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# Transforming Transportation and Logistics with Digitalization

Peng Zhongyang, Director of Huawei  
& President of Huawei's Enterprise Business Group

# Bridging the IT and OT Digital Divide with a New Digital Transportation Paradigm

Wang Guoyu, Vice President of Global Transportation Business,  
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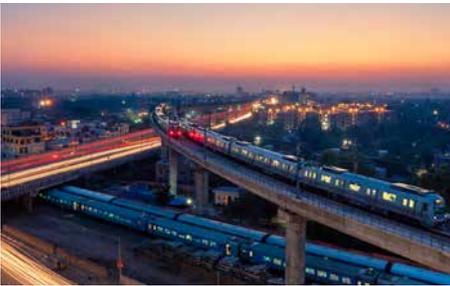
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# Transforming Transportation and Logistics with Digitalization

*By Peng Zhongyang, Director of Huawei & President of Huawei's Enterprise Business Group*



A stylized, handwritten signature in black ink, consisting of several fluid, connected strokes.

Before the Industrial Age began, prosperous cities often formed around waterways. Yangzhou — a wealthy city in eastern China, located just north of the Yangtze River — is one example. The northeastern Italian city of Venice — comprised of a series of islands, separated by canals and connected by bridges — is another. When the Industrial Age did begin, cities in the US, such as Georgia's capital, Atlanta, emerged at railway intersections. Then, in the 1920s, the construction of Route 66 — one of the country's first highways — boosted the development of many of the nation's inland cities.

Elsewhere and more recently, the development of the aviation industry has enabled somewhere like Dubai to become a transportation hub, boosting the city's importance in the Middle East and, as a result, its prosperity.

Throughout history, we can observe a clear pattern: Transportation and logistics are pivotal, linking global cities and playing a vital role in their development.

And while cities have developed and their transportation and logistics networks have become more sophisticated, digitalization is now permeating the industry. In 2021,

there are clear, tangible benefits that digitalization brings in terms of convenience. We can buy tickets on our smartphones, for example, wherever we are and whenever we want. Plus, we can also use our phones as personal, smart navigation devices, in a car or on foot.

Just as passenger travel has progressed, so has the logistics industry: We track the status and location of packages — again, anytime and anywhere — using our smartphones.

Clearly, digitalization and informatization have brought unprecedented convenience to our lives. That doesn't mean that problems don't persist in the transport and logistics sectors, however. So while buying tickets online is convenient, it doesn't in itself mean that our journeys are any more efficient. Indeed, despite technological advancements, the punctuality rate of global outbound flights is still only 75%. And commutes in cities around the world remain a source of frustration for far too many: In Beijing, for example, 26% of commuters spend more than an hour on their way to or from work. The situation is similar in the logistics field: Although packages can be tracked online, that

***With 5G eliminating the limits of physical distance and Artificial Intelligence (AI) enabling capabilities that haven't been seen before, the development of new ICT will drive the transportation industry's digital transformation.***

doesn't make them arrive any sooner.

Clearly then, the transportation industry's main pain point in most countries isn't a lack of roads or other infrastructure. The problem is that information doesn't flow as smoothly as it should. Indeed, when we look closer, we see that transportation data is scattered in siloed systems, and there's a real lack of interaction between information related to roads, vehicles, and passengers.

Much as transportation has enabled widespread mobility in the physical world, Information and Communications Technology (ICT) is promoting the data exchanges so central to the digital world.

With 5G eliminating the limits of physical distance and Artificial Intelligence (AI) enabling capabilities that haven't been seen before, the development of new ICT will drive the transportation industry's digital transformation. For example, in China, Electronic Toll Collection (ETC) has been deployed at all toll booths, replacing traditional manual operations. And the result? Greatly improved traffic efficiency with the knock-on effect of less congestion.

There are ways in which passenger experiences are improving, too. For example, at subway stations passengers can now use their smartphones to check which carriage has the fewest people on it before deciding to get onboard. By first digitizing infrastructure and business processes — physically converting analogue information into a digital format — smart transportation allows people, goods, vehicles, and business processes to be digitalized.

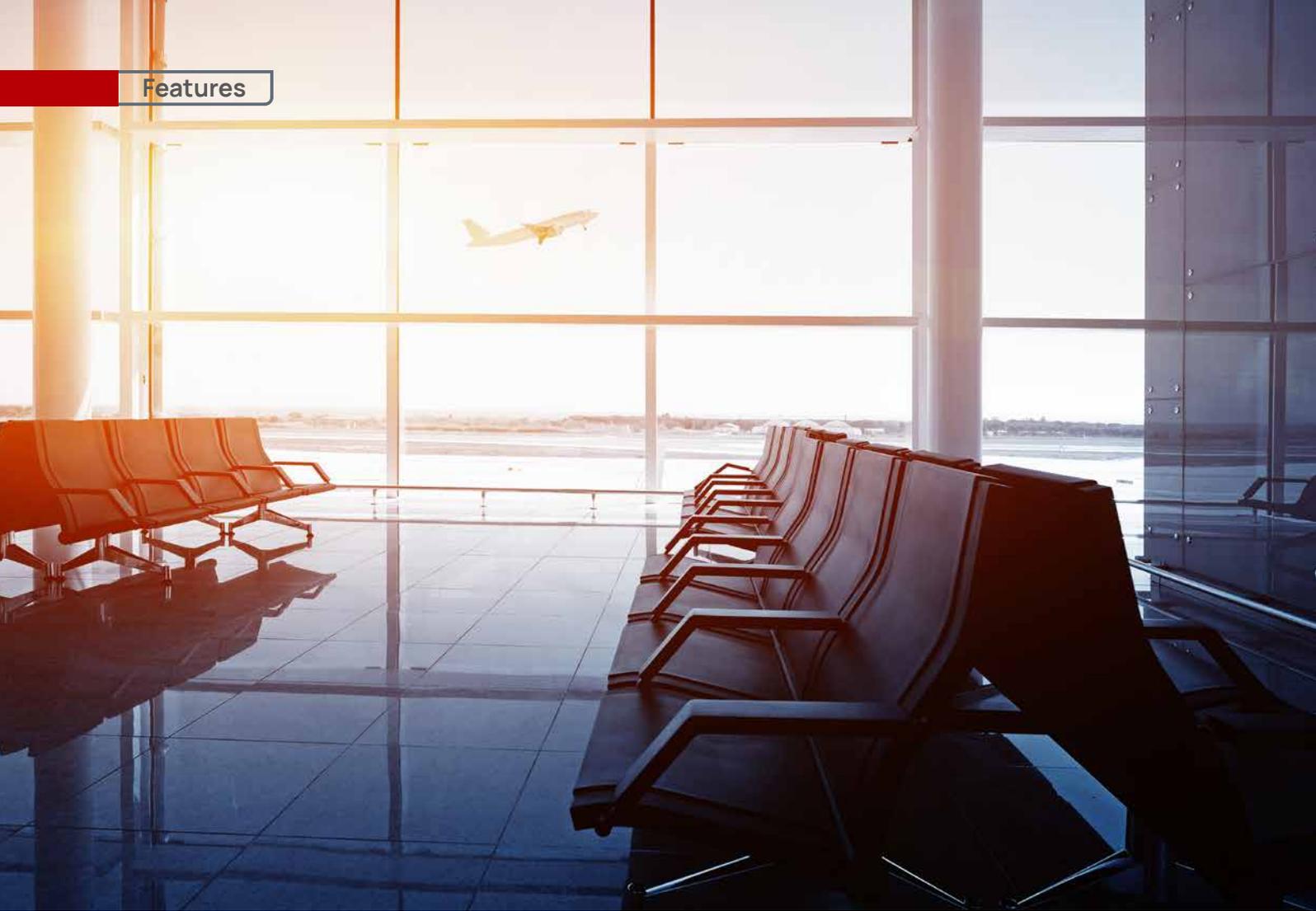
Along with advanced transportation systems that bring greater mobility to people, improving the travel experience, such systems also pool talent and resources for far more

efficient allocation, in turn boosting social and economic development.

By promoting cross-departmental information exchange and data convergence, and by focusing on full-cycle services for planning, construction and operations, smart transportation uses computing power to boost transportation capacity, extracting value from data. Ultimately, the aim of smart transportation is to comprehensively improve the security, efficiency, and experience of transportation in all its guises.

Obviously, industry digitalization encompasses a wide range of scenarios. But Huawei identifies the goal of digital transformation in the transportation industry as a relatively simple one: the construction of a comprehensive transportation system that offers an improved travel experience and more efficient logistics. As such, the company is committed to supporting End to End (E2E) digitalization of the industry, to achieve this, improving productivity, operations, business models, and public service capabilities.

Scenario digitalization requires technologies, industry knowledge, and practical experience. With more than two decades of experience in the transportation sector, Huawei integrates cutting-edge ICT — including cloud computing, big data, 5G, and AI — into transportation scenarios. Huawei works with global partners to deliver an overall transportation solution focused on 'One ID, One Order, and One Map.' This means that customers are able to use one form of ID for all travel, make one order for all goods shipments, and visualize all logistics and operations information on one map. With this solution, Huawei helps customers in the transportation industry go digital — enabling truly smarter and more efficient transportation across the globe. ▲



# Safely Restarting Aviation During COVID-19

By *Pascal Buchner, Director of Information Technology Services and CIO, IATA*

The aviation industry started 2020 with optimism: We expected to transport 4.7 billion passengers last year, but the COVID-19 pandemic has had a devastating impact. Passenger demand has evaporated — partly because people are afraid to travel, and partly because many borders are closed. And even when and where borders are open, governments are imposing quarantine periods.



## About IATA

International Air Transport Association is an international trade association for the world's airlines. The organization represents some 290 airlines, comprising 82% of global air traffic.

As a result, we're facing a US\$118.5 billion net loss for 2020. Losses of US\$38.7 billion are forecast for 2021. And we aren't expecting passenger demand to return to 2019 levels until 2024 — a year later than previously anticipated.

This is the biggest crisis in the history of the airline industry. We saw passenger demand hit rock bottom in April 2020, and demand was about 80% below 2019 levels by July. Clearly, the

industry has a lot of work to do to recover.

## A Layered Approach to Biosafety

The first priority is to ensure passengers can fly safely. IATA, national governments, the World Health Organization (WHO), and many industry partners have contributed to the International Civil Aviation Organization's (ICAO) take-off guidance to restart aviation.

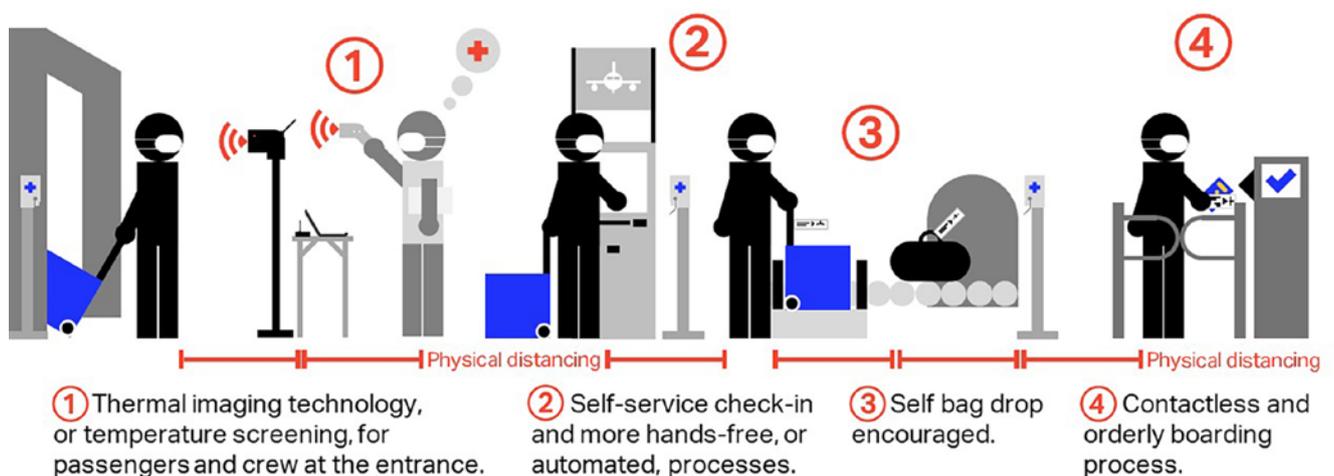
The key elements of the guidance include: mask-wearing during travel, more frequent and more thorough sanitization of aircraft, contactless processes, simplified cabin services, automated procedures for customs and border protection, limited access and temperature screening at airport terminals, health declarations, and social distancing where possible.

These pragmatic guidelines will reduce the risk of transmission when traveling. They were developed in record time, too — under the leadership of ICAO and with the full support of the industry. Now, they must be implemented. Because aviation is a network business, the implementation of these measures must be universal and respect local guidance. Many governments are trying to restart their economies, and they must act fast.

## Rebuilding Passenger Confidence

There is also an urgent need to rebuild passenger confidence, and this will be a significant challenge. At the beginning of March, approximately 60% of travelers said they would return to travel within a few

## A layered approach to biosafety: departure airport



When proven and available at scale, testing for COVID-19, antibody testing, or immunity passports could also be included as temporary biosafety measures.



months of the pandemic coming under control. By early June, that figure had dropped to 45%.

Communicating the measures that we have taken to keep travelers safe is key to addressing these concerns. At IATA, that's exactly what we're doing. And we're also working across the industry to send an aligned message — this includes addressing concerns about contracting COVID-19 on a flight.

In fact, there are very few cases of onboard transmission. That's partly because there are several cabin factors that naturally limit the spread of droplets: Everyone is facing forward, the seat backs are a barrier, people generally don't move around very much, and air circulates

from top to bottom — not back to front.

On top of that, the quality of air onboard is much better than most indoor environments. High-Efficiency Particulate Air (HEPA) filters in modern aircraft ensure that recirculated air is similar to what you would find in a hospital operating theater. And the air is exchanged for fresh air from outside 20 to 30 times an hour — about ten times more frequently than most office buildings. Add to that all the biosafety measures in place, following the ICAO's take-off guidance — such as mask wearing — and we have an impressive story to tell about the low risk of transmission on commercial flights.

### Re-opening Borders

Key to the recovery of the industry is the opening of borders, of course, and the lifting of travel restrictions and measures such as quarantining. Unfortunately, air travel remains largely closed around the world, despite the availability of global protocols to enable the safe restart of aviation.

The prerequisite to opening borders is the ICAO's take-off guidance. Additionally, IATA is proposing 'travel bubbles' — exclusive partnerships between countries that have demonstrable success in containing COVID-19 — to mitigate risks between specific markets, and foresees a much wider and strategic use of COVID-19 testing as technology improves accuracy, speed, and scalability.

IATA has also proposed a three-point action plan for governments to safely re-open borders:

1. **Implement** the ICAO take-off guidance universally.

**The risk of onboard transmission is counted as low**

To date, despite independent research, there is still little confirmed evidence of onboard COVID-19 transmission between passengers.

Sitting next to someone on a plane is low risk. Why?



**2. Build** on the solid work of ICAO Council's Aviation Recovery Task Force (CART) by developing an agreed common framework for states to use in coordinating the safe re-opening of their borders to aviation.

**3. Develop** COVID-19 testing measures that will enable the re-opening of borders by reducing the risk of COVID-19 importation to a level acceptable to public health authorities, with the accuracy, speed, and scalability that meet the exacting requirements for incorporation into the travel process.

### The Role of Technology in the COVID-19 Crisis

There is no single measure that can mitigate all the biosafety risks of restarting air travel. However, we believe that implementation of the measures we have outlined, which are already feasible, is the most effective way of balancing risk mitigation with the need to unlock economies and enable travel in the immediate term.

The following activities are good examples where technology has a critical role to accelerate these adaptations.

With concerns about limiting face-to-face interaction and the need to reduce the touching of common surfaces, contactless travel applications will be key. Based on self-sovereign identity and decentralized trust, these applications aim to securely share biometrics and travel data while reducing the number of physical touch points during the journey.

There are many touchpoints across the passenger journey. All these interactions across the different stakeholders in the industry

naturally present great opportunities for data collection, but have also been disrupted because of the pandemic.

To support the successful restart of the industry, innovative ways of factoring in all aspects of the 'new normal' are required: for example, advanced data analytics solutions, based on machine learning algorithms, could be used to provide leading indicators for capacity planning and industry dashboards.

Collecting and processing passenger data for health-related matters is becoming increasingly critical for the restart of the air industry and for restoring passengers' trust. This is why a multi-layered cybersecurity program is needed to respond to the cyber security challenge of remaining safe, secure, sustainable, and resilient to cyber security risks, while enabling state-of-the-art digitalization and connectivity in the industry. These initiatives will enable the industry to increase its profitability, boost efficiency, and improve the customer experience, in compliance with data privacy regulations, helping the aviation industry to rise out of this difficult period and gain new momentum. ▲



*A multi-layered cybersecurity program is needed to respond to the cyber security challenge of remaining safe, secure, sustainable, and resilient to cyber security risks, while enabling state-of-the-art digitalization and connectivity in the industry. >>*

### Comments from IATA



Huawei is a key strategic partner of IATA — helping us to deliver cross-industry solutions that are interoperable, consistent, secure, scalable, affordable, and simple to implement and operate.

— Pascal Buchner, Director of Information Technology Services and CIO, International Air Transport Association (IATA)



# Powered by the Cloud: How China is Developing Smarter Urban Rail Systems

*By Li Zhonghao and Xing Zhiming, Expert and Academic Committee of the China Association of Metros*

**W**hen a subway system opened in Hohhot, Inner Mongolia, in 2019, it was the very first time an urban rail cloud solution for underground transportation scenarios based on Chinese standards had been used. Indeed, the creation of the specialized cloud used was an important milestone in the development of China's rail transportation. And a key step in the process was the release of Smart Rail Transit — Specifications for IT Architecture and Cybersecurity — a set of guidelines for the nation's rail transport industry.

On December 29, 2019, the first ever subway train departed from a station in Hohhot, the provincial capital, taking the first ever subway journey — all made possible because of the nation's leading urban rail cloud solution.

## Planning the Urban Rail Cloud

If urban rail transport is to develop, it must become information-based. To put it another way, it must go through a

*With the emergence of new information technologies, new opportunities are being created for the urban rail industry in China, as people seek better transportation experiences and the government strives to build more powerful transportation infrastructures to support those experiences.*

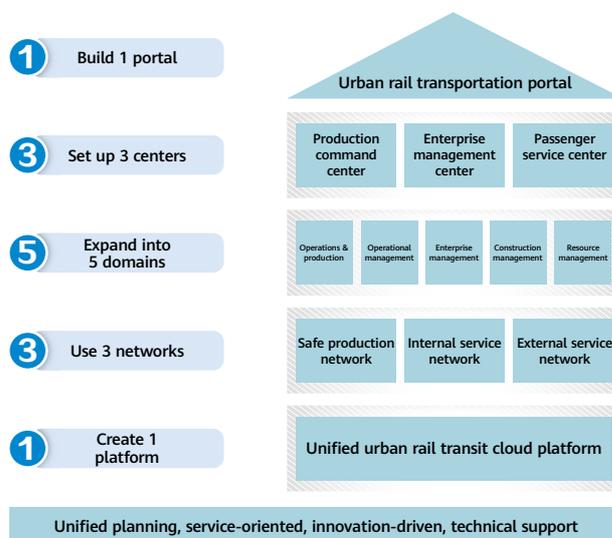
process of 'informatization.' However, there are several challenges to achieving this in China, such as a lack of top-level design, outdated system architecture, information silos, weak security infrastructure, and the absence of standards and specifications.

As new information technologies develop, new opportunities for the urban rail industry in China are created. As people continue to seek better transportation experiences, the government is striving to improve transportation infrastructure to facilitate such experiences. Meanwhile, enterprises working in the sector must take the opportunity to develop quality urban rail transit, tackling all the challenges that arise as they go.

