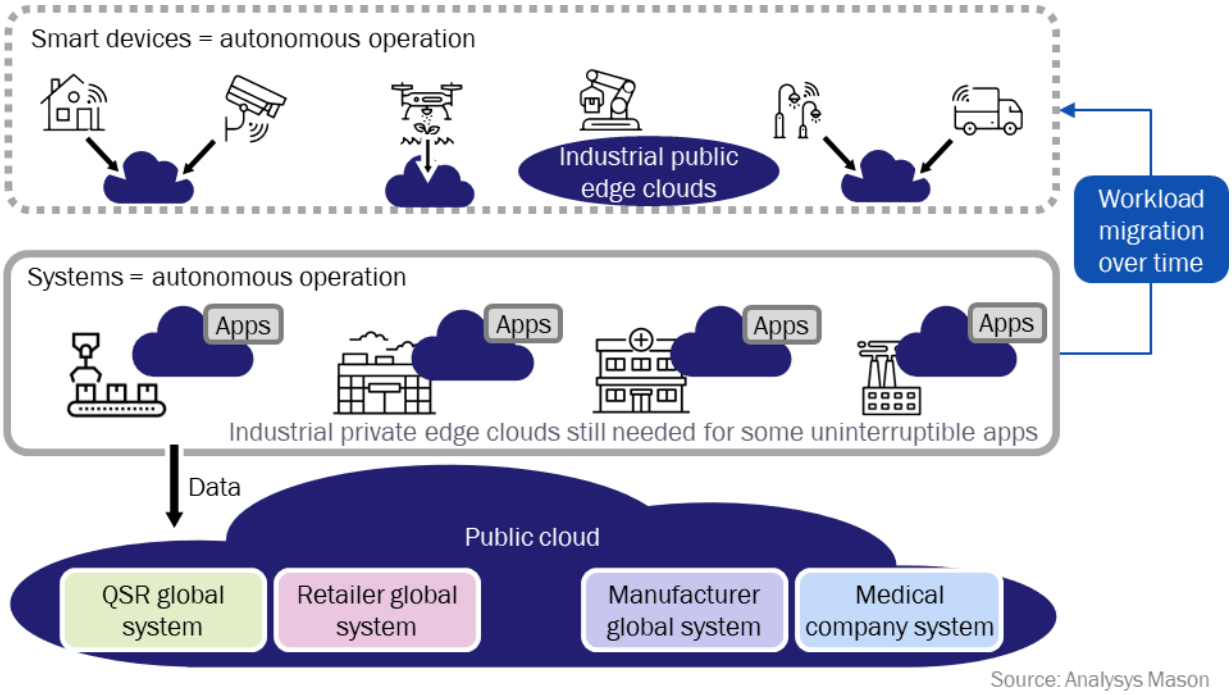
- **Open APIs:** the IEP should provide standardized API access to network capabilities so that service providers and industrial application developers can directly program the connectivity features they need into their applications. Developers will want access to ultra-low latency and hyper accurate positioning capabilities and to deterministic routing across network domains to ensure consistent quality of service end-to-end. Open APIs are critical to the creation of industrial application-specific network slices on-demand and will require the IEP provider to support new business models for API monetization.

- **AI/ML driven management and orchestration.** The connectivity and compute needs of different types of industrial applications vary. The IEP will span different compute locations and will incorporate the advanced connectivity capabilities discussed above. The platform will need to be able to apply the appropriate combination of compute and connectivity to each Industry 4.0 application to meet its individual requirements at any point in time. For example, the IEP will determine where industrial application microservices should run for latency purposes, based on its end-to-end understanding of the properties and resource profiles of those locations. The IEP can connect applications securely and provide MEC locations, private or public, depending on the workload and MEC node availability. This scheduling ability will be key to the value the IEP provides and for which an IEP provider will be able to charge. However, scheduling hundreds or thousands of industrial application and CNF microservices in real-time cannot be carried out manually or even with conventional automation approaches. AI-enabled automation will be needed to handle the number and speed of scheduling decisions.