In early 2016, the China Association of Metros (CAM) sought to address some of those challenges and proposed a blueprint for the informatization of urban rail transit in the country, based on an extensive analysis of global urban transit development and the latest Information Communications Technology (ICT) trends. To facilitate urban rail cloud research and application, the blueprint — known as '13531' — aims to build 1 portal (a smart metro portal website), set up 3 centers (a production and emergency command center, a passenger service center, and an enterprise management center), expand into 5 domains (operations, production, operational management, construction management, and resource management), use 3 networks (a safe production network, an internal service network, and an external service network), and create 1 platform (the urban rail transit cloud platform).

### Creating the Cloud

Subsequently, in early 2017, CAM incorporated



The '13531' blueprint based on the urban rail cloud

informatization into urban rail technical specifications, to support the construction of urban rail transit with higher levels of informatization. At this point, CAM began formulating Smart Rail Transit — Specifications of IT Architecture and Cybersecurity.

Many industry experts, subway operators, design and research institutes, and system suppliers worked together to formulate the specifications. After nearly two years of meticulous research and hard work — involving more than 100 institutions and over 160 experts from the industry — CAM published the document on July 26, 2019, with the specifications taking effect on December 1 of that year.

The specifications — which cover all urban rail modes and service domains, paving the way for a high-level design

of industry informatization — state that the industry must meet urban rail transit development needs and adapt to the development of next-generation Information Technology (IT). The specifications are significant for standardized informatization construction and operations while building urban rail transit systems.

Developed in line with the 13531 blueprint, the specifications follow the principles of innovation and coordination, green development, and openness and sharing. They also advocate building both a unified cloud, to bear all urban rail services, and a unified network, to cover all industry application systems.

The specifications proposed the idea of 'three domain-based cloud resource management' for the first time. They also call for the construction of a proprietary, open source cloud management platform, a big data sharing platform, and a robust cybersecurity defense system. A unified urban rail transit traffic data center should also be

built, and a comprehensive urban rail cloud Operations and Maintenance (O&M) system established. The implementation of the specifications is more than a breakthrough for the development of the urban rail cloud — it's also a new beginning for its application.

### Applying the Cloud

Based on the urban rail cloud platform, Hohhot Metro has 20 metro stations, a subway car depot, and a control center. To meet the requirements and support the features of urban rail transit, Hohhot Metro worked on large-scale testing, development, and innovation, involving more than 30 vendors on eight application systems at the Urban Rail Ecosystem Lab of Huawei's OpenLab in Suzhou. To ensure the successful implementation of the urban rail cloud solution, Hohhot Metro also carried out full simulation and testing based on project requirements. The project provided valuable experience and lays a solid foundation for the widespread deployment of the urban rail cloud.

Hohhot Metro's urban rail cloud platform is the first multi-line and multi-system urban rail cloud deployed in accordance with the specifications, demonstrating that they can effectively guide urban rail transit construction. Hohhot Metro created a unified cloud and network that can support all horizontal services and systems, including the urban rail operation and production, enterprise management information, and passenger service management systems, as well as supporting the two vertical departments of lines and stations (car depots).

Hohhot's urban rail cloud provides on-demand dynamic allocation of computing,

### Expert Insights



"Smart urban rail transit uses emerging information technologies — such as cloud computing, big data, Internet of Things (IoT), AI, 5G, and blockchain — to implement comprehensive sensing, in-depth interconnection, and intelligent convergence of entity information about passengers, facilities, equipment, and environments. The aim is to build convenient, efficient, green, new-generation smart urban rail transit systems. Smart urban rail transit can't be achieved with a single technology. Instead, smart urban rail transport needs a combination of both innovation and coordination in multiple areas."

— Li Zhonghao,

Expert and Academic Committee of the CAM

storage, network, and security resources. It also greatly improves service reliability using technologies such as High Availability (HA), live migration, and Cloud Server High Availability (CSHA).

As well as its obvious performance benefits, the solution is also cost effective, improving Central Processing Unit (CPU) resource usage by more than five times and reducing the initial investment required by approximately 40%. Meanwhile, unified O&M reduces labor costs by more than 30%. With new lines sharing cloud resources, and with the full cloudification of station and depot systems in the future, there will be greater equipment room construction savings to be made.

Hohhot's urban rail cloud represents the first ever cloudification of all urban rail services in China. The project also provides valuable experience for global urban rail cloud construction.

CAM has also embarked on an urban rail network informatization project for the city of Wuhan. CAM is making good progress on the project and has created a new architecture based on a cloud platform and big data. Dual-active data centers have been built in different geographical locations, and the information systems of all lines — both existing and new — have been migrated to the cloud platform.

### Hitting New Heights

The implementation of Smart Rail Transit — Specifications for IT Architecture and Cybersecurity represents progress for urban rail informatization construction in China, including standardization of construction and operations. The entire industry should

reach consensus and work to ensure the specifications are used as a guideline for urban rail transportation informatization construction.

CAM will refine the specifications and continue to carry out in-depth research on key areas related to the cloud platform, big data, network architecture, cybersecurity, and the operations and dispatch command center. Ultimately, all will come together to form a comprehensive regulatory system that can guide unified urban rail informatization construction. Emerging ICT — such as cloud computing, big data, and Artificial Intelligence (AI) — will lead to a new round of technological innovations and promote economic and social development. Indeed, cloud computing has already been implemented in China's urban rail industry.

As well as Hohhot Metro, the research and application of an urban rail cloud is underway in several other Chinese cities. China's urban rail cloud has entered a new stage of development and innovation, empowering more and more cities as they seek to build or upgrade their subway systems. ▲

### Expert Insights



"Cloud computing has been implemented in China's urban rail industry. With the specifications released and implemented, the application and research of the urban rail cloud is underway in several other Chinese cities, as well as the Hohhot Metro system."

— Xing Zhiming,  
Informatization Committee of the CAM

# The Community of Metros (COMET): 10 Major Trends of the Digital Transformation in the Urban Rail Transit Industry

*Based on speeches by Richard Anderson and Sally Kao from the Transport Strategy Centre at Imperial College London*

## Abstract

At the China International Urban Rail Transit Development Trend Forum on November 6, 2020, experts from the Community of Metros (COMET) outlined the ten urban rail transit digital transformation trends.

### Trend 1

#### Using the passenger train synchronization technology to monitor the status of tracks, tunnels, and power supply systems in real time:

In some countries, metro operators have started to use passenger trains to collect device information along tracks and send it back to maintenance centers. This improves the frequency of equipment inspection and reduces the maintenance and repair costs at nighttime.

### Trend 2

#### 3D image-based station management system:

Metro operators around the world are beginning to centrally manage devices at stations. In this way, devices at stations can be started remotely, and metro staff can choose specific cameras to monitor onsite situations.

### Trend 3

#### Providing real-time information on passenger flow and crowdedness:

Metros can now provide passengers with more real-time information, including the crowdedness of a certain section of track. Metro operators are now trying to provide even more specific information, such as details about the crowdedness and internal temperature of individual carriages.

### Trend 4

#### Intelligent recognition technology:

The use of intelligent recognition technology at metro stations has become increasingly common. As well as its application in the ticketing system, metro operators are also beginning to deploy intelligent recognition to improve security and maintenance.

### Trend 5

#### Using Virtual Reality (VR) for metro staff training and safety education:

VR technology, widely used in online gaming, has now been extended to metro staff training. For example, VR can be used to train metro drivers and station attendants on how to handle emergencies. The main advantage of VR lies in its lifelike simulation and immersive experience.



## Trend 6

### Using vehicle image detection technology for train overhaul:

In terms of train maintenance at stations, Chinese metro companies have installed fixed image detectors in repair centers and used robots to quickly scan train components before more careful manual repair.

## Trend 8

### Artificial Intelligence (AI) apps and mobile apps:

AI has been gradually put into use in metros. Robots that can provide services such as online consulting, guidance at stations, and cleaning device inspection have been deployed. In Europe and North America, mobile voice guidance systems provide comprehensive and tailored services to meet special passenger requirements.

## Trend 9

### Long-distance ticket induction entry:

For some passengers with special requirements, long-distance ticket induction can be used for entry and exit, improving convenience for passengers in wheelchairs and for those carrying heavy baggage.

## Trend 10

### Equipping all staff at stations with tablet computers (information integration system):

With labor costs increasing, many European and American subways have taken various measures to reduce the manpower at stations. Because each station attendant plays several roles, they must be equipped with tablets to quickly respond to passenger requirements, report device repair status, and make contact in case of emergencies. ▲

## Trend 7

### Multiple applications of image detection technology:

With the development of imaging technology, many countries have begun deploying cameras at metro stations. Cameras at platforms can be used to estimate the waiting time of passengers, and detect whether there are any passengers falling from escalators, or identify improper behavior by the train driver. Cameras can also be used to detect unattended luggage and illegal entry of people into the track area. Cameras can be applied in a wide range of scenarios as well as security protection.

# Bridging the IT and OT Digital Divide with a New Digital Transportation Paradigm

By Wang Guoyu, Vice President of Global Transportation Business, Huawei Enterprise Business Group

Since the 'New Infrastructure Construction' policy and the Outline for Building China's Strength in Transportation were implemented — in 2018 and 2019, respectively — the digital transformation of the nation's transportation industry has reached a critical juncture, as it has in other countries around the globe. Traditional modes can no longer meet new requirements that digital transformation brings, so a new mode is needed. And in recent years, a new digital paradigm has started to develop.

The use of new technologies — such as 5G, cloud computing, big data, Internet of Things (IoT), and Artificial Intelligence (AI) — is leading the transportation industry into the digital era.

The deep integration, bidirectional interaction, and real-time coupling of Information Technology (IT) and Operational Technology (OT) empowers the transportation industry's digital transformation and comprehensively improves the precise sensing, precise analysis, and intricate management capabilities of transportation infrastructure, as well as the modernization level of the governance of transportation.

Many countries around the world — in Europe, North America, and Asia Pacific — are planning comprehensive digital transformation solutions for transportation. For example, the European Union (EU) has devised a plan that will provide 2 trillion euros (about US\$2.43 trillion) to finance a European economic recovery after the deep recession that

the coronavirus pandemic is expected to cause. From that fund, 1.1 trillion euros (about US\$1.33 trillion) will be used to build a 20,000-km high-speed railway network that connects the capitals of EU countries. In 2020, the German government and Deutsche Bahn AG released a railway construction investment plan for the next decade, indicating that Germany is expected to invest 86 billion euros (about US\$104 billion) to build a comprehensive pan-European transportation network by 2030.

## Digital Transformation of Transportation Industry Enters Uncertain Period

In recent years, we've seen several disruptive events; some of them were foreseeable, while others were impossible to predict. Clearly, the future is becoming increasingly uncertain. Many innovations have been gradually integrated into the





*The Comprehensive Transport Solution integrates technologies such as 5G, cloud computing, big data, and AI with business scenarios, to achieve Huawei's vision of making travel as convenient as possible.*  
— Wang Guoyu, Vice President of Global Transportation Business, Huawei Enterprise Business Group



transportation industry's production process. As the digital transformation of the industry develops, determining how to radically innovate and create that much-needed new digital paradigm has become a priority.

Transportation infrastructure generally has a low level of digitization. The transportation industry is asset-heavy, and it has strict security requirements as well as high specialization and mobility levels, so it faces significant challenges as it integrates with new technologies such as 5G, cloud computing, and big data. Frankly, it lags behind the Internet, finance, and telecom industries in terms of digital transformation.

In the past 30 years, the transportation industry adopted IT technologies very early, but most transportation infrastructure has lacked digital capabilities. Many roadside, trackside, terminal, and hub devices are still 'dumb'; they're not included in traffic operations management, and they can't be used for traffic management and dispersion. This is fairly typical of the industry: Most IT applications are scattered in various information silos, and transportation is still far from being truly digitalized.

Modern transportation isn't merely the independent transportation of passengers and cargoes in vertical transportation domains, including railway transportation, highway transportation, water transportation, and air transportation. Instead, it's integrated, comprehensive transportation based on the passenger, cargo, and vehicle flows, plus a digital, networked, and intelligent travel service system. Digital transformation is the only way to achieve comprehensive transportation, but it's very difficult because this kind of 'comprehensive' transportation is complex.

With the rapid development of urban rail transit and city cluster construction, urban rail construction has begun to evolve — from a series of separate lines to a complicated network consisting of diversified urban rail transit modes, such as metro, light rail, commuter rail, and Bus Rapid Transit (BRT). This has led to a sharp increase in the number of construction projects. For example, in recent years Shenzhen Metro's construction projects increased from 60 to 400, sometimes involving about 70,000 construction workers per month. This rapid development has also made the process



*Future transportation won't be merely independent transportation of passengers and cargoes in vertical transportation domains – railway, highway, water, and air transportation, and so on; it will be integrated, comprehensive transportation. >>*

management of urban rail construction much more complicated. No matter where you look around the world, there isn't a great deal of experience in making such a large rail network digital. To explore and innovate in the field, we need to make use of next-generation IT technologies — such as 5G, cloud computing, big data, IoT, and AI.

Further complicating matters, vehicles are always evolving and constantly being upgraded. The operations and management of new vehicles — drones, unmanned vehicles, electric vehicles, and intelligent rail transit — pose challenges to the digital operations and management of China's modern transportation systems. In this context, the priority is developing a new digital transformation paradigm.

## Building a New Digital Transformation paradigm

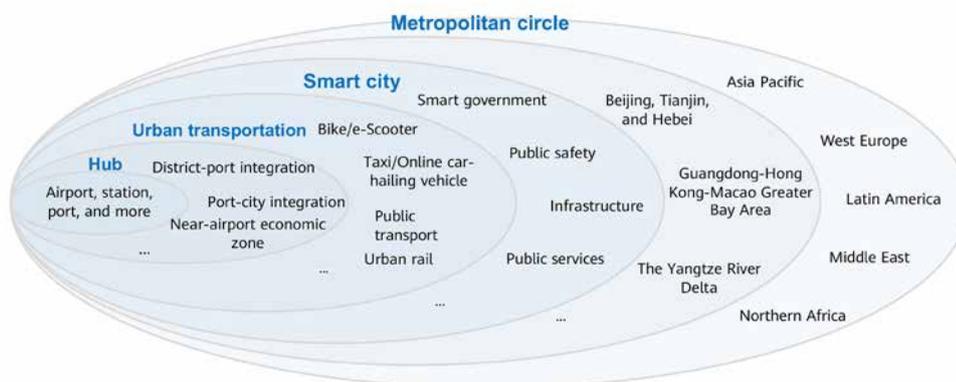
With Information and Communications Technology (ICT) advantages accumulated over 30 years and more than 20 years of experience in transportation industry solutions,

Huawei has provided transportation solutions for 23 Fortune Global 500 customers.

The Comprehensive Transportation Solution — jointly launched by Huawei and its ecosystem partners — is one of the most popular solutions; it integrates technologies such as 5G, cloud computing, big data, and AI with business scenarios, to achieve Huawei's vision of making travel as convenient as possible for passengers and ensuring that all logistics for cargo transportation are run smoothly, improving the security, efficiency, and experiences of transportation.

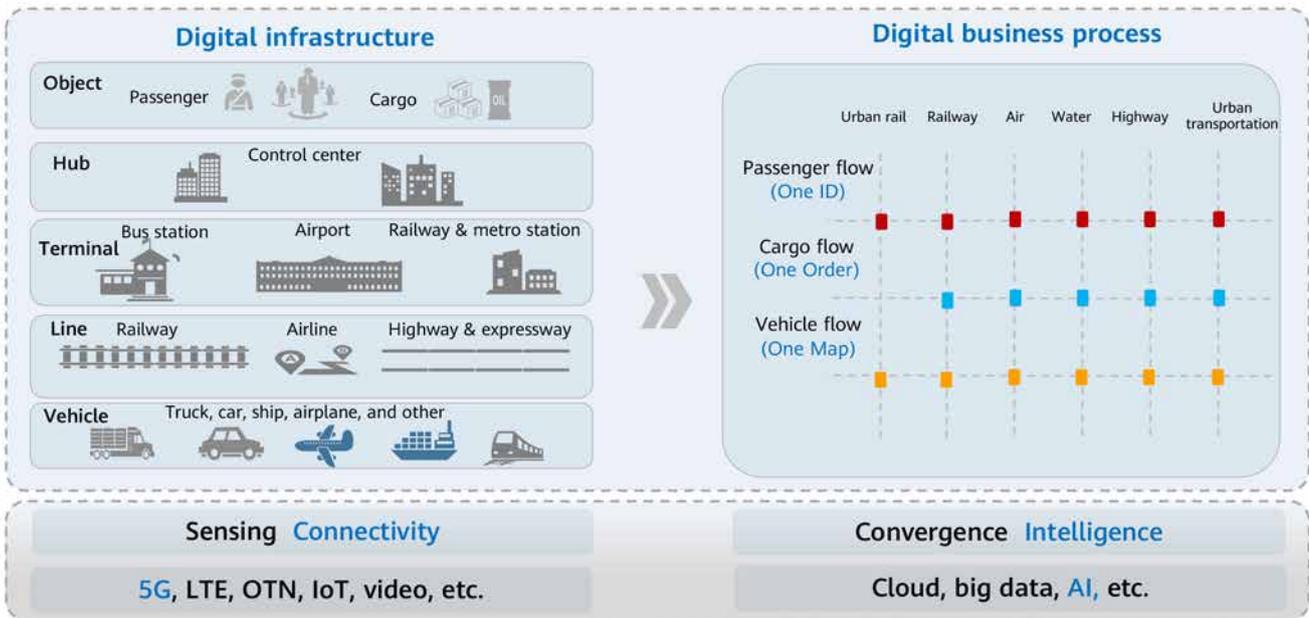
## Comprehensive Transportation Solution

Future transportation won't be merely independent transportation of passengers and cargoes in vertical transportation domains — railway, highway, water, and air transportation, and so on; it will be integrated, comprehensive transportation. Integrated, comprehensive transportation covers people's door-to-door journeys and end-to-end transfers of cargoes; it makes those journeys and transfers quicker,



Integrated, comprehensive transportation

Transportation enables mobility in the physical world; communications drives data interaction in the digital world.



Digital transportation encompasses digital infrastructure and digital business processes.

safer, and cheaper, and it guarantees better experiences.

As more industrial plans are proposed — such as the Outline for Building China's Strength in Transportation, as well as other regional plans of the Yangtze River Delta, Guangdong-Hong Kong-Macao Greater Bay Area, Beijing-Tianjin-Hebei Region, Jiangsu province, and Guangdong — building an 'air, water, ground, and underground' integrated, comprehensive transportation system, from hubs to cities and then to metropolitan circles meets the transportation industry's development needs.

Ultimately, the aims of making transportation digital are to solve business problems, improve security, efficiency, and experiences, stimulate productivity, and ensure high-quality development of the industry by building a comprehensive transportation system that covers the entire process, architecture, and lifecycle. This digital, integrated transportation system must be implemented step by step.

The first step is to make each business scenario in vertical

sub-industries — aviation, urban rail, railway, highway, logistics, and port — digital. Then, multiple digital business scenarios are connected in series to form streamlined business flows of passengers, cargoes, and vehicles. In this way, vertical sub-industries become digital.

The second step entails connecting digital vertical sub-industries in parallel to bridge breakpoints, forming a door-to-door travel service flow and an end-to-end goods transportation flow. This way, the entire process can be sensed, predicted, coordinated, and linked — building a future-ready comprehensive transportation system.

Huawei's Comprehensive Transportation Solution includes smart airports, urban rails, highways, logistics, railways, and ports — covering major modes of transportation and logistics. Huawei is also participating in the planning, design, Research and Development (R&D), and implementation of comprehensive digital transportation construction in several Chinese cities. For example, Huawei is helping Shenzhen

strengthen its urban traffic governance capacity to alleviate congestion in the city and increase its travel service level to make public travel safer and more pleasant.

As a comprehensive transportation hub that integrates sea, ground, air, and rail transportation, Shenzhen Airport prioritized the converged development of transportation modes in recent years, to build an aviation service ecosystem of combined air-ground, air-sea, and air-rail transportation, becoming a '4-in-1' airport. This kind of convergence generates huge digital value, and it inevitably results in a vast amount of data traffic.

An important task for Shenzhen Airport is to explore how to enable 4-in-1 airports for digital transformation and build comprehensive airport hubs. To build a future-ready digital platform, Huawei and Shenzhen Airport are working together, following the 'Platform + Ecosystem' strategy, which entails the use of a digital platform and an ecosystem of partners working together. Based on Huawei's ICT infrastructure, the two parties have integrated the IoT, a combination of big data and AI, video cloud, Geographic Information System (GIS), and Integrated Communication Platform (ICP) resources.

### Digitization and Digitalization

Digital transportation includes digital infrastructure (digitization) and digital business processes (digitalization). Digitization is the basis for digitalization, and digitalization is key to bridging breakpoints and addressing difficulties and pain points.

Digital infrastructure is capable of all-round sensing and connectivity, and involves

technologies such as IoT, 5G, machine vision, and radar. Digital business processes are converged, intelligent, visible, and they provide support for decision-making. These processes typically involve technologies such as cloud computing, big data, and AI.

Applying more than 20 years of experience in digital transformation of the transportation industry, Huawei has developed Traffic Intelligent Twins (TrafficGo), which integrate multiple technologies — such as connectivity, cloud, AI, computing, and application — and is an open, intelligent system that features three-dimensional sensing, multi-domain collaboration, accurate judgment, and continuous evolution — realizing cloud-network-edge-device synergy.

Taking connectivity and intelligence as an example:

**Connectivity:** 5G features high bandwidth and low latency, providing infinite possibilities for digital transportation.

The digitization of roadside, trackside, terminal, hub, and vehicle infrastructure is necessary for business process digitalization, and depends on sensing and connectivity technologies for data collection and transmission.

5G is one of Huawei's core technological strengths. With high bandwidth, low latency, wide connectivity, and high reliability, 5G can make a significant difference in the transportation industry. For metro facility maintenance, manual detection is inefficient and prone to false alarms and omissions.

The 5G train-to-ground wireless communications solution piloted on Shenzhen Metro's Line 11 can transmit data to stations, car depots, and monitoring stations when the



*To build a future-ready digital platform, Huawei and Shenzhen Airport are working together, following the 'Platform + Ecosystem' strategy, which entails the use of a digital platform and an ecosystem of partners working together. >>*

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train is running, so that the metro operation organization can monitor train facilities, train status, tunnels, and passengers. When a train runs for an hour, it generates about 25 GB of data. In the past, it took at least 120 minutes to copy that data. Now, that data can be automatically copied within 2.5 minutes. This supports prompt health management and status analysis of facilities.

**Intelligence:** AI reduces the amount of manual labor needed for major, frequent, and repetitive tasks.

To digitalize business processes, business experts and IT experts need to work together to select appropriate business scenarios and find the difficulties and pain points in the operations and production processes in the transportation industry. Then technologies can be used to solve the problems to improve security, efficiency, and experiences.

For example, whether the number of times passengers take shuttle bus at an airport is related to both the technology of aircraft stand allocation and the management system. An airport usually arranges for the most competent commander to allocate aircraft stands, and the commander typically spends four to five hours on this task. In the event of traffic control or weather changes on the following day, the commander needs to quickly adjust the allocation.

AI can complete the allocation in only one minute, and makes adjustments in seconds. Shenzhen Airport's intelligent

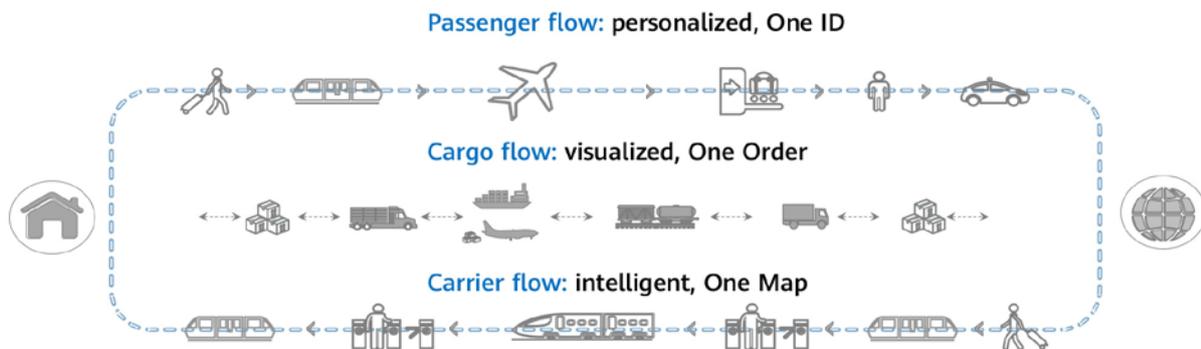
stand allocation system first introduced AI algorithms to airports in China, helping Shenzhen Airport allocate stands automatically and intelligently. By deploying this system, the airport has greatly improved its bridge-to-aircraft docking rate, as well as bridge turnover rate — enabling about 2.6 million passengers to directly board the aircraft through bridges and reducing passenger waiting time by 125 hours each year.

The convergence of connectivity and computing will change all walks of life. Metcalfe's Law states that a network's value is proportional to the square of the number of nodes in the network. This means that a network's value increases exponentially when the number of connections in the network increases, ultimately creating value for society. In the transportation industry, connectivity and computing should be integrated with business scenarios and address pain points in production systems to create value. All of these scenarios constitute a blueprint for comprehensive transportation.

### Three Business Flows

The transportation industry has three business flows: passenger, cargo, and vehicle.

**Passenger flow:** Providing personalized, differentiated, and more convenient travel experiences for passengers is the eternal pursuit of various transportation enterprises.



IT technologies such as 5G, IoT, video, big data, cloud, and AI are integrated to provide optimal security, efficiency, and experiences

Three business flows

**Cargo flow:** Smooth circulation of cargoes can improve logistics efficiency and reduce social costs.

**Vehicle flow:** Resources and requirements can be better matched by linking elements such as passengers, cargoes, roads, vehicles, terminals, and stations.

We need to focus on core business flows and apply IT technologies in key business scenarios to resolve pain points — increasing production efficiency, enhancing operations management, innovating business models, and improving public service capabilities.

The combined application of IT technologies — such as 5G, cloud computing, big data, and AI — can deepen the convergence of multi-source data, integrate online and offline resources, and promote the opening and sharing and converged development of information about a range of fields — such as transportation, business travel, and tourism and shopping — building Mobility as a Service (MaaS) that's centered on mobility rather than on transportation resources. Mobility requirements and transportation service resources are matched based on data, making mobility an on-demand instant service and creating a new mobility experience.

How can we apply IT to improve the passenger experience at airports and shorten the passenger processing time? The Smart Airport solution is passenger-centric, and provides precise, all-scenario, personalized, and online-offline converged services along passengers' travel routes, building an airport travel solution that creates a seamless airport travel experience for passengers, in which only one form of ID is needed. Chengdu Shuangliu

International Airport is expected to provide end-to-end seamless self-help services soon — creating an efficient travel experience for passengers and reducing the risk of ID document loss. Meanwhile, the smart flight information display system provides flight information and indoor navigation information for passengers. In China, all airports have equipped their boarding gates with self-service facilities, reducing the average passenger processing time by more than 15 minutes.

### Lifecycle Alignment

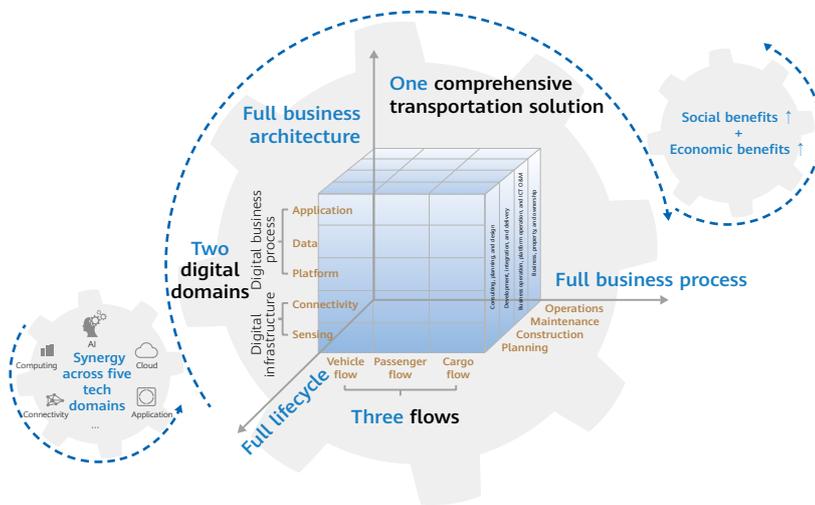
It usually takes several years from preparing to build transportation infrastructure to the infrastructure being used. As technologies develop rapidly, digital enablement should cover four phases: planning, construction, maintenance, and operations. Coordinated deployment and iterative innovation should go throughout the lifecycle. For example, smart urban railways need to be analyzed in terms of construction, maintenance, operations, business management, and passenger travel; smart highways need to be approached comprehensively, from road network sensing and road network cognition to road network intelligence; and smart railways need to be considered from operational communications to smart train maintenance, as well as from perimeter security protection to smart freight yards and smart stations.

The business of transportation enterprises and institutions is usually divided into the aforementioned four phases. Each phase requires careful planning and effective use of IT. The four phases should be aligned from end to end in order to obtain complete digital



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Comprehensive transportation, covering the entire process, architecture, and lifecycle

insights, support planning and decision-making, implement comprehensive scheduling and operations of all processes, scenarios, and elements, and verify and explore innovative business models.

Huawei's solutions and platforms are deterministic so we can decide how to deploy them to perform better services. Meanwhile, the application scenarios for those solutions and platforms are non-deterministic and constantly change, so we need to collaborate and work closely with ecosystem partners, create a unified architecture, with coordinated deployment, and efficiently iterate new technologies.

Industrial digital transformation is a systematic process. To keep this process on track, top-level design needs to be performed in the project planning phase. Under the premise of a unified architecture, decision makers need to consider the long project period and fast technology iteration, devise a plan, calculate the entire lifecycle and

costs, and estimate the requirements of the maintenance and operations phases. Deterministic platforms and products should be deployed in a coordinated way. Digital platforms — as ICT infrastructure — are the foundation for the transportation industry's digital transformation, and they should be constructed first, to improve efficiency.

In the construction and maintenance phases, we should embrace new technologies — such as 5G, cloud computing, AI, big data, and IoT — and preferentially adopt stable and open platforms, as well as technologies and solutions that can be flexibly iterated.

In the operations phase, transportation enterprises and institutions can build customer profiles based on big data analytics to explore new business models and revenue sources.

We need to collaborate with ecosystem partners, and quickly iterate technologies to cope with non-deterministic application scenarios.

The Yangchenghu Expressway Service Area in Jiangsu province is an example of successful lifecycle alignment. Up to 100,000 vehicles stop by the service area every day. Each vehicle carries at least two people, and each person spends over CNY70 (about US\$11) there, creating over CNY7 million (US\$10.8 million) in revenue for the service area. Yangchenghu Expressway Service Area is planned as a node on the tourism industrial chain and operated as a commercial district.

Digital transformation should run throughout the lifecycle of transportation business. In the future, this will become normal for construction of new transportation infrastructure.



*To succeed, the entire industry needs to work together. Only when the industry uses unified standards and builds a healthy ecosystem can all parties achieve collaborative division of labor, complement each other's advantages, and flourish. >>*

## Ecosystem Collaboration

The digital economy has proven a significant driver for stabilizing investment, promoting consumption, facilitating industrial upgrades, and cultivating new momentum for economic growth. To create value, the digital transformation of the transportation industry requires synergy.

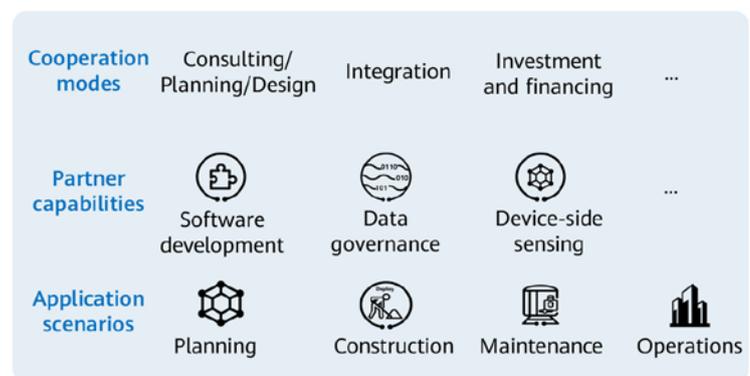
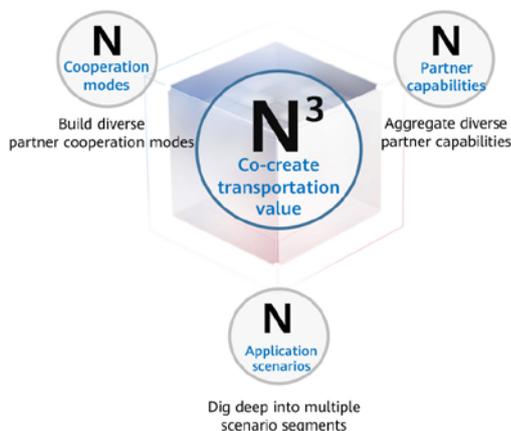
Huawei applies its technological capabilities and focuses on scenario-based transportation solutions through synergy across five tech domains: 5G, cloud, AI, computing, and industry applications. To succeed, the entire industry needs to work together. Only when the industry uses unified standards and builds a healthy ecosystem can all parties achieve collaborative division of labor, complement each other's advantages, and flourish.

To help establish that healthy ecosystem, Huawei will enable partners. As well as traditional partners, Huawei will also cooperate with five types of ecosystem partners: consulting and planning partners, data governance partners, integration

implementation partners, application development partners, and platform operations partners.

To aggregate the capabilities of these partners, Huawei will explore multiple cooperation modes, including device-side sensing, software development, data governance, and smart applications, for joint innovation. As the construction of new infrastructure progresses and new business models evolve, the investment in infrastructure construction increases year by year. More investment and financing partners need to join in, to dig deep into the segmented business scenarios of the transportation industry. Huawei and our partners will complement each other's advantages and jointly build a digital cube — incorporating cooperation modes, partner capabilities, and application scenarios to create value for the industry — to continuously capitalize on ecological potential.

Huawei adopts an open and cooperative attitude, and enables partners through this digital cube to promote the digital transformation of transportation. ▲



The digital cube of comprehensive transportation

# Reducing Delays and Specializing Services: How Digital Transformation Empowers Airports

By *Xiao Tingli, Global Transportation Business Dept. of Huawei Enterprise Business Group*

**H**aving greatly improved punctuality and enhanced safety in recent years, Shenzhen Airport has become a benchmark for industrial digital transformation. The airport's management is striving to consolidate the foundation that supports its digital transformation by accumulating digital platform assets and attracting partners to join the ecosystem. This helps the airport reduce flight delays, ensure flight punctuality, provide better services, and enable smoother, easier travel.

Over the past two years, Shenzhen Airport has had significantly fewer delays, leading to improved punctuality. In 2019, the on-time release rate exceeded 87%, and this indicator remained stable at over 80% for 15 consecutive months for the first time in the airport's history. Through an intelligent, comprehensive operations control system — including the Airport Collaborative Decision Making System (A-CDM) and Intelligent Operation Center (IOC) — Shenzhen Airport has implemented airport-wide situational awareness, stand arrival prediction, emergency warnings, collaborative operations, and intelligent decision-making, with shortened aircraft turnaround times. As Shenzhen Airport's digital transformation soars, flying higher than any other national civil aviation airport, all these developments have only been made possible through the adoption of digital airport methods and advanced technologies.

Rewind to November 5, 2019, when the National Civil Aviation Conference outlined the four critical periods

that the civil aviation industry would go through: peak planning and construction; high operational safety; the critical transformation period; and, finally, the world-leading period. During these times, the construction of '4-in-1 airports' — airports that are safe, green, smart, and passenger-oriented speeds up high-quality industry development.

Going further, the Outline of Action for the Construction of 4-in-1 Airports (2020-2035) states that smart airports must feature Internet of Things (IoT)-based production elements, data sharing, efficient collaboration, and intelligent operations — all of which can be built through smart methods.

Then on January 6, 2020, the Civil Aviation Administration of China (CAAC) held a work conference, concluding that the civil aviation industry should pursue development and innovation and apply technologies — such big data, AI, and blockchain — to improve its governance capabilities.

Clearly, digitalization is critical for airports to improve



*Airport managers must be determined to continue making breakthroughs and promote digital transformation. Instead of exploring what successful digital transformation is, managers should focus on determining the objectives they want to achieve and then work toward them, proactively solving any problems that may jeopardize the success of said objectives.*  
— Xiao Tingli, Global Transportation Business Dept. of Huawei's Enterprise Business Group



competitiveness. And digital transformation is therefore at the very top of the agenda for airports. However, while pursuing digital transformation, airports must address multiple issues.

### **China Needs New Technology to Cope with Increased Passenger Volume**

The total air transport turnover volume in the Chinese Mainland ranks fifth globally, following the US, Germany, the UK, and Japan, according to statistics from the International Civil Aviation Organization (ICAO). This ranking improves to number two when the turnover volume of Hong Kong (China), Macao (China), and Taiwan (China) is taken into account. Increasing volume inevitably leads to serious challenges for the civil aviation industry in China, in terms of safety, operations, and services.

**The safety situation is becoming more and more complicated.** Quite simply, safety risks increase as business volumes do. Airport safety is ensured through inspection.

Although video surveillance systems are widely deployed at airports, airport staff still need to manually identify exceptions by watching many videos.

**A lack of collaboration between isolated industry organizations leads to low efficiency.** The separate mechanisms of airlines and airports build strong barriers between different organizations, hindering the industry's overall Information and Communications Technology (ICT)-based development. For example, increasingly complex flight support requires efficient collaboration between Air Traffic Control (ATC) authorities, airlines, airports, and other support units. However, these organizations are often unable to find each other's support processes because the data is scattered. The result is an inability to completely deal with flight punctuality issues.

**The public is looking for better services and an improved experience.** Just as the Internet has habituated us to hyper-customized experiences, passengers now also expect a wider range of services attuned to their precise



*China is transitioning from a large civil aviation country to a strong one. Faced with significant changes, the civil aviation industry will use technologies — particularly those that capitalize on data — to cope with safety, efficiency, and service issues. >>*

needs. Yet, at most airports, passengers still have to queue in long lines, go through complex security checks, and sometimes even have to rush to their gate to board the plane as a result. And since time inside airports is often scarce, passengers don't always make the best decisions. As such, it's challenging for airports to exceed passenger expectations.

China is transitioning from a large civil aviation country to a strong one. Faced with significant changes, the civil aviation industry will use technologies — particularly those that capitalize on data — to cope with safety, efficiency, and service issues.

### **Transforming Digitally with Customized Solutions**

Digital transformation varies for different airports, depending on their own development phases and requirements. Solution providers should appreciate that the digital infrastructure construction of airports varies and offer customized solutions to meet these differing needs.

In China, airports can typically be classified into four types, each confronted with different digital transformation challenges.

**Type 1: Ultra-large airports (90 million passengers or more), large airports (60–90 million passengers), and medium airports (30–50 million passengers).** As aviation hubs, such airports need to tackle multiple problems during operations, such as limited resources, many safety requirements, and collaboration difficulties. However, they can streamline data, converge businesses, and increase efficiency through digital transformation, at

the same time demonstrating the value of the airport as an overall operations coordination platform. Although hub airports have similar requirements, their processes for promoting digital transformation are vastly different, because their status of digital infrastructure construction is different.