3.3 Industrial use cases will migrate to public networks and edge over time

The pace of industrial transformation depends on the re-engineering of large and complex industrial systems that may have been in place for decades. New or refactored cloud-native industrial applications will need to talk to legacy systems that cannot easily play in the digital world of the cloud for many years to come. Companies will therefore want the edge cloud capabilities within an IEP to be deployed initially on-premises (Figure 3.3).

Figure 3.3: Existing industrial apps will be refactored for industrial private edge clouds while new apps are being developed for industrial public edge clouds



Over time, we expect public network and edge cloud infrastructure to provide a natural extension to the on-premises IEP to help companies undergoing Industry 4.0 transformations to contain the cost of expensive hardware and graphics processing units (GPUs) deployed in private edges and to support wide-area use cases. Such public edge cloud infrastructure will develop independently of private edge nodes to support emerging industrial and B2B2C use cases that are being born at the edge and which involve mobility. IEP connectivity will be needed to stitch both public and private edge nodes together.

4. CSPs that build an IEP will benefit from industrial transformation revenue

4.1 CSPs should build an IEP to address the Industry 4.0 opportunity

The IEP will have a key role to play in helping companies to accelerate their adoption of the new network technologies and edge infrastructure that they need to support Industry 4.0 use cases. The 5G network is central to the IEP since it was conceived to support a wide diversity of industrial use cases, some of which are

impossible to achieve with other available networks. The 5G network is designed to support enterprise zero-trust networking concepts since it can expose security features through APIs to Industry 4.0 application developers. This allows developers to create secure application pipelines with the appropriate quality of service for a specific use case while CSPs can monetize the 5GA and other features they have built into their networks.

As deployers of the world's 5G networks, CSPs have a key role to play in the Industry 4.0 value chain, enabling industrial transformation and enriching both the global economy and themselves. Analysys Mason has modelled[1] the increase in GDP that would be directly enabled if 5G cloud-based networks are deployed globally by 2030. We estimate that USD179 billion will be generated by new use cases that are enabled by a confluence of 5G with a host of other technologies that support Industry 4.0 use cases, including IoT, AI/ML and edge cloud.

4.2 CSPs are well-placed to provide an IEP to industrial customers

CSPs are investing in many of the components of an IEP and by combining them into a single offer for the Industry 4.0 market will have an opportunity to drive the enterprise revenue that many originally envisaged for their 5G networks. These components include the following.

- **5G networks**, which offer a range of benefits that make them well-suited to supporting Industry 4.0, use cases including high speeds, low latency, and large numbers of devices. CSPs will need to ensure they have a roadmap for supporting 5G Advanced functionality and two dimensions of converged access, both LTE/5G convergence and fixed/mobile/Wi-Fi convergence to ensure their IEP is flexible enough to meet the current and future needs of industrial applications.

- **Network virtualization and cloud-native automation.** The IEP will be an open, Kubernetes-based connectivity platform. CSPs that are implementing cloud-native 5G Standalone cores and virtualised RAN are likely to have the architectural flexibility to deliver industrial connectivity with the properties and price points that companies are looking for. CSPs also expect the cloud-native 5G network to be programmable, allowing them to create innovative network experiences for industrial customers. Cloud-native automation is an inherent part of a cloud-native 5G network, reducing operational costs if it is implemented correctly, consistently and extensively across cloud-native infrastructure and network functions.