Shenzhen Airport, for instance, went back to the drawing board and conceived its digital blueprint from scratch. Despite weak legacy ICT infrastructure and outdated technologies, it planned to streamline business processes and implement its digital platform architecture by upgrading and reconstructing existing infrastructure. The airport integrates various technologies, ensuring a complete digital platform architecture can be implemented.

Indeed, after years of ICT development, many airports in Tier 1 cities have built digital infrastructure that's more robust than Shenzhen Airport's, and they have also established capable teams for Information Technology (IT) management, development, and Operations and Maintenance (O&M). With solid operating performance and sufficient funds, the decision-makers for these airports tend to stay in their comfort zone and pursue digital transformation through incremental improvements, rather than via total reconstruction or breakthroughs.

**Type 2: Small airports (10–20 million passengers).** Generally, this type of airport has a low-level of informatization, IT teams that are relatively weak, and limited funds. Executives at these airports often focus on motivating their teams, improving morale, and

making their airports leaders at their level.

**Type 3: Newly-built, reconstructed, and expanded airports.** Most of these airports focus on reconstruction and expansion. They want to adopt the very latest technologies during the construction of major projects. These airports require a clear blueprint and abundant funds to facilitate digital transformation.

Once these kinds of airports have successfully endured the long, early planning stage — overcoming complex engineering procedures and difficulties in terms of streamlining businesses — it's fairly easy for them to implement a digital transformation platform architecture. Overall planning and design is required during the initial stage, to ensure that all kinds of smart scenario-specific solutions and data services are available during Low-Level Design (LLD) and bidding stages.

**Type 4: Airport groups.** The management and control needs of airport groups can be a catalyst for group-wide digital transformation. For example, the Capital Airport Holding Company (CAH) has built a group-level cloud platform for smart airport clusters. It has also published data standards and shared data and application specifications, related to production and operation services, with its trunk airports, asking them to solve data-sharing issues at feeder airports.

Airport groups also need to foster such collaboration between trunk airports and feeder airports, because of a lack of ATC, security check, and IT talent. Such a shortage is especially apparent at feeder and general aviation airports, which need to be remotely

enabled by trunk airports.

### Enabling Airport Digital Transportation

Airport managers must be determined to continue making breakthroughs and promote digital transformation. Instead of exploring what successful digital transformation is, managers should focus on determining the objectives they want to achieve and then work toward them, proactively solving any problems that may jeopardize the success of those objectives. The digital transformation journey that enterprises embark on as they work toward these aims is arduous, and it requires both great patience and significant investment.

Airport managers should bear in mind that informatization isn't the fundamental goal of digital transformation. Instead, an airport should apply digital methods to improve its capabilities to gain insight into passengers' needs and, ultimately, better serve them. To achieve that, informatization transformation technologies must be directly linked to airport business scenarios. Solutions can only be applied to business scenarios through full cooperation between airports and technical vendors.

### From Indicator System to Business Processes

Although airport digital transformation paths vary depending on an airport's type, they all share a similar overall major process — including indicator system determination, business process streamlining, data collection, standards finalization, and platform setup.



*As a benchmark for industrial digital transformation, Shenzhen Airport needs to consolidate its foundation, by accumulating digital platform assets and attracting partners to join the industry ecosystem. >>*

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The business indicator system must be determined based on customer benefits. Airlines are the most important customers that airports serve directly, so airports need to build a complete digital architecture that spans across the boundaries of authorities and organizations, to create benefits for airlines. Airlines want to improve their competitiveness while reducing their operational costs. Competitiveness is boosted through improved flight punctuality, better assurance for flight safety, more efficient services, more benefits for members, and more passenger-friendly and convenient travel experiences. Operational costs are reduced through efficient usage of

support resources, reduced taxiing time, and shortest-possible waiting time on runways. This indicator system also evaluates the capabilities of airports to serve airlines.

Business processes related to aircraft, passengers, baggage, and commercial services are streamlined according to these indicators, involving various departments — such as ATC authorities, airports, ground service companies, airport-stationed organizations, and merchants. Each of these elements functions as a single node in a flight support or passenger service process. As such, the entire process should be streamlined and coordinated to benefit airlines. Data has a key



role in fulfilling these indicators, as well as streamlining and guiding business processes. This means it is critical to ensure that the data collected for key elements during each process is integrated and accurate. Data can be abstracted from existing systems via connection, collected manually or using technical methods, and calculated based on fixed rules. Naturally, more complete, accurate, and real-time data ensures more precise indicator calculation.

Data can only be streamlined after relevant standards are finalized. Business data is only available after business and data models are established.

A digital platform can be built with indicators, processes, and data. Its basic architecture consists of the device and infrastructure layer for data collection and transmission, as well as the platform layer for data convergence, cleansing, governance, and business convergence. The platform layer — also known as the capability layer — includes big data, video analysis, Artificial Intelligence (AI), Integrated Communications Platform (ICP), Geographic Information System (GIS), and integration enablement.

Assets and capabilities that are accumulated on the platform foster the development of applications that are used to process business logic, as well as display data and businesses. A solid platform enables applications to satisfy customer requirements, with minimal costs and maximum efficiency. Applications running on the platform include the existing informatization achievements of process-related units, as well as new applications that are constantly being created with the expansion of transformation and business

scenarios. Rather than disrupting existing achievements, digital transformation maximizes the value of existing investments and ensures future investments will have even greater value.

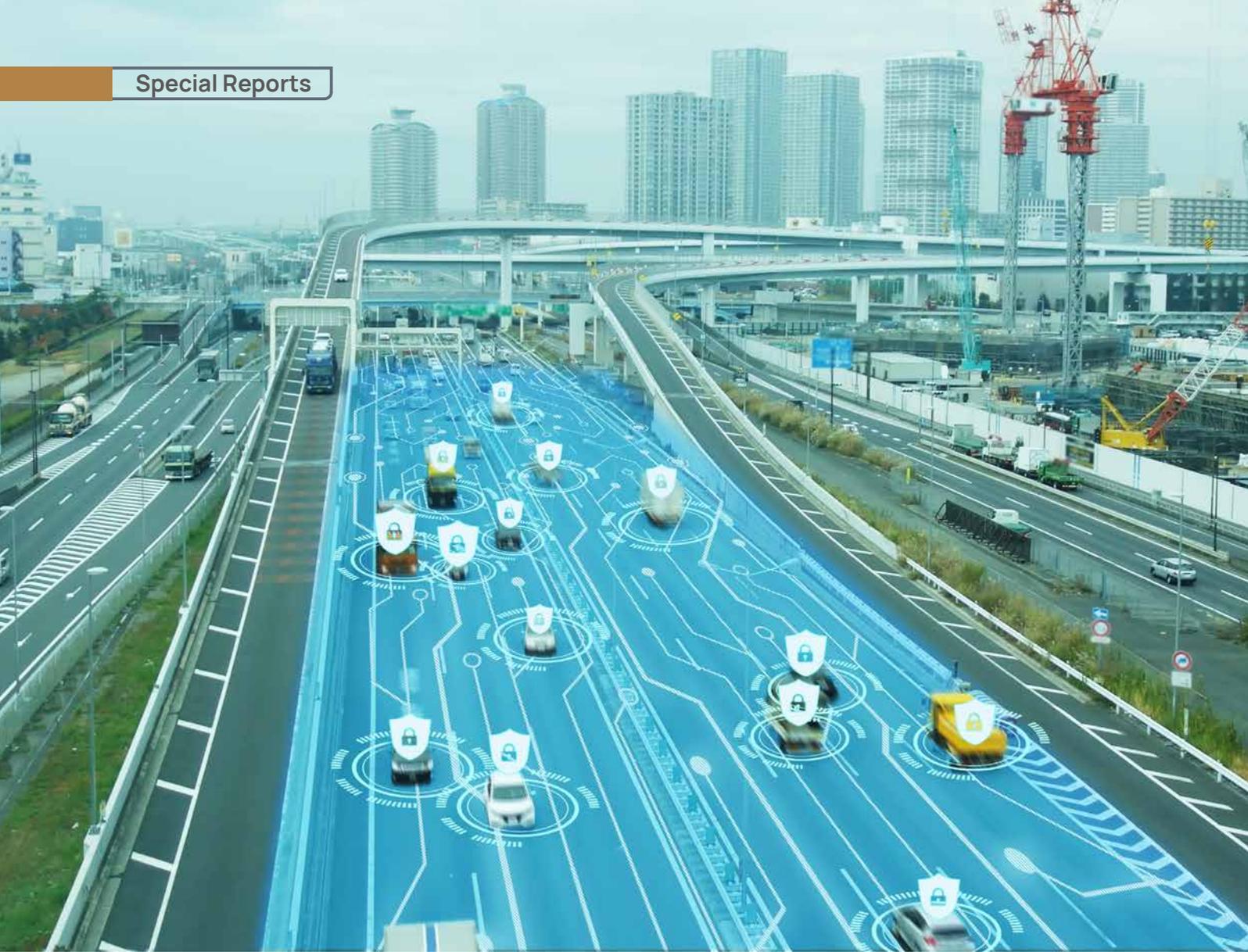
Inevitably, digital transformation will remove barriers between organizations, reconstructing the value chain — so organizations and processes need to be restructured accordingly. Digital transformation aims to break operational data silos, streamline data and business processes, reshape the business chain, and ultimately improve customer benefits. The establishment of a digital platform architecture signals the formulation of standards and a framework for future ICT-based construction, with future-oriented business developments bringing new requirements. The digital platform architecture can maximize the value of digital assets on application platforms and minimize future investment, facilitating easier and more convenient application system construction. Meanwhile, data assets generated during the development of new applications will be accumulated on the platform, improving the platform's competencies. Digital transformation achievements will also be continuously consolidated in the future.

As a benchmark for industrial digital transformation, Shenzhen Airport needs to consolidate its foundation, by accumulating digital platform assets and attracting partners to join the industry ecosystem, creating greater value for the industry overall. A powerful digital platform should support the digital transformation of China's civil aviation industry, helping airports reduce flight delays, ensure flight punctuality, provide more refined services, and enable smoother mobility.▲



*As a benchmark for industrial digital transformation, Shenzhen Airport needs to consolidate its foundation, by accumulating digital platform assets and attracting partners to join the industry ecosystem, creating greater value for the industry overall. >>*

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# Streamlining Data and Services to Empower Digital Transformation

*By Pan Peigen, Executive Solution Architect of Global Transportation Business Unit of Huawei's Enterprise Business Group*

**E**nterprises in the transportation industry pursue digital transformation so that they can more effectively manage and control their service flows. With this in mind, the priority in helping transportation enterprises to thrive by digitally transforming becomes clear: We have to enable them to streamline their connected data and services.

The aim for enterprises in the transportation industry is to optimize service flows to enhance safety, increase efficiency, and improve the services they provide. This is their primary concern and is central to their digital transformation.

## **Streamlining Two Focuses**

To successfully digitally transform, digital upgrade is necessary. It helps build a data exchange platform to centrally

collect and store data that is scattered across data silos and is isolated.

Full connectivity and refined management and control of service flows can't be achieved with numerous data silos. While eliminating them doesn't guarantee success, it's the first and most fundamental step according to many failure cases.

To meet transportation enterprises' service needs for digital transformation, we need to address two issues: connecting data and connecting services.

- **Connecting data**

Digital upgrade must be driven by the value of data. To ensure that happens, there are several questions to consider: How can data value be maximized? Does data connection mean to collect scattered data from various service systems and centrally store it? How can we implement data governance? Should we name data in a unified way or convert it into a unified format?

- **Connecting services**

To an extent, digital upgrade is a process of redefining service processes without changing departments' functions and responsibilities. For example, digital upgrade could involve determining how airports can manage and coordinate all processes based on service flows.

Only by streamlining the two focuses can we truly empower enterprises to successfully digitally transform. First and foremost, a new data-driven service mode needs to be built — to fully connect data and services, capitalizing on the value of data flows.

### **IOC: Service Processes**

Digital transformation typically involves

the creation of an Intelligent Operation Center (IOC), which aims to enable global dynamic visualization against complex service flows and implement situational awareness, service collaboration, and assisted decision-making.

For example, flight operation support — the most critical airport services process — includes taxiing guidance, stand allocation, and ground handling for inbound flights as well as the waiting, taxiing, and takeoff processes for outbound flights, and it involves multiple units, business departments, and work procedures (personnel, tools, steps, and so on).

This process must ensure safe and efficient arrivals, ground services, and departures, and it must meet airlines' needs for transporting passengers and carrying cargos. Accordingly, an airport usually develops multiple information systems — such as a ground handling system, a Flight Information Display System (FIDS), a Departure Control System (DCS), and an integration system — to support its services. The Airport Operation Center (AOC) needs to handle multiple systems and terminals: It organizes airport staff to analyze and compare various information sources and deliver dispatch and command instructions through handheld terminals.

When using multiple service systems for a single process, a lack of End-to-End (E2E) management and control of service flows makes it difficult to enable collaboration and scheduling within seconds in complex scenarios. This is why customers require digital upgrade.

Scenario-based solutions for data-driven



**Key to digital transformation:**  
streamlining data and service scenarios

***By digitalizing scheduling rules, Huawei's intelligent stand allocation system uses Artificial Intelligence (AI) algorithms to automatically schedule stands based on real-time data awareness. As well as reducing manual operations, it also enables dynamic stand allocation and scheduling within seconds based on real-time surface status.***

services, instead of data exchange and integration, are needed. The IOC connects services through two-layer modeling — service modeling and data modeling.

Service modeling aims to achieve the objectives and address challenges of management and control of service flows, monitor all operations along the service chain to better implement more effective collaboration and scheduling across various tasks, departments, and units — ensuring safer and more efficient flight operations. Service modeling raises new requirements, such as situational awareness, surface monitoring, coordinated scheduling, and decision-making support.

The IOC constructs service flow models based on a service overview. It needs to answer the following questions: What are the users, scenarios, requirements, and problems? What information should be obtained? What commands need to be delivered?

Take the air route view, designed for resource scheduling agents, as an example. It sorts and tracks inbound flights and focuses on the agents' biggest priority — airport resource allocation.

It then addresses questions such as: Can the system dynamically calculate a more accurate Estimated Time of Arrival (ETA) based on flying and approaching status? Can the system predict the stand arrival time based on surface operations? Can the system predict potential stand conflicts based on the aircraft stand arrival time and rules of stand usage by preceding and following flights? Can the system automatically devise a more reasonable stand adjustment plan in the event of stand conflict risks? Once the plan is determined, can the system adjust the stands in one click and

synchronize the adjustment to all operation systems according to service rules?

The real-time terminal passing status, support process of preceding flights, and stand capacity are displayed on the air route view, to provide comprehensive airport running status for dispatchers — facilitating collaboration and scheduling.

Based on service modeling, an E2E mode is established — helping airports implement sensing, management and control, collaboration, and decision-making support of the entire service chain by pre-event forecast, in-event collaboration, and post-event analysis.

Undoubtedly, data plays a critical role in E2E management and control of service flows, so data modeling is crucial. Data modeling doesn't mean to exchange or integrate operation data of multiple service systems, or reconstruct the original system functions. Instead, it focuses on bridging data and process breakpoints and uses model algorithms and indicator systems to better manage and control the digitalization of processes and rules.

By digitalizing scheduling rules, Huawei's intelligent stand allocation system uses Artificial Intelligence (AI) algorithms to automatically schedule stands based on real-time data awareness. As well as reducing manual operations, it also enables dynamic stand allocation and scheduling within seconds based on real-time surface status (including conflicts and ETA). Similarly, the Variable Taxiing Time (VTT) algorithm can predict the entire process, from an aircraft landing on the runway to moving into a designated stand. This allows the apron and ground service departments and others to perform scheduling and collaboration within seconds.

Meanwhile, Huawei's measurement indicators and indicator



*With digital transformation's influence expanding, the IOC must be continuously upgraded and iterated. It should function as both an integrated front-end platform to meet users' needs and an extensive service platform. >>*

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systems for service flow digitalization help the AOC implement in-depth management and control from operations indicators, to service indicators, and ultimately to dynamic service status.

Based on service and data modeling, the IOC serves as an integrated and collaborative service platform that fully connects all services. And the IOC platform fully supports data collection, tracking, analysis, and reports in just two weeks.

With digital transformation's influence expanding, the IOC must be continuously upgraded and iterated. It should function as both an integrated front-end platform to meet users' needs and an extensive service platform to implement functions such as forecasting, sensing, collaboration, and decision-making support. It's worth noting that building this kind of service platform doesn't mean there's any need to reconstruct existing production operation systems.

### **Data: Industry Data Models**

Fully-connected data from service flows is a prerequisite for digital upgrade to implement collaboration and scheduling across tasks, departments, and units. To meet service digital transformation requirements, data can be fully connected by using industry data models to build a data asset platform rather than a simple data exchange, or data aggregation and report display, as a conventional data warehouse does.

When the concept of big data was proposed many years ago, it attracted huge investment from many enterprises. Those companies, including Huawei, have since conducted

many practices and tried to transform their service modes to make them data-driven. All enterprises that are successfully transforming have converted data into assets that support transformation and help to generate value for enterprises by aligning with business scenarios and meeting business needs in terms of data governance, modeling, and services, as well as accumulating industry insight. In these cases, a trustworthy, available, and manageable asset platform is set up.

Huawei has developed a methodology called the "V model," which covers the process of streamlining service, data, to application flows: Sort out service capabilities by domain (sub-domain). Then, streamline scenarios, workflows, and activities. Next, work out service objects. Finally, review data entities to form conceptual models.

The key to implementing the V model into data asset construction is to build industry data models.

Building industry data models requires E2E governance of raw data, focusing on trustworthiness, availability, and manageability. "Trustworthiness" means that data quality must be reliable, and this is the top priority. It requires that data standards are defined in a traditional way; data is converted into assets, and business and quality standards are developed based on the business process. "Availability" refers to data service requirements proposed by businesses — a prerequisite for turning data into assets. Meanwhile, "manageability" includes data security, Operations and Maintenance (O&M), as well as operations that can support future flexible services.