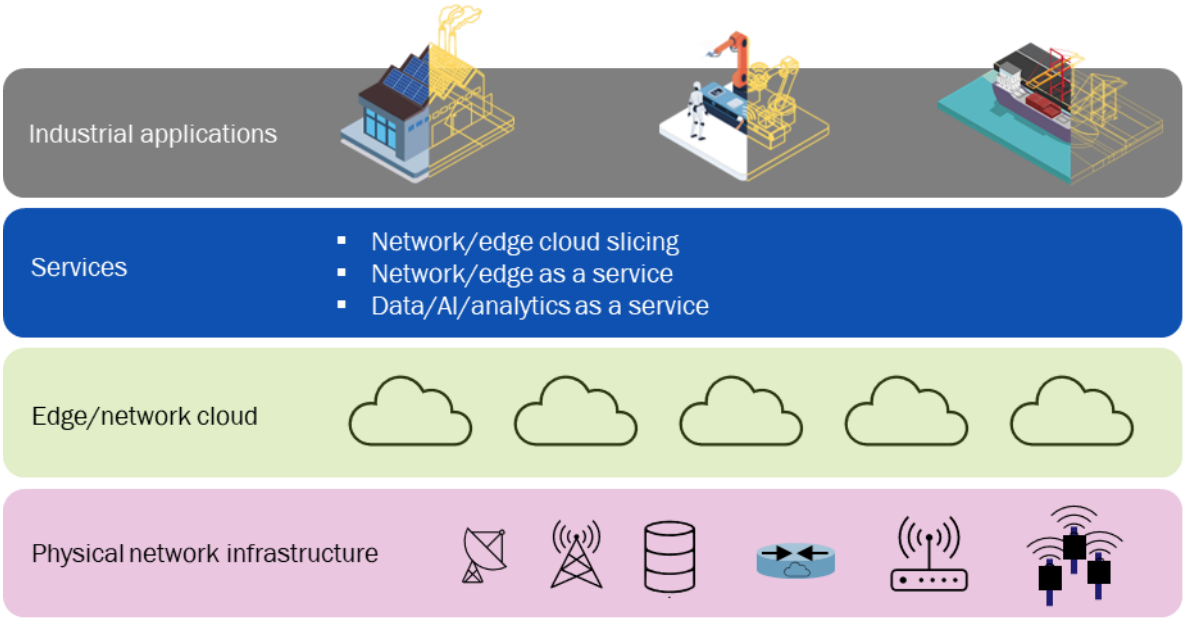
- **Edge cloud locations**. CSPs have a wealth of physical locations where public industrial edge clouds can be located, from metro data centers to central offices and cell towers. Some CSPs are already deploying edge compute nodes in all these locations, but CSPs' choices of edge location will vary by geography, footprint and considerations such as the availability of fiber. Bharti Airtel, for example, has announced plans to build a 5G-enabled edge computing platform consisting of 120 edge nodes in 20 cities to support manufacturing and automotive customers with Industry 4.0 use cases. The platform's pre-launch customer, Maruti Suzuki, will use the edge platform to increase the accuracy and efficiency of quality inspections on its factory floor.

- **Big data and AI capabilities**: Leading CSPs are building these into their edge nodes so that industrial customers can drive real-time insights from an IEP. For example, such capabilities will enable customers to process data from sensors, including cameras, at the edge or execute other AI-enabled use cases, such as photorealistic rendering of structures and augmented/virtual reality-driven maintenance. Automating visual inspections with AI is a leading use case for edge compute: advanced CSPs, such as Dish, are deploying big data and AI platforms in their edge clouds to support industrial customers.

[1] For more information, see Analysys Mason's *The economic impact of open and disaggregated technologies and the role of TIP*.

- **Security**: Industrial companies want to migrate factory floor applications to edge cloud environments but they are unwilling to expose core intellectual property or data that is sensitive from a regulatory perspective, such as videos of employees, to public networks or public cloud. For such customers it is essential that they have an isolated control plane that neither depends on the public cloud nor exposes them to the internet. Data sovereignty is an increasingly important issue as government regulation of data becomes more stringent. Companies that deploy hundreds or thousands of devices unattended in the field, supported by intermittent connectivity, also have security concerns. CSPs' status as regulated entities providing in-country edge nodes helps to address many of these issues while their increasingly programmable and encrypted 5G networks enable them to provide zero-trust connectivity. CSP support for network slicing, for example, will enable enterprises to establish ephemeral connections with field devices for short periods of time to download updates, for example, before the connection is terminated and the slice handed back.

Figure 4.1: Industrial edge platform



Source: Analysys Mason

4.3 CSPs' right to play in the industrial edge is not a foregone conclusion

Industry 4.0 represents a large opportunity for CSPs but they will need to accelerate their own rate of change and adoption of cloud-native 5G networks, including transforming their organisations, to be effective in an industrial context. Private 4G/5G networks are a key component of an IEP but according to Analysys Mason research, 64% of publicly announced private 4G/5G networks have been provided by systems integrators (SIs) and network equipment providers (NEPs) in 3Q 2022.[2] SIs are strong partners for enterprises and well-placed as prime contractors because they are structured to deliver bespoke solutions and have strong integration skills that enable them to assemble components into IEP-like solutions. The NEPs are delivering cloud-based private networks with high levels of automation at price points that CSPs are struggling to match. According to our estimates, only 11% of CSP-delivered private networks today include an edge cloud component while our research suggests that public cloud providers are top of mind as providers of edge nodes.