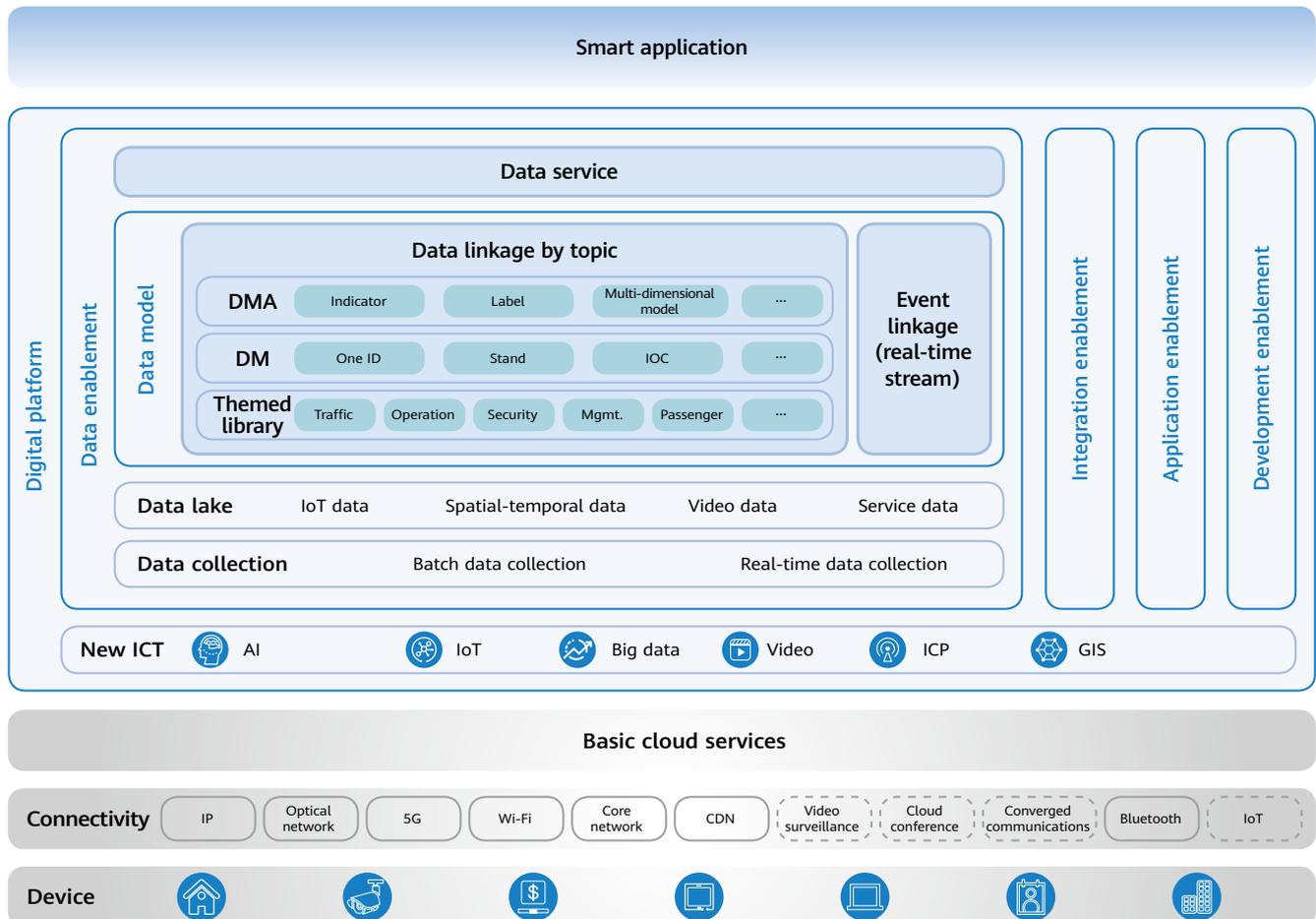
The Third Normal Form (3NF) method

is adopted for layered data modeling by following industry rules. Data entities are determined and their attributes are defined during the process of streamlining service flows, data flows, and data entities, forming a Conceptual Data Model (CDM). On this basis, the Logical Data Model (LDM) can be further refined based on industry standards. The 3NF, or dimensional modeling method, is used to adjust and optimize relationships between data entities — ensuring no data is missing as

well as balancing redundancy and flexibility.

This modeling mode is employed in all service domains to ensure the value of data processing. Data governance, data quality, and operating flow during data processing all depend on data modeling, reflecting data mapping service process.

Service indicator systems and algorithm models are built based on the industry's standard themed library, to quickly meet data needs during the digital transformation of



An overview of the industry data model

service processes.

Key to this is developing operations and service indicator systems to help management and business departments digitally control service processes.

Take the production and operation indicator system as an example. It defines inputs and outputs for each service activity based on the service flow, and determines measurement indicators and impact factors for service activities based on the objective of the service flow (on-time performance of flight support). Based on this, the AOC can be aware of the pressure on each support process in advance and understand the impact of the support progress on flight departure punctuality, so that it can determine whether to get involved early in the process, or coordinate with other departments, to ensure the flight departs on time.

Another priority is to focus on process and data breakpoints, to build an algorithm model warehouse and promote refined management and control of service flows. For example, intelligent stand allocation digitalizes allocation rules to enable dynamic stand allocation in minutes, greatly improving the stand turnover rate and rate of passengers using boarding gates. Aiming to enable more accurate prediction of ground taxiing time, the solution adopts the VTT algorithm to develop algorithm models based on complicated surface operations — helping the AOC implement management, control, and collaboration of apron surfaces within seconds.

At the data service layer, the data asset platform serves as an integrated platform for O&M, management, control, and operations.

It enables business departments to become the owners of data asset management and service value application, truly integrating data and services.

Huawei typically sorts out service and data flows with its V model to build industry data models, implementing trustworthy, available, and manageable data governance. Aiming to manage and control service flows, Huawei develops a production and operation indicator system and an algorithm model warehouse, to empower digital transformation.

While digital transformation driven by vision brings opportunities, it also creates challenges. In the transportation industry, digital transformation means more than Information and Communications Technology (ICT) construction; it also requires digitally upgrading to data-driven service flows.

Technically, a platform-based architecture must be adopted to realize data-driven service flows, which can't be supported by a single application or functional system. In this way, digital transformation differs greatly from the previous ICT construction modes.

Digital transformation poses various challenges — in terms of technology, products, personnel, organization, and process — to Huawei, its enterprise customers, and the entire ecosystem, as it changes and optimizes conventional modes.

To address these challenges, we should focus on customer requirements for digital upgrade, for example, how data drives the management and control of service flows.

Ultimately, we can only replicate data models on a large scale — as we need to — when we build industry insight capabilities and data ecosystems. ▲



*While digital transformation driven by vision brings opportunities, it also creates challenges. In the transportation industry, digital transformation means more than ICT construction; it also requires digitally upgrading to data-driven service flows.*

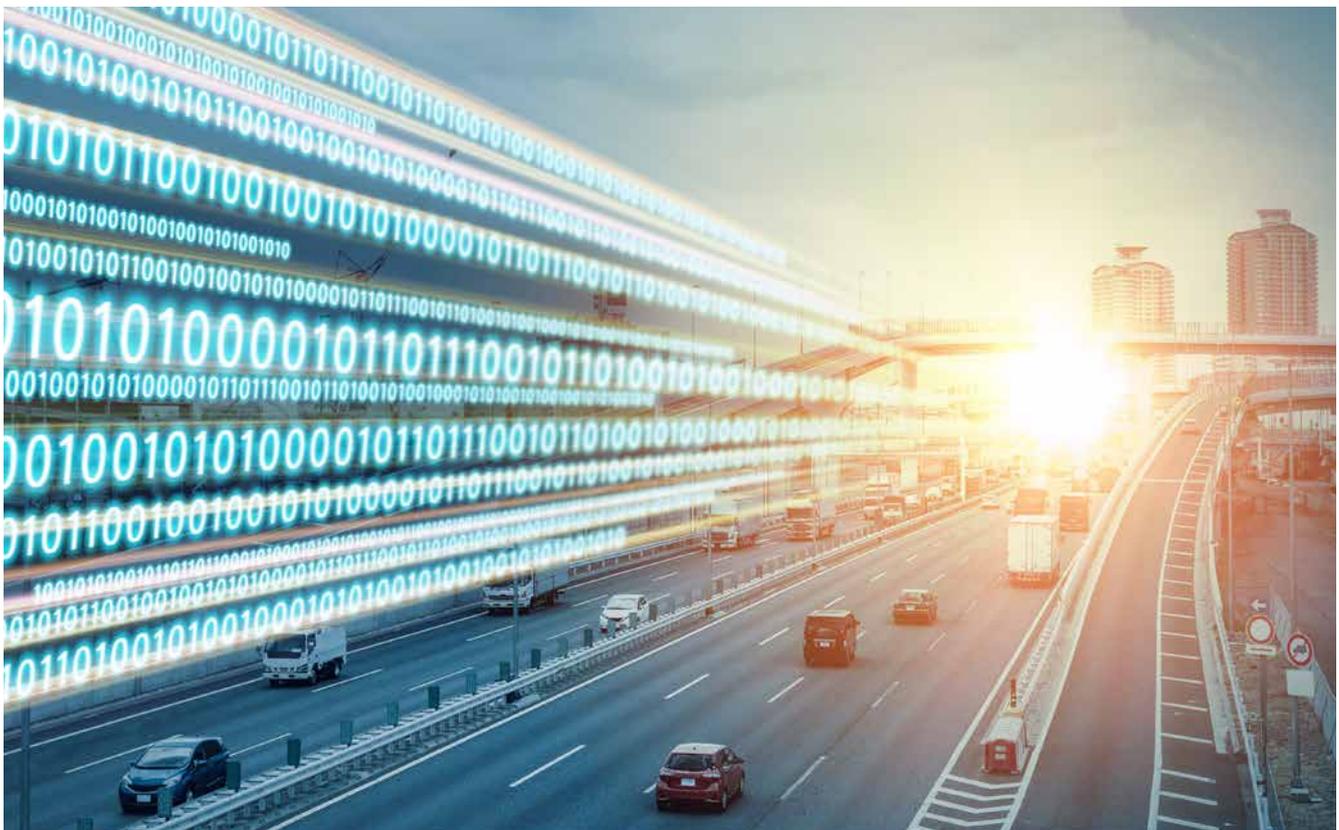
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# How Comprehensive Transportation Will Evolve in the Digital Era

*By Zhao Yibin, Chief Architect of Integrated Transportation Solutions, Global Transportation Business Unit of Huawei's Enterprise Business Group*

**H**ow will transportation systems evolve in the future? New technologies such as 5G, AI, IoT, and big data make it possible for smart transportation enterprises to continuously expand the number of services they can provide.



*The Outline aims to establish 1-2-3 Transport Rings — in which commutes within a city take one hour, travel between city clusters is possible in two hours, and trips between the country's major cities can be made in three hours.*

At the end of its 13th Five-Year Plan in 2020, China's urbanization level had reached about 45%. With the growth of megalopolises such as the Yangtze River Delta, Greater Bay Area, and Beijing-Tianjin-Hebei economic zone, China's urbanization level is expected to be between 50% and 60% in 2025. Urban areas such as these accommodate numerous industries and vast populations, which means more active social and economic activities. In turn, different regions and cities will be more closely linked, and the number of vehicles will continue to rise, leading to severe challenges for the entire transportation system. In short, transportation planning modes that rely on deploying more infrastructure and conducting system-specific design based on the total capacity requirement will no longer meet the surging needs for transportation.

In these circumstances, China's Ministry of Transport issued the Outline for Building National Strength in Transportation. Unlike previous transportation plans — in the 12th and 13th Five-Year Plans — the Outline doesn't focus on the development objectives of a single transportation mode or a certain transportation element. Instead, it aims to establish 1-2-3 Transport Rings — in which commutes within a city take one hour, travel between city clusters is possible in two hours, and trips between the country's major cities can be made in three hours. It also intends to create 1-2-3 Logistics Circles. In these circles, delivery of goods within the country will take one day, delivery of goods to neighboring countries can be completed in two days, and delivery to major cities will be possible in three days. The ultimate goal is to build a comprehensive and systematic transportation system with advanced expressways, a complete backbone road network, and a nationwide basic road network.

### Building a Comprehensive Transport System to Support Urbanization

A traditional urban planning system typically focuses on dividing lands into different functional areas, with transportation positioned as 'auxiliary facilities' that connect different functional areas of a city. When decision makers noticed the association between land use, the relationship between work sites and residential buildings, and transportation, they introduced a systematic engineering concept and created the four-phase model, describing and predicting the association quantitatively for the first time, which made transportation planning more systematic and engineering-oriented and significantly boosted industry development during the early stages of urbanization.

This model, however, is system-specific, which means studies on various transportation elements — such as public buses and railways, road facilities and road vehicles, and dynamic transportation and static transportation — are conducted separately. As a result, this model fails to take into account the association between sub-systems and different elements.

Meanwhile, Europe, North America, and Japan have a longer history of urbanization and correspondingly higher urbanization rates (over 75% in the Greater Tokyo Area, Greater London, and Singapore). To meet the extensive and intensive transport requirements of increasing urbanization, these cities and districts have developed comprehensive transportation systems in their own ways. In Tokyo, different metro line operators break the boundaries between cities through cross-line operation. Its Transit-Oriented

*As we review the scope of smart transportation and the services involved, new technologies such as AI and big data bring unlimited possibilities.*

Development (TOD) model is used for hub-based land use and transportation planning. Meanwhile, London uses the Electronic Road Pricing (ERP) system to coordinate the use of road infrastructures and modes of transportation. In Singapore, the urban rail transit is integrated with regular ground transport for unified road network planning and rail transit shuttle planning.

These measures have improved the entire transportation systems' capacity, optimized passenger experience, and elevated urban development.

### Developing Comprehensive Transportation with New Technologies

Because their technologies aren't particularly mature, traditional smart transportation practitioners tend to set boundaries for themselves in terms of the services that they offer, so they don't prioritize matters such as infrastructure — roads, bridges, tunnels, and so on — operations of transportation enterprises, and passenger services. This has hindered the development of digital and intelligent transportation and led to a restricted knowledge of the solutions available in this field.

As we review the scope of smart transportation and the services involved, new technologies such as AI and big data bring unlimited possibilities.

#### • Edge Computing and AI

The route planning for buses and subways is highly dependent on the spatial-temporal features — Origin-Destination matrix, or OD matrix — of current and future travel. Take the passenger flow analysis of the traditional

public transportation system for example. In these scenarios, the data is mainly collected through swiping of transport cards. The usual technical path is a model in which data is collected when a passenger swipes his card, and vehicle operation data is uploaded, then traffic survey data is referenced for the model calibration. Because of various factors such as data quality, the difficulties of keeping traffic survey data up to date, and spatial-temporal resolution issues, it's difficult for the OD matrix to accurately reflect the actual status of traffic flows. Consequently, network planning based on such an OD matrix is insufficient.

In recent years, the rapid development of computer vision and Artificial Intelligence (AI) has significantly improved the resolution of cameras and the recognition capability of AI algorithms, and the computing cost has plummeted. This means technologies originally used in high-value service scenarios can now be widely adopted in the public transportation industry. The video AI-based head-shoulder recognition person re-identification technology (which matches people across disjointed camera views in a multi-camera system) on the hardware platform based on a combination of a low-cost vehicle-mounted camera and edge computing can be applied in public transportation for passenger flow recognition and precise passenger flow analysis at a low cost. It provides network planning with an OD matrix that covers all times of day and all passenger flows, which can greatly improve the precision of spatial-temporal matching of transport capacity and passenger flow distribution, and increase computing power without adding vehicles. In this way, the transportation network can accommodate more passengers.



*Different modes of transport, different transportation scenarios, and different service flows are like cold and warm ocean currents, which can bring about great changes when they meet. >>*

## • Big Data and Cloud Computing

Highways, especially expressways, are the lifeline of social and economic operation. For many years, freight transport on highways accounted for more than 70% of China's total freight transport. That proportion has continued to rise in recent years and is now 78%. The trunk highways are all fully loaded, or even overloaded, which is a great challenge to the highway system. To tackle this issue, the usual approach in the industry is to build new roads, or reconstruct or expand existing expressways — expanding four-lane roads into six-lane ones and eight-lane ones, for example. The drawbacks of projects like these are that they're very costly and they require vast areas of land that is typically used as farmland.

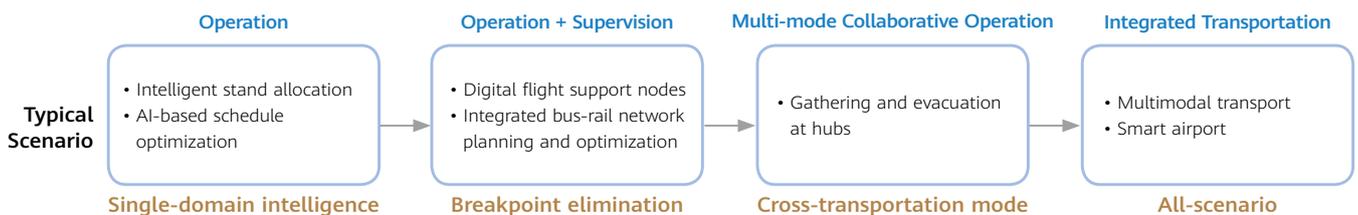
Based on cloud computing and big data, for complex computing tasks — such as holographic perception of a single road section, situational awareness of the road network in an entire area, minute-level short-term prediction, and management and control simulation and deduction in complex scenarios — expressway operation staff can now implement proactive and refined management and control measures, such as ramp control, flow division and merging guidance, section-based rate limiting, and temporary opening of the emergency lane.

In this way, minor traffic accidents won't interrupt traffic flow, soft capacity expansion is achieved without any need for significant physical reconstruction or expansion, and the vehicle passing efficiency can be boosted with only small reconstruction or expansion.

## Convergence: A Highlight of the Digital, Comprehensive Transportation System

Different modes of transport (bus, subway, and private car), different transportation scenarios (urban transportation system and inter-city transportation system), and different service flows (supervision flows of transportation bureaus and operation flows of transportation enterprises) are like cold and warm ocean currents, which can bring about great changes when they meet. The joining points of modes, scenarios, and flows (for example, traffic hubs such as high-speed railway stations and airports, and planning and optimization of the integrated public transportation line network as the joining point of service supervision flow and operation flow of public transportation) are similar to those of cold and warm currents. The digitalization and intelligence of these joining points can really make a difference.

Smart transportation practitioners



An overview of a comprehensive transportation system

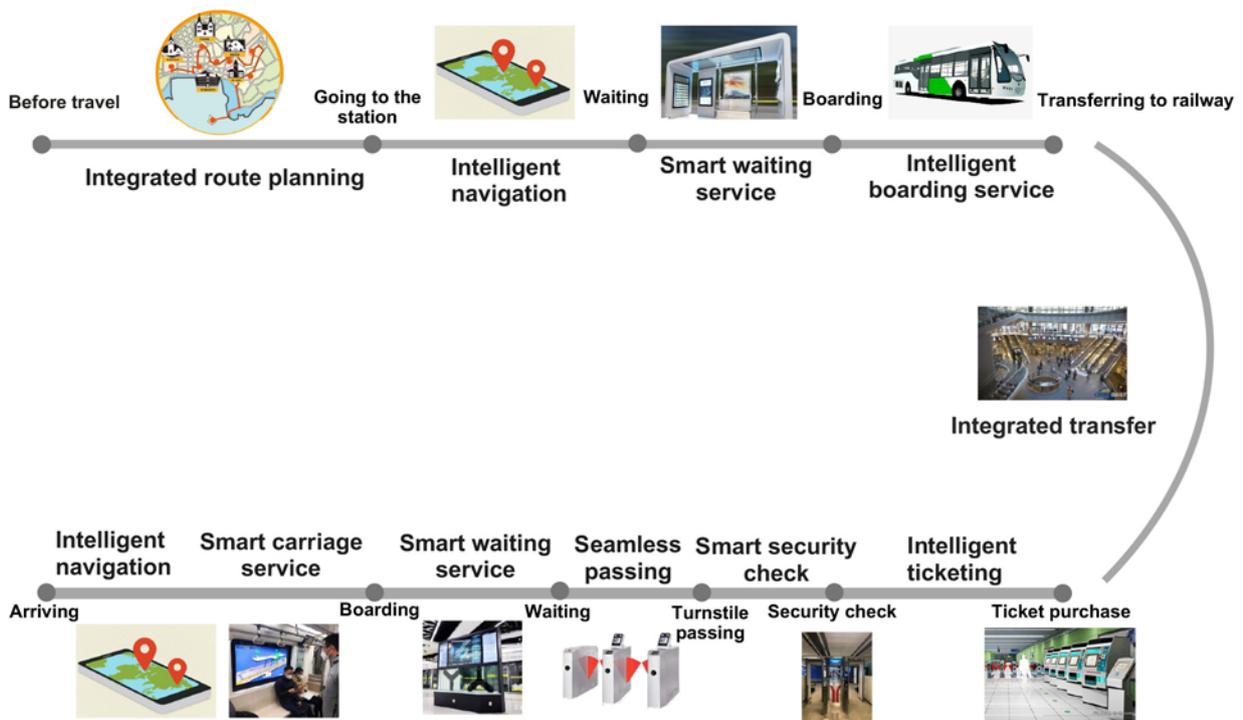
should gradually abandon single-domain digitalization and strive to remove process breakpoints, implement multi-mode collaborative operations, and achieve cross-scenario in-depth development, developing solutions that can maximize business value for customers.

• **Cross-Transportation Modes**

Urban rail transit is the main focus of China's transportation construction in recent years. As the most important public transport mode in cities, urban rail transit bears most of the public transportation traffic. Meanwhile, the development of traditional ground public transportation also faces great challenges. However, because of the split management and lack of technologies, ground public

transportation and urban rail transit are hard to coordinate. In some regions, they are even competing with each other, resulting in the waste of public resources and inefficient operations.

Urban rail transit is designed to provide long-distance travel services across urban functional areas. Shuttle services are required to take passengers to and away from metro stations, and buses can meet this need. Based on the cloud and big data technology, the integrated OD analysis and transportation capacity matching and dispatch as well as AI-based video analysis can apply the respective strengths of buses and subways, build a complete industry chain that covers all passengers, and provide one-



Different transportation modes in urban rail transit

stop, seamless travel services, achieving the goal of increasing transportation capacity with computing power.

• **Cross-Scenario**

Airports, wharfs, and high-speed railway stations are hubs of urban transportation and the windows to display the city image and the operation efficiency of the transportation system. They connect inter-city and intra-city transportation scenarios, transporting most of the passengers of a city. These hubs need to gather the departing passengers from various places in the city efficiently and conveniently. They also need to provide safe, convenient, and swift access for arriving passengers to enter the urban transportation system (bus, rail, and taxi), so transportation hubs must be able to accurately predict passenger flows, and predict and dispatch the transportation capacity between multiple transportation modes.

The process includes streamlining arrival hall security check (Stage 2) and shuttle station entry (Stage 3) for quick passing through hubs; connecting getting on or off the vehicle (Stage 1) and urban rail, bus, or taxi (Stage 5) for accurate passenger flow forecasting and transportation capacity matching; linking Stage 1 and hub entrance and exit (Stage 6) for emergency response in case of huge traffic volumes.

These core capabilities need to be designed and developed based on digitalization of single domains and comprehensive AI and big data to accurately match the transportation

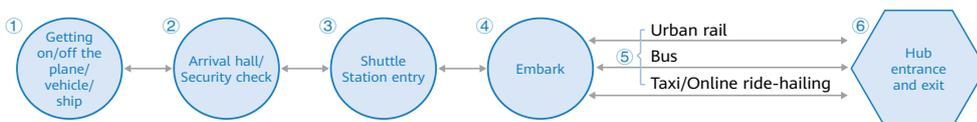
	AI/Big Data Requirements	Basic Digital Technology Requirements
1	One ID transfer	Video cloud and machine vision
2	Precise passenger flow prediction algorithm and capacity matching algorithm	Big data modeling
3	Scenario-based large passenger flow emergency response solution and passenger flow simulation	Video cloud, camera, and big data
4	Precise positioning in complex environments (reusing the architecture of the airport solution and the high-speed vehicle-road synergy solution)	Vehicle-road synergy

Technical requirements of urban transportation hubs

capacity with the passenger flow and quickly, securely, and conveniently gather and divert passengers in the hub.

The continuous improvement of digital and information-based technologies in the transportation domain boosts the efficiency and security of the transportation system, reduces the carbon emission of the entire transportation system, and enhances the transportation experience for passengers.

New technologies such as 5G, AI, IoT, and big data enable smart transportation practitioners to consider how to implement the digitalization and informatization of transportation infrastructure from a deeper and more integrated perspective. This way, they can continuously expand smart transportation's service boundaries and gradually shift from infrastructure digitalization to service process digitalization. Ultimately, this will enable them to plan and design innovative and smart comprehensive transportation solutions that span across different facilities, transportation modes, scenarios, and service processes. ▲



Process of urban transportation hubs



# Shenzhen Airport Adds Intelligence to Stand Allocation

By *Huang Qiang, Solution Engineer of Global Transportation Business Dept. of Huawei's Enterprise Business Group*

As they handle massive passenger flow every single day, airports must effectively and efficiently manage their airport stands — the areas where planes park before departure. At Shenzhen Airport, which has an annual passenger flow exceeding 50 million, this is clearly a priority. To address this issue, it has deployed Huawei's Intelligent Stand Allocation Solution, which applies big data and Artificial Intelligence (AI) to help the airport maximize its stand usage. The solution increases the usage of contact stands — areas where passenger boarding bridges can be used — by 5% to 10%, reducing airside transfer bus passenger flow by 2.6 million every year. By deploying Huawei's intelligent stand allocation system, Shenzhen Airport has become a pioneer in exploring and innovating Information Communications Technology (ICT) for the civil aviation industry.

The Airport Operation Center (AOC) prioritizes stand allocation, because the allocation directly impacts airport operations — including flight takeoff and landing, airfield safety, and passenger services — as well as determines the proper allocation of airport resources, such as boarding gates, airside transfer buses, and baggage carousels. The AOC must quickly adjust stand allocation plans when exceptions — such as flight delays, cancellations, or returns — occur.

## Conventional Methods Couldn't Support Business Development

The entire airport stand allocation process includes information collection, allocation based on static restrictions and priority rules, overall adjustment of constraints, and solution generation and fine-tuning. Currently, stands are manually allocated in the Operation Resource Management

*The intelligent stand allocation system assists commanders in intelligent pre-allocation and real-time allocation of stands, and builds a solid foundation for intelligent distribution of check-in counters, boarding gates, and baggage carousels, further improving the airport operational efficiency and passenger experiences.*

System (ORMS), requiring airport staff to obtain flight plans, confirm the flights to be allocated by aircraft no., query air route directions and aircraft models, and analyze passenger information.

Airports in China typically assign operational commanders for stand allocation on the Gantt chart — such as stand allocation modules in the ORMS and Airport Collaborative Decision Making System (A-CDM) — depending on airport constraints. This manual allocation mode is inefficient and involves multiple allocation rules, as well as the need to address various unplanned issues. More importantly, it leads to a higher risk of conflicts during aircraft taxiing, stand arrival, and pushback.

With busy operations and limited stand resources, Shenzhen Airport's conventional stand allocation mode needed to cope with the following challenges:

- **Inefficient allocation**

Shenzhen Airport has a total of 225 stands, of which 62 are contact stands. Using conventional methods, commanders needed to memorize numerous basic rules — such as flight plans, aircraft models, flight types, air route types, as well as priority rules — because of different stand features. This time-consuming method relied heavily on expert experience, and was completely inefficient.

To address these pain points, Shenzhen Airport assigned dedicated resource-allocation agents to dynamically allocate and adjust stands around the clock, and allocated extra staff resources to handle overnight parking flights for three to four hours per day. Although real-time data was available, it was still difficult to evaluate the stand allocation effects. Manual allocation couldn't meet urgent, unexpected allocation

requirements in the event of exceptions, such as failure to take off or land because of bad weather, flight delays, and diversions.

- **Difficult optimization of core indicators**

Aircraft docking rate, the ratio between stands allocated to different airlines, passengers' walking distance, conflicts between stand arrival and pushback, and task type all affect the optimization of stand allocation. The conventional allocation mode couldn't implement a global optimized allocation solution to improve a specific indicator (such as aircraft docking rate or conflict rate in different weather conditions) according to various scenarios.

- **Low level of intelligence**

Shenzhen Airport needed more effective and prompt process-based flight information transfer because the surrounding information — regarding airfield planning layout, taxiing program design, and terminal business layout — failed to interact with the manual stand allocation system. Complicating matters, data from different sources — including airlines, ground service departments, and Air Traffic Control (ATC) authorities — couldn't be efficiently aggregated and synchronized, hindering the deep mining and comprehensive analysis of the allocation data.

- **Restrictions on global allocation efficiency improvement**

The allocation effects of a single stand or airport-wide stands couldn't be evaluated, nor could they be quantified and reflected using real-time data. Failure to quickly and accurately adapt to changing allocation rules created a bottleneck, making it harder to increase the airport's operational efficiency.

In recent years, the vast amount of passenger traffic has

led to multiple safety, operational, and service challenges to airport operations. In these circumstances, an efficient stand allocation system was urgently needed, to scientifically use and properly allocate key scenario-specific resources of the airport.

The rapid development of intelligent technologies, notably AI, has driven relevant research units and technology companies to delve into algorithms for stand allocation. The intelligent stand allocation system assists commanders in intelligent pre-allocation and real-time allocation of stands, and builds a solid foundation for intelligent distribution of check-in counters, boarding gates, and

baggage carousels, further improving the airport operational efficiency and passenger experiences.

### Using Data and AI to Develop an Intelligent Stand Allocation System

The scenario-specific intelligent stand allocation solution co-developed by Shenzhen Airport and Huawei is a groundbreaking project in the industry — the first application of AI in an airport's core production system. Guided by the 4A enterprise (business, application, data, and technology) architecture, the two parties



scientifically analyzed each of these aspects in detail, and used AI technologies featured on Huawei's digital platform, to implement automatic and intelligent stand allocation, led by IT operations and facilitated by manual operations.

Many optimized scheduling rules and AI algorithms support intelligent stand allocation and dynamic adjustment. By applying these, core indicators — such as the rate of aircraft docking with jet bridges and bridge turnover rate — are improved. Meanwhile, stand or taxiing conflicts are minimized, enabling airport-wide optimal resource allocation and improving ground handling efficiency, as well as passenger satisfaction, all while ensuring safety.

The intelligent stand allocation system builds an AI platform based on Shenzhen Airport's unified big data platform. Various engine systems are constructed on the AI platform for intelligent stand scheduling. A unified, open, and interactive platform is also established at the top layer — realizing intelligent and visualized stand management.

### • Data platform

The big data platform extracts data from peripheral systems and processes it in real time. The platform forms a specialized industry library based on industry experience, and pushes the data to the data module of the upper-layer application system through a standard interface. The integrated data is then used as an AI algorithm input.

### • AI platform

The AI platform provides bottom-layer algorithms for the upper-layer engine system, including various algorithm libraries — such as the common basic algorithm library and

operational planning optimization algorithm library. Appropriate AI algorithms, as well as mathematical programming and metaheuristic algorithms can be applied to meet stand allocation requirements.

### • Algorithm engine

The stand allocation algorithm engine is built based on mathematical optimization and heuristic algorithms. It supports batch allocation and dynamic adjustment, and provides decision-making support — such as intelligent rule engine, intelligent scheduling optimization engine, and simulation engine — for a variety of practical business applications.

As the core of the system, the intelligent rule engine uses operational planning optimization algorithms — such as metaheuristic, heuristic, and accurate solution algorithms — to perform modeling based on over 60 basic stand allocation rules. By factoring in multiple indicators — such as the aircraft docking rate, conflict rate, and passenger experience — the rule engine delivers a set of intelligent stand allocation results to help the airport operate more efficiently.

### Contact Stand Usage Rate Increases by 5%

The industry's first scenario-specific, AI-based intelligent stand allocation solution has reformed and innovated the conventional manual allocation mode; it has also paved a path for the airport industry to digitalize operations. Shenzhen Airport has made the following improvements:

**Intelligent stand allocation that is led by IT operations and facilitated by manual operations.** Compared with manual



*The industry's first scenario-specific, AI-based intelligent stand allocation solution has reformed and innovated the conventional manual allocation mode; it has also paved a path for the airport industry to digitalize operations. >>*



*By deploying Huawei's intelligent stand allocation system, Shenzhen Airport has become a pioneer in innovating and exploring ICT for the civil aviation industry. The airport's management team has gained a deeper understanding and forward-looking perspectives in advancing the industry with technological innovations. >>*

allocation, the intelligent stand allocation system — dealing with more than 1000 flights per day — slashes the time required for allocating stands from four hours to less than one minute, with solution rolling updates performed every 10 minutes (each update lasts 10 seconds). The system also allows for manual intervention at any time.

**Significant improvement in core indicators.** The application of the intelligent stand allocation system has increased the aircraft docking rate at Shenzhen Airport from 71% to 76%. As the airport transports over 50 million passengers annually, this 5% increase translates to more than 2.6 million passengers annually that no longer require airside transfer buses.

Once the satellite hall has been built and is in operation, there will be more contact stands. This will maximize the efficiency of the intelligent stand allocation system and increase the aircraft docking rate by 10% to 15%.

The system can also improve the bridge turnover rate, increasing the number of flights docking to a bridge per day from 10.24 to 11.

**Best use of airport-wide core resources.** The system uses AI algorithms and operational research strategies to optimize the allocation of airports' core operational resources. As well as enabling intelligent stand allocation, the system can define new objectives and develop them quickly through flexible expansion without conflicting with the existing systems. With boarding gates, check-in counters, baggage carousels, and security checkpoints gradually applying the system, the global coordinated resource allocation will be more efficient.

**In-depth integration of technologies and businesses.** The intelligent stand allocation system incorporates the existing business rules (over 60 basic rules) to the AI algorithm engine, as well as converges and processes massive amounts of data from various IT system and departments — such as flights, stands, ATC data, and runway information. To cope with complex business procedures, system developers and business personnel worked together to conduct in-depth research on the internal stand allocation rules using AI and other innovative technologies. To date, this project has applied for three patents.

### Employing AI Throughout the Allocation Process

By deploying Huawei's intelligent stand allocation system, Shenzhen Airport has become a pioneer in innovating and exploring ICT for the civil aviation industry. The airport's management team has gained a deeper understanding and forward-looking perspectives in advancing the industry with technological innovations.

Following these successes, Huawei will continue expanding the application of AI technologies in airport resource allocation. Based on the existing system, we will use AI technologies to add intelligence to the allocation of airport-wide resources. This will maximize the benefits of sharing airport resources, achieve optimal resource usage, and eliminate increasingly prominent resource support bottlenecks — helping Shenzhen Airport become a forward-thinking and world-leading airport. ▲

# Shenzhen Opens 5G-Empowered, Cloud-Based Metro Lines

*By Chen Huijuan, Senior Marketing Manager of the Global Transportation Business Unit of Huawei's Enterprise Business Group  
Li Qiwei, Marketing Manager of Huawei's Enterprise Business Marketing Dept.*

**S**henzhen Metro's Lines 6 and 10 are the first lines in China to deploy Huawei's urban rail cloud solution. As the basis of smart subway construction, the solution showcases a new construction approach for the urban rail transit industry.



Huawei Station, on Shenzhen Metro's Line 10. (Photo by Li Qiwei)

*The urban rail cloud is the foundation of smart metro construction. It brings innovations and improvements — breaking information silos, optimizing existing system architecture, and carrying smart metro services. The cloud platform provides comprehensive support for the operations and management of urban rail transit.*

When Shenzhen Metro Lines 6 and 10 opened on August 18, 2020, they became both the first lines in Shenzhen with full 5G coverage and the first in China to use Huawei's urban rail cloud solution. The metro lines are also the first in China's urban rail transit industry to apply computing and big data technologies to carry several key subway service systems.

With a length of about 49 km and a total of 27 stations, Line 6 links the Science Museum Station to Songgang Station, running through Futian, Luohu, Longhua, Guangming, and Bao'an districts. As well as making travel more convenient for people living in neighborhoods along the line, it will also be integral to the development of Guangming District and Longhua District, as well as boosting economic integration throughout the city.

Meanwhile, spanning about 29 km and with 24 stations, Line 10 connects Futian Checkpoint to Shuangyong Street — traversing Shenzhen's central areas, including Futian, Meilin Checkpoint, and Banxuegang Science and Technology Park. Line 10 is the first north-south metro line in Shenzhen that accommodates eight-car trains, so it already has a key role, as both a trunk and a local line. When riding Line 10, it takes just 45 minutes to travel from Futian Checkpoint to Pinghu, substantially reducing congestion on the roads. With the line up and running, areas such as Pinghu, Banxuegang, Huawei's Bantian campus, and areas east of Meilin Checkpoint are finally incorporated into Shenzhen's huge metro network, after being excluded from it for years.

### **New Line Connects Shenzhen's North and South**

For Shenzhen's many commuters, the huge traffic jams at

Meilin Checkpoint were a source of great frustration — day in day out — for more than a decade. With Line 10 in operation, that frustration is now over.

Line 10 was designed to connect the northern and southern parts of Shenzhen and alleviate congestion at the metro lines that predate it. As well as expanding the subway capacity, Shenzhen Metro also aimed to optimize and innovate in areas such as security performance and operational efficiency.

To achieve these aims, Shenzhen Metro adopted Huawei's industry-leading urban rail cloud solution — building a unified, open, and intelligent urban rail digital platform and applying key technologies such as cloud computing, big data, 5G, and AI. This platform provides comprehensive support for the operations and management of urban rail transit.

### **Smart Urban Rail Construction: Creating the Urban Rail Cloud**

Because China has rapidly urbanized in recent years, many Chinese cities have begun constructing new — or developing existing — urban rail transit systems to make commuting and other short distance travel more convenient. In many cities, the opening of new metro lines drastically increases the difficulty of metro network operations and management, and creates huge challenges for existing Information Communications Technology (ICT) infrastructure.

In urban rail network operations, the service processes and operation rules of all metro lines require unified management, and the service management needs to be standardized — to improve the operational, production and management

efficiency and reduce operational costs. Service application deployment must be unified, and all data must be centrally managed. In these circumstances, it's inevitable that the urban rail transit industry will use emerging technologies to implement cloud-based digital transformation, so an urban rail cloud solution is integral.

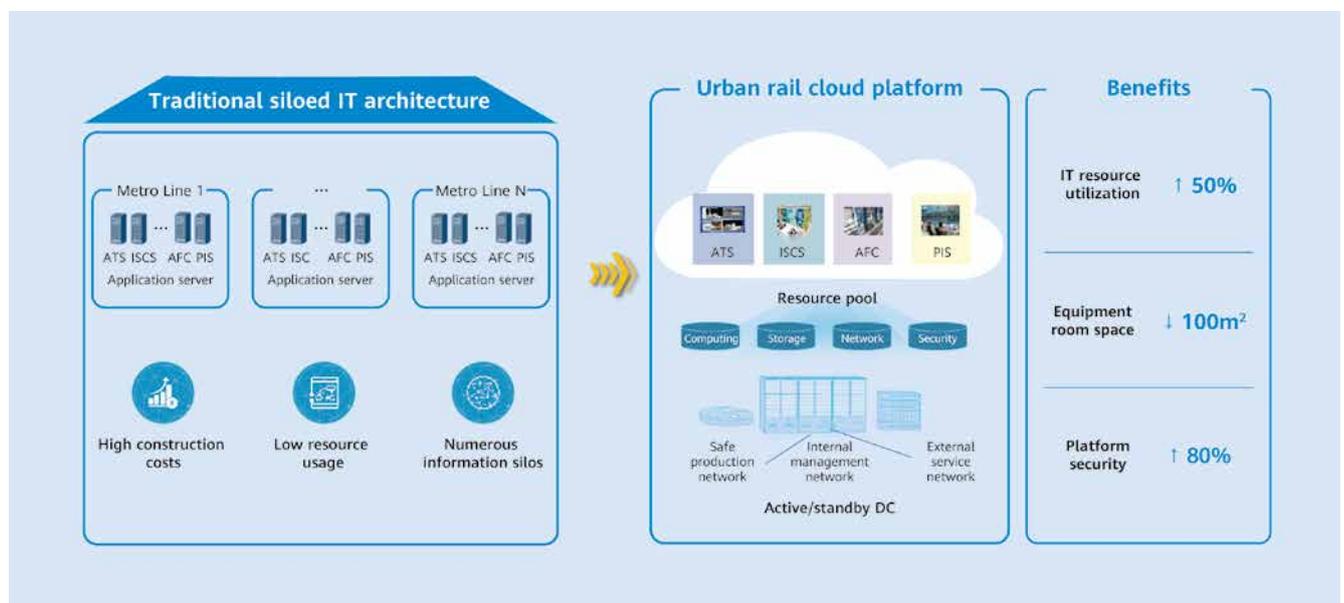
The urban rail cloud is the basis for smart metro construction. It brings innovations and improvements — breaking information silos, optimizing existing system architecture, and carrying smart metro services.