2 For more information, see Analysys Mason's *Private LTE/5G networks tracker 4Q 2022*.

Over time, CSPs may be able to redress the balance as enterprises transition to industrial use cases that have a greater reliance on the operator network. Customized, CSP-orchestrated network slices that draw on the extensive features of an IEP may prove attractive to enterprises, especially if the slices are integrated with CSP-provided edge compute or a CSP-managed hybrid private/public edge cloud, as Dish is intending to offer. The increased use of common assets across the CSP network should reduce costs for industrial customers and speed up application deployment times.

However, CSPs cannot afford to be complacent. As carrier-neutral metro and tower data centers are built out and as public cloud providers extend their cloud footprints and networks, a new set of edge and connectivity service providers could emerge, using these alternative locations for their versions of an IEP. Cloud-capable new entrants may find it easier to build programmable, cloud-native networks and service platforms to serve the industrial community than CSPs currently do. CSPs can accelerate their own ability to address the Industry 4.0 opportunity and to build an IEP if they choose the right partner to work with.

5. The importance of partnerships to unlock the full value of industrial transformation

5.1 The industrial edge will be an ecosystem play

CSPs will need an ecosystem to help them to build an IEP given its multi-faceted nature and the long list of components they will have to assemble and integrate. Ecosystem partners can help CSPs with the organizational changes they must make and the skillsets they must acquire to operate an IEP. Selecting the right ecosystem partners will be key to the level of innovation that CSPs can bring to the Industry 4.0 market and the network experience they can deliver to their industrial customers. CSPs will also need a range of ecosystem partners depending on the role they decide to play in the Industry 4.0 value chain.

For example, some CSPs may choose to deliver digital infrastructure only (connectivity and compute) while others may wish to move higher up the value chain to offer end-to-end Industry 4.0 solutions. The former group will need an ecosystem that can help them build an IEP with the right cloud-native technologies so that they can deliver connectivity and compute services with the levels of programmability, scalability, security and resilience needed in an industrial setting.

CSPs that want to deliver higher-value services should build an ecosystem that can help them to acquire the right competencies such as systems integration, API-driven delivery models and DevOps and software skills.

5.2 CSPs will bring an IEP to market faster through technology partnership

CSPs face challenges in building the IEP. Most CSPs have continued with ‘business-as-usual’ models for their 5G networks. These models focus on offering faster speeds and improving the reliability of mobile broadband rather than on seeking out new groups of customers and markets, such as the market for industrial transformation. Most CSPs are therefore taking an incremental approach to adding 5G capabilities to their networks and have not yet addressed the disruption to their organizations and operations that the cloud-native 5G SA core and cloud-native RAN approaches will bring.

The IEP will be a cloud-native platform but Analysys Mason's research into CSP cloud-native readiness shows that only a handful of CSPs are prepared for this major technology shift. Some advanced CSPs are greenfield operators that do not have a legacy organization to transform. Some are large enough to buy in scarce and expensive cloud-native resources and skills to build their own network clouds as a foundation for an IEP.

Many CSPs, however, will struggle with the organizational and operational change needed to build and maintain a converged connectivity and compute platform for industrial use cases. They will find it challenging to integrate the range of networking, IT and cloud capabilities required to deliver the IEP. These CSPs should consider partnering to accelerate IEP development. A partner that can provide key technology components of the IEP, such as an edge cloud stack that can support both cloud-native network functions and industrial applications, cloud-native infrastructure and application lifecycle management and automation, end-to-end orchestration across network domains, big data/AI/analytics and security services and experience with API enablement and management will help CSPs bring an IEP to market faster, enabling them to gain access sooner to the revenue opportunities that industrial transformation presents.