### Future-Oriented Architecture of Huawei's Urban Rail Cloud

Shenzhen Metro Line 6 and 10's use of the urban rail cloud solution is the first application of cloud computing and big data

technologies to carry metro service systems in China. This solution replaces the siloed vertical architecture used in the traditional metro systems, and implements unified planning and construction, on-demand allocation and use, and effective sharing of ICT infrastructure resources — laying a solid foundation for Shenzhen Metro to deploy more smart applications and facilitating the intelligent, digital upgrade of subway systems in the future.

By building an integrated, cloud-based service platform that supports the Integrated Supervisory Control System (ISCS); the backup Automatic Train Supervision System (ATS); the Passenger Information System (PIS); the security protection system (including video surveillance and access control), the intelligent depot system; and the Office Automation (OA) system, Shenzhen Metro has greatly reduced



Urban rail cloud: Unified bearing, unified architecture and unified platform



*Adopting the latest technologies, including cloud computing, big data, 5G, and AI in subway systems improves passenger experience, empowering Shenzhen as it builds a smart metro system and focuses on developing as a smart, hi-tech city. >>*

the need to repeatedly invest in different systems; it's also achieved full integration and fast deployment of various service systems. As a result, Operations and Maintenance (O&M) is simplified and more efficient.

The urban rail cloud solution also improves the security of the entire platform by 80% and increases the IT resource usage by more than 50%. The platform centrally provisions resources to improve operational and management efficiency. Meanwhile, replication technology is used to deploy real-time server services for 20 stations within 30 minutes.

Lines 6 and 10 use the modular equipment room solution, which has significant tangible benefits: the equipment room area of a single station is reduced by roughly 50%, the electricity bill is slashed by about 2 million RMB (about US\$306,000) per year, the cabinet space is reduced by about 10%, and the data center's Power Usage Effectiveness (PUE) is reduced to 1.5.

Lines 6 and 10 are the first lines in China to adopt cloud-computing technology to construct multiple service systems. The lines provide a good example to follow for the urban rail transit industry in terms of building new cloud architectures as they seek to ensure reliable transportation, efficient operations, and unified O&M.

### **Smart Metro: One-Click Global Visibility and Unified and Associated Operations**

Empowered by cloud computing and big data technologies, Lines 6 and 10 optimize service application systems and

integrate various operations and production information resources. Meanwhile, effective integration of subsystems and collaboration between service departments enable information-based management of the entire operation and production process as well as remote, centralized control of operations — breaking down both information and automation silos.

Based on the urban rail cloud platform and applying the capabilities of Huawei's FusionInsight distributed big data platform, Shenzhen Metro has developed a big data analysis platform that supports line-level data analysis of equipment health, energy consumption management, passenger flow statistics, line monitoring, emergency decision-making, and image-based fire detection. Huawei also works with ecosystem partners to provide basic platform support for Shenzhen Metro's intelligent applications, such as intelligent linkage and big data analytics.

The urban rail cloud and the big data platform integrate heterogeneous data resources of Lines 6 and 10, activating the data assets of the lines. As well as using a unified monitoring 'map' to sense and display all kinds of data about the metro system, the solution also provides 'one-click global visibility' — meaning that the metro operator can access all running status information with a simple click of the mouse — and an integrated linking of operations.

### **5G Enables Enhanced Passenger Experiences**

With 4G networks, subway passengers

are often plagued by very poor online experiences because there are so many users and the network capacity is insufficient to handle the traffic. Sometimes, the network is so congested that you can't even send a text message. The 5G network will eliminate such problems, because it has much higher bandwidth and network capacity than 4G, and it supports smooth and stable access for smart terminals.

Passengers can enjoy smooth and stable connections to the 5G network on their 5G smartphones in the station halls, platforms as well as in the trains, despite the crowds.

Shenzhen Metro, Huawei, and the three major Chinese carriers (China Telecom, China Unicom, and China Mobile) worked together, taking only ten weeks to complete equipment installation and commissioning at the platforms, station halls, and tunnel sites of Lines 6 and 10 — achieving full 5G coverage. The engineering staff could only work on installation and commissioning after the halt of subway operations at night, so this was a truly impressive feat.

Because of the sustained efforts of our 5G construction engineers, passengers can now conveniently enjoy the benefits of 5G while on the metro. As 5G technology develops, those passengers will be able to enjoy more benefits brought by ubiquitous 5G.

### **5G+ Urban Rail Cloud Accelerates Smart Metro Development**

5G brings optimal network experiences for passengers, and with unique features — such as ultra-high bandwidth and ultra-low latency

— facilitates metro construction, operations, and management.

When building metro systems, the high bandwidth of 5G networks can support the visualized management of engineering construction. In metro operations, the high-bandwidth and low-latency of Huawei's AirFlash 5G train-to-ground data dump solution can be used to automatically upload vehicle-mounted CCTV videos and monitoring data to the urban rail cloud platform — allowing for equipment health management and efficient status analysis, while big data analytics and AI enable the shift from status management to preventive management.

5G can change society and empower a variety of vertical industries. Applying 5G in metro networks can bring sweeping changes. The integration of 5G with the urban rail cloud solution can help metro companies reduce costs and improve efficiency, security, and reliability. What's more, potential risks can be eliminated efficiently with the help of 5G. We are confident that 5G technology will be fully integrated into all corners of metro systems in the near future, offering passengers more convenient, comfortable, and safer trip experiences.

Shenzhen Metro Lines 6 and 10 include numerous innovations, many of which are first of their kinds in subway construction in Shenzhen and China as a whole. Adopting latest technologies — cloud computing, big data, 5G and AI — in subway systems creates better passenger experiences, empowering Shenzhen as it builds a smart metro system and focuses on developing as a smart, hi-tech city. ▲



*5G brings optimal network experiences for passengers, and with unique features — such as ultra-high bandwidth and ultra-low latency — facilitates metro construction, operations, and management. >>*

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# Exploring and Practicing Smart Expressway Construction

*By Fei Jixiang, Senior Solution Architect, Global Transportation Department, Huawei's Enterprise Business Group*

**D**riven by new development concepts and technological innovation, China has launched strategies in recent years to enable industry upgrade and build integrated infrastructure systems. This is necessary to meet the demand for high-quality development, and this is why the transportation industry needs smart expressways. During the process of building those expressways, it's critical to coordinate people, vehicles, roads, and environments, in order to build high-quality highways. A backbone expressway network has taken shape in China, and the focus of China's expressway industry has shifted from construction and management to construction, management, and Operations and Maintenance (O&M). With the annual compound growth rate of automobiles in use reaching 12% in China, people are pursuing faster journeys, which puts greater demands on roads to be more efficient.



*The industry must coordinate people, vehicles, roads, and environments; accelerate the construction of smart highways; improve the management and service capabilities; and achieve the development objectives of integrated, smart, green, and safe transportation.*

Despite fast technological progress, highways remain inefficient at toll collection. More alarmingly, traffic congestion and serious traffic accidents persist at highway toll stations during holidays. Meanwhile, traffic accidents caused by dangerous goods transport vehicles can seriously damage roads.

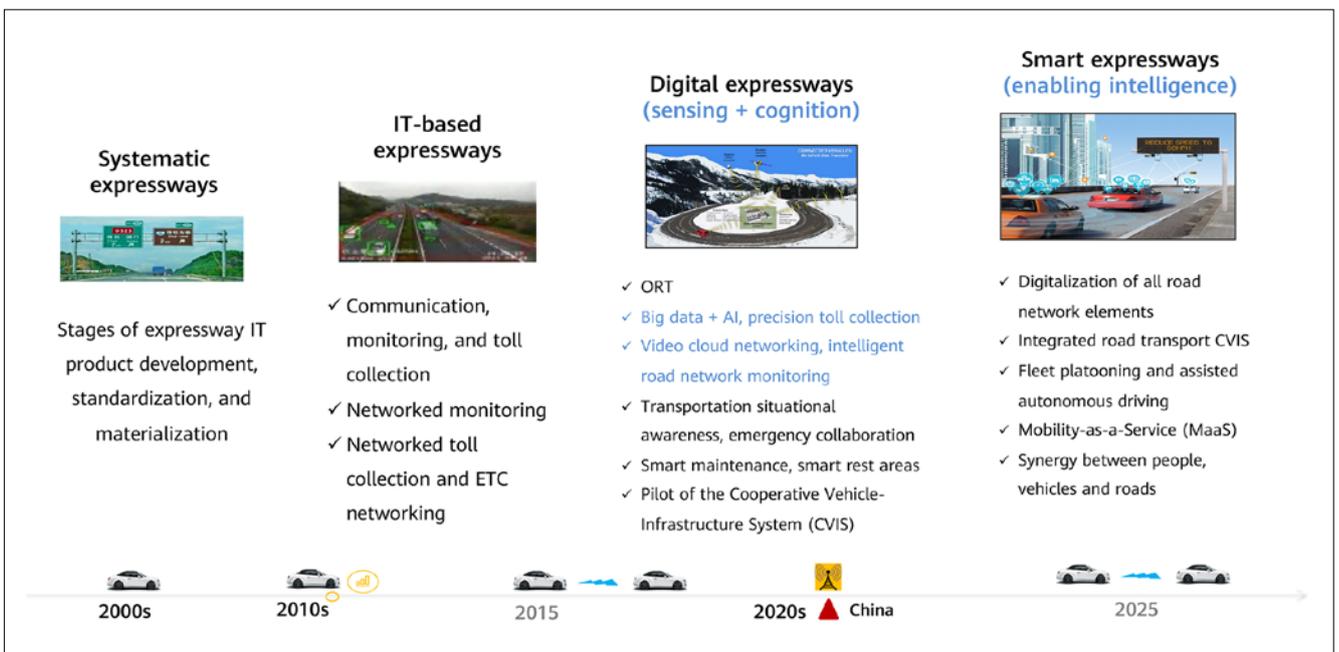
All of these factors indicate that further intelligence is required to build smart highways. To address these challenges, the industry must coordinate people, vehicles, roads, and environments; accelerate the construction of smart highways; improve the management and service capabilities; and achieve

the development objectives of integrated, smart, green, and safe transportation.

## Evolution and Challenges of Smart Expressways

### • Evolutionary Roadmap

Highways have entered the digital era, and they will become increasingly intelligent in the future. In this process, Electronic Toll Collection (ETC) is just the start, just one example of digitalization, which is the foundation of smart expressways. Digitalization will focus on empowering highway



Highway evolutionary roadmap

*Guided by overall construction objectives of achieving all-road awareness, all-round service, all-weather access, full-process management and control, and digital operations, China is continuously improving the safety, efficiency, service, and management level of highways through digital transformation.*

networks with perceptive and cognitive capabilities, which smart highways can then be built on top of — to achieve coordination between people, vehicles, and roads.

• **Construction Objectives**

Guided by overall construction objectives of achieving all-road awareness, all-round service, all-weather access, full-process management and control, and digital operations, China is continuously improving the safety, efficiency, service, and management level of highways through digital transformation.

**Safe:** China will build a complete highway safety assurance system. In the long run, all-weather expressway safety with zero major traffic accidents will be possible, based on infrastructure digitalization, integrated road transport Cooperative Vehicle-Infrastructure System (CVIS), integrated BeiDou (China's satellite navigation system) high-precision positioning applications, big data-based, unified road network management, integrated Internet+ road network services, and new-generation traffic control networks.

**Fast:** ETC will be deployed at all expressways in China, and a big data-driven intelligent cloud control platform will be created, which will employ intelligent systems and vehicle management and control measures to improve the traffic efficiency and to increase the average vehicle speeds on expressways by 20% to 30%.

**Green:** Build converged and efficient smart transportation infrastructure. Encourage the deployment of photovoltaic (PV) power generation facilities along expressway rest areas and slopes, and connect them to the mains electricity for power supply. In the 14th and 15th Five-Year Plans, China will strengthen the development of wind power and solar power.

In 2021, the PV industry will see explosive growth.

**Intelligent:** New technologies will be used to build a comprehensive sensing system for people-vehicle-road synergy and a comprehensive road network operation monitoring and warning system to implement Open Road Tolling (ORT). In the future, an Internet of Vehicle (IoV) system will also be built, to support autonomous driving.

• **Current Challenges**

In the next decade, smart expressway construction in China will face challenges in terms of new technologies, new models, and new business models:

**Insufficient sensing facilities and low level of intelligence:**

Transformation toward the smart expressway will be impossible without data. The coverage of sensing facilities is insufficient, detection methods aren't intelligent enough, and data sensing needs to be improved.

**Insufficient data sharing and weak analysis capability:**

Expressway data analysis depends on data collected by vehicle detectors and cameras. There's a lack of structured data collected in other modes and there's no integration with other data such as toll collection data. The capability of analyzing and processing real-time data is insufficient.

**Services aren't associated with each other, lacking collaboration:**

There is no linkage between services of different road sections and between corresponding maintenance services. Cross-section and cross-road network collaboration is insufficient, leading to weak joint dispatching and command capabilities.

**The prediction capability can barely support decision-making:**

Because of the lack of data support, the prediction capability of the system is poor and can't provide effective assistance for manual decision-making. As a result, decision-making relies purely on the experience of managers.

### **Lack of perception methods and slow response:**

The lack of comprehensive sensing methods and low level of intelligence make it impossible to learn the onsite situation efficiently and quickly generate emergency instructions after an incident occurs, leading to slow response.

### **Poor problem source tracing and weak management and control:**

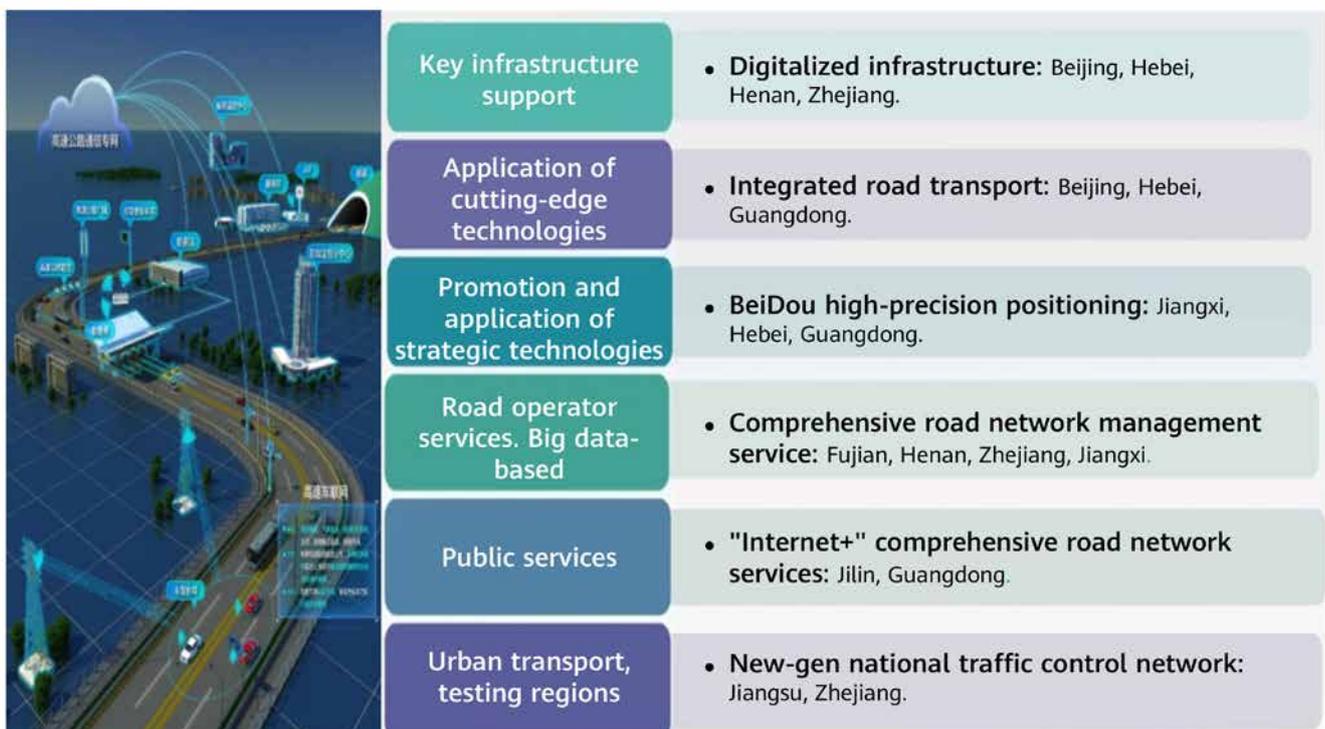
Because of the lack of comprehensive

perception data, the root cause of an incident can't be traced through simulation or other methods. As a result, precision management and control can't be achieved.

### **Lack of a comprehensive management and control network:**

Highway facilities and systems are still operated, maintained, and managed in a passive mode. A comprehensive management and control network and an O&M platform are urgently needed for unified, efficient, and automatic management and service.

There are other prominent problems such as network security and information silos. Meanwhile, standards and specifications need to be strengthened, and public service quality needs to be enhanced.



Smart expressway pilot projects

## Architecture and Features of Smart Expressways

Smart expressways can only be developed through comprehensive transformation of technologies, development models, and services. It requires an integrated system with digital perception, ubiquitous connectivity, digital platforms, and smart applications. To this end, multiple parties need to work together to innovate and achieve optimal outcomes.

### • Characteristics of Smart Expressways

The characteristics of smart expressways include comprehensive sensing, intelligent analysis, collaborative operations, autonomous decision-making, instantaneous response, and accurate management and control.

**Comprehensive sensing:** Provide comprehensive, intelligent, real-time, and accurate perception of facilities, vehicles, and environments along highways, proactively detect exceptions, and provide data support for subsequent autonomous decision-making, instant response, and precise management and control.

**Intelligent analysis:** Multi-source information obtained

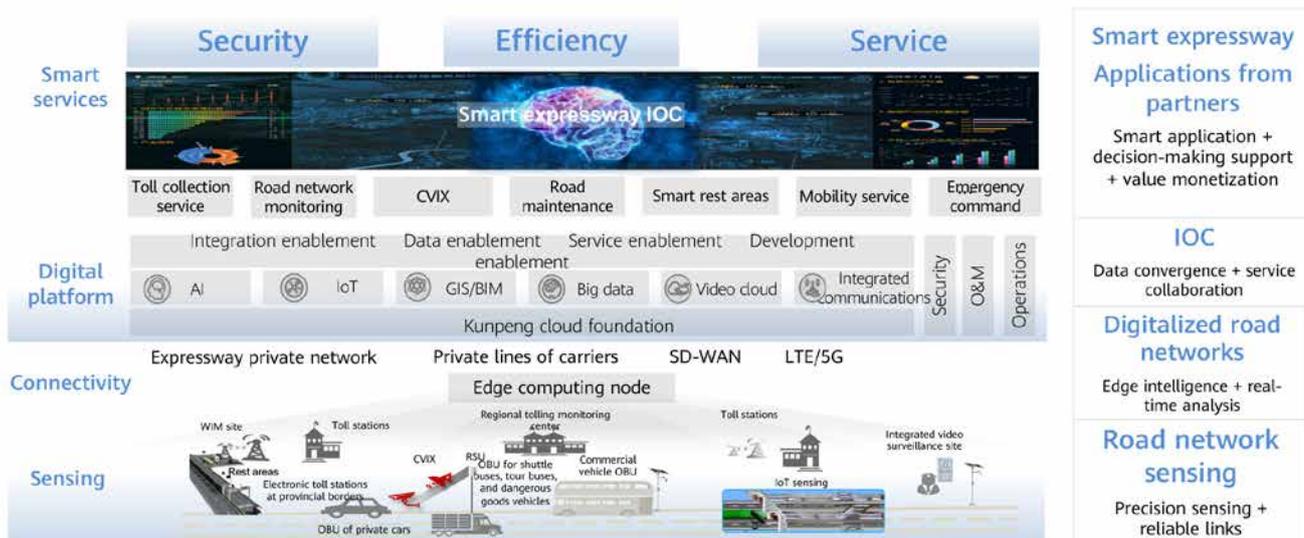
through various sensing methods, such as group and individual information, historical information, and real-time information, can be intelligently analyzed in typical scenarios to help identify exceptions and support autonomous decision-making.