5.3 CSPs should partner with industry specialists to strengthen their position in the Industry 4.0 value chain

CSPs have long-standing relationships with enterprises' network and IT departments but traditionally have had less visibility into enterprises' operational technology organizations. This is becoming easier as industrial companies converge their IT and OT teams but addressing industrial use cases nevertheless needs deep vertical market and even company-specific knowledge. CSPs will need access to such knowledge to maximise the market opportunity for their IEPs.

Some CSPs will want to reposition themselves from being providers of connectivity services to becoming organizations that can deliver business outcomes. Such CSPs will need professional services organizations with industry-specific expertise which can assemble bespoke solutions to address customers' Industry 4.0 use cases. The IEP would be one component of such a solution, alongside industrial applications, IoT devices, public cloud services, consulting, and systems integration.

Other CSPs that do not have the resources to build or master all the capabilities needed to deliver industrial transformation solutions will need to offer their IEPs to partners that can. CSPs should look for business partners that can provide a set of solutions that are a good fit for the features and locations the CSP supports in its IEP and which have strong relationships with industrial customers.

6. Conclusion and recommendations

In conclusion, industrial transformation is gaining momentum. Leading-edge companies across industries are exploring their digital infrastructure (compute and connectivity) requirements for existing operational systems and new use cases. This infrastructure will initially comprise on-premises edge cloud and 5G networks, evolving to public edge cloud and a more holistic zero-trust approach to enterprise networking – 6G – in future. CSPs are building cloud-native 5G networks that both contain capabilities of interest to industrial use cases and require the support of an edge platform with similar properties to those demanded by such use cases. CSPs are therefore in a strong position to provide the digital infrastructure needed for industrial transformation in the form of an IEP.

To succeed in this market, however, CSPs should address the following.

- **Decide on the value chain role they wish to play** in industrial transformation and evaluate whether they have the right capabilities to succeed at different levels: as a digital infrastructure (IEP) supplier (edge compute and connectivity services) or as a full industrial solution provider, which will require specific vertical industry knowledge, a professional services offer, and application partnerships.

- **Choose the right ecosystem partner(s) to work with** depending on the value chain role that the CSPs wants to play. Such a partner(s) should be able to help with the variety of commercial and technology issues that CSPs will face when developing the IEP and bringing it to market. These challenges include ensuring that the IEP is a platform for innovation that can be extended over time to meet the differing network experience needs of customers; helping the IEP to offer the data, AI and analytics capabilities that will drive real-time insights for industrial use cases; supporting the monetization potential of the IEP by providing developer-friendly APIs to platform capabilities; and if necessary, helping to provide an application and developer ecosystem around the IEP from which higher-value, end-to-end solutions can be built.

- **Accelerate their rate of adoption of the cloud-native technologies and skills needed to build the IEP** if CSPs are to avoid ceding the opportunity to competitors with superior software and integration capabilities. CSPs should select a partner(s) that can shorten the time-to-market for their IEPs so that CSPs can win early reference customers and returns on their investment.

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7. About the authors

Caroline Chappell (Research Director) heads Analysys Mason's Cloud research practice. Her research focuses on service provider adoption of cloud to deliver business services, support digital transformation and re-architect fixed and mobile networks for the 5G era. She is a leading exponent of the edge computing market and its impact on service provider network deployments and new revenue opportunities. She monitors public cloud provider strategies for the telecoms industry and investigates how key cloud platform services can enhance service provider value. Caroline is a leading authority on the application of cloud-native technologies to the network and helps telecoms customers to devise strategies that exploit the powerful capabilities of cloud while mitigating its disruptive effects.

Daniel Beazer (Senior Analyst) leads Analysys Mason's *Edge and Media Platforms* research programme. His research focuses on the key building block technologies and architecture of the edge computing infrastructure currently emerging to support the delivery of applications and services for 5G, media, entertainment and other industries. Before joining Analysys Mason, he led Structure Research's Edge, 5G and Cloud practice. Daniel has worked extensively in the internet infrastructure industry in management and strategy roles and has several years' experience working as a consultant for leading vendors and investors in the space. He was educated at Oxford University where he read Ancient History and Philosophy.

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