**Collaborative operations:** Implement interconnection and collaborative linkage between different services in the same expressway section, between different expressway sections, between expressways and common roads, between expressways and transportation tools, and between expressways and traffic participants, in order to improve management efficiency and service quality.

**Autonomous decision-making:** Machine learning can be used for autonomous learning of expressway exceptions, perform real-time calculation of these exceptions, accurately predict the exception development track and results, and quickly provide the best solution to comprehensively improve the intelligence level of decision-making.

**Instantaneous response:** Detect expressway emergencies in real time, quickly determine the severity of emergencies,

1 + 1 + N: A set of all-element sensing systems, an Intelligent Operation Center (IOC), and N smart applications



Architecture of Huawei's Smart Expressway Solution

instantly generate detailed emergency plans, and quickly schedule resources to handle emergencies.

**Accurate management and control:** Has comprehensive expressway sensing capability and the capability of identifying expressway exceptions. Implement proactive and accurate management and control of road sections, lanes, and special vehicles — improving the expressway management and control level and ensuring safe, orderly, and smooth transportation.

### • Smart Expressway Solution Architecture

Huawei's smart expressway solution connects all transportation elements based on digital, networked, and intelligent roads. With the digital platform as the core, a multi-service scenario solution is constructed, including a set of all-element sensing systems, an Intelligent Operation Center (IOC), and N smart applications. With this solution, we can build smart expressways that are visualized, controllable and serviceable — improving transportation safety, efficiency, and experience.

**All-element sensing:** The sensing of the road network depends on many data collection devices — such as video cameras, sensors, and traffic flow detectors — of which video is the most important data format. There have been three defining phases of video perception: transformation from common cameras to smart cameras, transformation from single-point intelligence to network-wide intelligence, and transformation from single-mode video collection to multi-source video collection. As physical and digital worlds become more connected, data, software, and AI algorithms can flow freely on the cloud,

edge, and devices, allowing for all-round perception of transportation infrastructure and real-time information exchange.

**Intelligent connection:** 5G and other technologies are used to deliver ultra-broadband, seamless, and lossless network coverage featuring low-latency and high-reliability.

**All-weather access:** Edge computing and edge intelligence technologies must be based on AI capabilities and applications to shorten the end-to-end latency. This way, when an accident occurs, the solution can ensure quick emergency handling and traffic restoration and avoid the need to take more extreme measures such as closing the road. In Huawei's smart expressway solution, the computing power and AI capabilities are deployed at the edge to shorten the service-processing latency. Also, useless data is removed at the edge before being backhauled, reducing the pressure on bandwidth.

**IOC:** The IOC is at the heart of smart expressways, and it's the engine that supports full-service scenarios and propels full-lifecycle industry upgrade. As key parts of the IOC, smart applications must be able to streamline siloed systems and perform centralized data aggregation and governance. By mining data value and revitalizing digital assets, smart applications can help build a unified map for smart expressways.

**Full-process management and control:** Through collaborative innovation with customers and partners, Huawei is able to help customers from the transport sector improve safety, efficiency, and experience. Meanwhile, end-to-end precision management and control can be achieved for construction,



*The IOC is at the heart of smart expressways and it's the engine that supports full-service scenarios and propels full-lifecycle industry upgrade. >>*

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*Driven by both technological development and market demands, smart expressways face a period of challenges and opportunities. >>*

management, maintenance, transportation, and services. As a result, Huawei's solution can reduce traffic accidents and congestion, improve transportation capacity and cut operational costs.

### Smart Expressway Construction

Smart expressway construction must meet the following requirements to become digitalized, informatized, and intelligent:

**Digital infrastructure:** Digitally display the running status of the road infrastructures so that objects can "speak" (3-D high-precision map, sensing the running status of the road, bridge, tunnel, and slope), enabling advanced risk warning and response.

**Network-based:** Digital facilities are connected through the network to enable data interaction and communication between objects (dynamic management and control of facilities on the road and customized information services for different vehicles).

**Intelligent:** Intelligent response and control based on network transmission can be implemented (vehicle-infrastructure interaction and big data-based road network coordination and control). With the help of the Internet of Everything (IoE), ubiquitous road network perception and full-process vehicle control are made possible.

5G devices can be used to provide low-latency and high-bandwidth wireless connections, and all-optical Fifth-Generation Fixed Network (F5G) networks are used to build a comprehensive sensing system for people-vehicle-road synergy. Based on high-precision maps and the BeiDou navigation

satellite system, autonomous driving can be supported in the future.

Huawei helped Beijing Capital Highway Development Company build the first high-tech, smart expressway in China — Beijing-Chongli Expressway (Beijing section). With this expressway, 5G-empowered, scenario-based solutions are used to support autonomous driving with vehicle-road synergy. In 2019, TuSimple — a self-driving truck company — and its partner, Huawei, used advanced technologies such as Cellular Vehicle-to-Everything (C-V2X) and high-precision maps to perform millisecond-level L4 autonomous driving and fleet formation full-scenario tests on multiple types of large and small vehicles on the Beijing-Chongli Expressway.

In Hunan province, Huawei worked with the Hunan Expressway Group to implement online vehicle charging audit. Multi-dimensional data about charging, vehicle license plates, and vehicle features is converged and online training with Artificial Intelligence (AI) algorithms is performed, achieving second-level diagnosis and analysis and online automatic warning response.

To become a transportation powerhouse, China must invest more in smart expressway construction, which will drive the nation's ICT industry development. Smart expressways will evolve to support LTE-V and self-driving vehicles — achieving intelligent synergy between people, vehicles, roads and environments. Driven by both technological development and market demands, smart expressways face a period of challenges and opportunities. With that period approaching, Huawei is ready to cooperate with all industry partners to jointly build better smart expressways. ▲



Building a Fully Connected,  
Intelligent World

# HUAWEI IdeaHub

## New Style **Smart Office**

**3-in-1** Whiteboard | Projector | Online Meeting



## Mexico's SEPOMEX Gears Up for the Age of E-Commerce with Huawei AirEngine Wi-Fi 6

**A**cross the world, the boom in e-commerce — inevitably exacerbated by the global pandemic — is totally transforming traditional postal services. While in the past postal workers on bicycles or on foot delivered lightweight letters and cards, the industry now handles far greater numbers of packages, big and small. A traditional postman or postwoman has been turned into a full-fledged delivery service, no longer pedaling a bicycle but driving a van.



### Set to Explode

Mexico was the country with the fastest growing e-commerce sector in 2019 yet still, compared to bricks and mortar retail, it accounted for just 2% of the country's total sales, lagging behind its northern neighbor, the US, where e-commerce contributed 10% to the total figure. It's increasingly clear that, as the Internet and smartphones have become ever more accessible, e-commerce in Mexico is set to explode, which will lead to rapid growth in express package delivery services.

The Mexican Postal Service — SEPOMEX — was well aware of this fact, covering 96.71% of Mexico's population. With a pivotal role to play in both strengthening social connections and promoting economic development, SEPOMEX knew that it needed to enhance its express delivery service capabilities and upgrade its Information Technology (IT) infrastructure, boosting mobile office efficiency. This in turn would also give it the ability to innovate and develop new services in the future, putting it in a strong position to adapt to potential future industry changes.

### Challenges Facing Office Networks

As e-commerce develops, order numbers spiral, increasing pressure gets put on delivery times, and the frequency of deliveries grows and grows. Traditional operations, such as laboriously filling out paper forms, are simply unable to keep pace with these most modern service demands. It was in this environment that SEPOMEX decided to

build an electronic, digital, and all-wireless integrated office network, using Mobile Office Automation (OA) software to process service requirements in real-time, helping it to obtain the data required — covering all its services, warehousing, transportation, and distribution — for comprehensive decision-making. Since the network was deployed, overall service quality and efficiency has been improved, while the management process has been standardized and automated.

On SEPOMEX's legacy office network, Customer Premises Equipment (CPE) had insufficient uplink bandwidth, and the OA software often encountered frame freezing, lowering work efficiency. Meanwhile, wired access networks restricted employees' work locations. Additionally, some wireless access networks that had been running for a significant period of time couldn't differentiate between employees and guests in terms of access permissions, which posed network security risks.

### Huawei E2E Agile Campus Solution

To tackle the issues that SEPOMEX faced, Huawei brought its extensive experience in all-wireless campus network construction and Operations and Maintenance (O&M), to offer an End to End (E2E) agile campus solution powered by next generation AirEngine Wi-Fi 6. Featuring highly reliable carrier-class devices, all-wireless access, and a platform for intelligent security defense and unified management, the solution helped SEPOMEX build an agile wireless campus network. It also delivers a highly secure, efficient, and reliable mobile office experience for employees.



*To tackle the issues that SEPOMEX faced, Huawei brought its extensive experience in all-wireless campus network construction and Operations and Maintenance (O&M), to offer an End to End (E2E) agile campus solution powered by next generation AirEngine WiFi 6. >>*

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*Through data analysis and value mining, Huawei has provided intelligent support for SEPOMEX's services and decision-making. The upgraded network enables efficient network management and intelligent security control, paving the way for the digitalization of SEPOMEX's services.*

All-wireless high-speed access based on the next generation Wi-Fi 6 standard (802.11ax). AirEngine 5760-10 is a Wi-Fi 6 wireless Access Point (AP) that supports 2 x 2 Multiple Input Multiple Output (MIMO). It provides services simultaneously on both the 2.4 GHz and 5 GHz frequency bands, achieving a device rate of up to 1.774 Gbit/s. With built-in Smart Antennas, signals can target users as they move, providing significantly improved wireless coverage. In addition, the AP allows expansion of an Internet of Things (IoT) module through a Universal Serial Bus (USB) port. This module supports IoT protocols such as Radio Frequency Identification (RFID) and ZigBee, as well as flexible extension of IoT applications in the future, such as asset location.

A highly reliable and easy-to-deploy campus network. CloudEngine S5731-H Series access switches and CloudEngine S12700E Series aggregation switches offer non-blocking switching and zero packet loss even in high concurrency and heavy load environments. The switches enable network deployment within minutes and can respond to postal service changes more flexibly.

AirEngine 9700-M — a Huawei wireless Access Controller (AC) — employs user- and role-based access control to isolate guests from employees, improving the security of the office network.

Advanced threat detection that's powered by Artificial Intelligence (AI). HiSecEngine USG6500E Series firewalls work with the SecoManager security controller to implement service-driven policy management based on AI technologies. Additionally, network devices, security devices, and HiSec Insight (a security situational awareness system) work together to build a proactive network security defense system. Such

a system features comprehensive threat awareness, analysis, and response, safeguarding SEPOMEX's postal services across all aspects of its operations.

A simplified and unified management platform. Huawei's eSight Information and Communications Technology (ICT) infrastructure management system manages both wired and wireless devices, as well as visualizing all network traffic. It effectively monitors network quality, manages security policy, and demarcates faults quickly, as soon as they occur. Such functionality simplifies network O&M, improves O&M efficiency, and lowers O&M skill requirements.

### **A Modern and Efficient Office**

After upgrading its network with Huawei AirEngine Wi-Fi 6, high-speed wireless network coverage has been implemented across four SEPOMEX office buildings, easily meeting network requirements for various services.

Meanwhile, efficient collaboration among applications, terminals, and edge data has been achieved, improving office efficiency. Through data analysis and value mining, Huawei has provided intelligent support for SEPOMEX's services and decision-making. The upgraded network enables efficient network management and intelligent security control, paving the way for the digitalization of SEPOMEX's services.

Undoubtedly, it's the ever-changing expectations and needs of customers that drive SEPOMEX's digital transformation. And only by delivering quality services can SEPOMEX fully achieve its goal of connecting society and revitalizing the economy. ▲

# Landing in Shenzhen: The Airport of the Future

By Xu Shenglan

**S**henzhen Metro Group is integrating emerging technologies into construction to empower digital, intelligent metros. Cooperating with high-tech enterprises, the group is deploying Huawei's Urban Rail Cloud Solution adhering to the 'advanced smart construction concept,' which prioritizes full-lifecycle management.



*Our mission is to build airports that are safe, green, smart, and passenger-friendly, and to pioneer smart airport construction in China.*

*— Chen Jinzu, General Manager of Shenzhen Airport Group*

***"Our mission to build airports that are safe, green, smart, and passenger-friendly, and to pioneer smart airport construction in China."***

### Keeping It Human Is the Smart Move

**Q: Tell us about your One Airport, One Dream vision.**

**Chen Jinzu:** Our mission is to build airports that are safe, green, smart, and passenger-friendly, and to pioneer smart airport construction in China. We began looking at smart technologies back in 2017. And in September of that year, we signed an MOU with the International Air Transport Association (IATA) to join the New Experience in Travel and Technologies (NEXTT) initiative, making us the only airport in the Chinese mainland to do so.

Since 2018, traveling through Shenzhen Airport has become more convenient, with fewer delays and a better experience due to smart technology based on imperceptible whole-process self-service. Passengers can use apps like WeChat's mini program to check in online. And along with Spring Airlines, we're the first to provide open, shared self-service check-in kiosks across all domestic airlines, so passengers don't have to waste time looking for a particular airline's kiosks. We've also launched smart services like self-service bag drop offs, baggage tracking via RFID, and self-service boarding.

Intelligent recognition, appointment-based security checks, and full-process self-service security checks have made security smoother and friendlier. And as part of the first batch of pilot airports implementing the Civil Aviation Administration's Passenger Easy Security Check program, Shenzhen Airport has also launched an "Easy Security Check" platform, which allows passengers to book the smart security channel online.

Punctual flights are top of all passengers' wish lists, so Shenzhen Airport has strengthened precision management,

the control of flights, and monitoring key phases through the digital transformation of each operational stage. In 2019, the average flight clearance delivery rate for the full year was close to 88%, ranking the airport among the top of China's major airports. Our outbound flight punctuality was sixth out of all major airports globally.

We use an AI-powered system to automate and allocate terminal stands within one minute for the 1000-plus flights arriving and departing from Shenzhen Airport every day, a task that originally took four hours to complete manually. Algorithms have further improved contact stand rates and passenger boarding bridge turnaround times, allowing millions of passengers to experience near-boarding gate travel at Shenzhen Airport every year, giving the convenience you expect from a smart airport.

We looked at transformation from the user point of view, so our focus was on using technology to optimize service operations, improve services with technological innovation, and create an experience-rich digital airport. This smart technology will help passengers experience Shenzhen's warmth.

### Starting With a Dream

**Q: What challenges is Shenzhen Airport facing in the digital transformation process?**

**Chen:** In the early planning stages of digital transformation and smart airport construction in 2017, we cast our gaze abroad and around China, but we found no use cases to learn from. So, we set out on our own path and found three main challenges:



Whether to transform or not? Specifically, we asked if we could unify understanding about integrating systems, services, processes, and the organization so that transformation was in fact viable.

The scope of transformation. Were we transforming a single service, architecture, or system, or transforming all services, processes, and systems?

How to achieve integration. How could we achieve the integration of infrastructure, service systems, and planning, construction, and O&M through digital transformation?

Problem 1: We had to work out IT organizational governance, which would require a coordinating department to implement the project. Two departments were possible — a group-level IT center responsible for group-level planning and system building and an IT company, a public company controlled by the group, which was responsible for O&M services and some software development. But, we were missing a department that could plan and carry out the project with a global view.

So, the group's management decided to reform and integrate these two units into one business department that became the digital management center. The department then formed three sections delineated by service attributes: planning management, construction management, and operations management.

At the airport group level, planning management integrates the planning and aggregation of all requirements. After a plan is formulated, the construction management department organizes and manages the project build. It's then over to

the operations management department, which takes on the management planning, construction, and O&M systems.

After more than two years of trial and error, the current operation is very smooth. We've unified requirements, in turn enabling immediate response and good communications.

Problem 2: Tackling deployment, as our smart airport project involves three concurrent programs: the future airport, electrical installation for airport satellite terminals, and upgrading and transforming Terminal 3.

Each program contains hundreds of projects, so the wrong choice in terms of construction model would mean big headaches farther down the road. For partners, we insisted on companies with a proven track record of scale, quality, and competence. Huawei is an example of a company with scale, as it has technology, capability, and strategy. Second, the construction model was very important. Huawei is responsible for the total design, implementation, and oversight of our current implementation process for four main reasons: First, unifying the technical architecture and plan would be impossible if we were dealing with different vendors. Second, one-time bidding is simpler to manage and faster. Third, Huawei can coordinate technology and planning during implementation. Fourth, is turnkey project construction: Companies can coordinate and implement internal production and plans and in accordance with a blueprint. Packaging the programs together can boost construction efficiency and quality and help drive all projects forward.

Problem 3: Timing construction. Instead of charging ahead without a plan, we wanted to be more systematic. So we set

*During the outbreak, Shenzhen Airport has used smart technology to improve the accuracy and scientific basis of pandemic prevention, so that passengers could have peace of mind when they travel. The airport is the city's first 'line of defense' against the virus.*

up three stages, each with different goals: build the basic platform, build the applications on the platform, and realize full smartification.

### Platform + Ecosystem

**Q: In 2019, the airport handled 1100 flights and 170,000 passengers per day on average, making it one of the busiest airports in the world. How is technology helping to cope with this?**

**Chen:** Building ICT infrastructure and an integration platform is a major, long-term undertaking where you don't necessarily see the immediate value, but which has long-term benefits. We started envisaging the platform as a foundation, comprising an integrated platform and five general platforms. The integrated platform unifies and enables data exchange between different internal and external service systems. It can launch and recombine services to support various new service functions and processes. The five general platforms are big data, video services, converged communications, geographic information services, and IoT. Together, the six platforms support 40 application systems, which provide various services.

Shenzhen Airport and Huawei have also built a Future Airport Digital Platform based on the 'platform + ecosystem' concept. The platform is based on Huawei's ICT infrastructure. The industry ecosystem, which we've built with our partners, features four service systems: big operations control, big security, big services, and big management. This in turn has enabled us to develop a new model comprising one map operations, one network security, and one line service.

Big operations control includes smart airport operations

control and smart resource allocation; big security provides active smart security guarantees and collaborative emergency management; and big services cover personalized, automated, and fully connected services, as well as whole-process, visualized services.

We've digitally transformed each operational stage to create an airport operations control 'brain'. At the center of big operations is air traffic control, which we transformed into the 'one map' approach. Our Intelligent Operations Center (IOC) provides visual information services for ramp control, air traffic control towers, operations command, and security. It has helped us enable efficient multi-party coordination. In the area of aircraft stand allocation, we've implemented a smart stand allocation project, thanks to which the contact stand performance at Shenzhen Airport has improved dramatically.

Millions of passengers every year can board without taking a shuttle bus. By linking up the ground service system, assured phases acquisition system, A-CDM, and integrated system, we've slashed delays, exceeding an unprecedented air traffic clearance rate of 80% for 23 consecutive months as of July 2020.

For passenger flow, we developed the one line travel flow and transformed services. We carried out digital transformation on the complete process, both online and offline, including whole-process imperceptible self-service, with a self-service check-in ratio of 77%. We're the first to implement intelligent recognition-based self-service security verification, and we've achieved 100% coverage of self-service equipment at domestic boarding gates.

With intelligent recognition-based boarding, it only takes one to two seconds for each passenger to pass the gate,

doubling boarding efficiency. Shenzhen Airport's WeChat mini program provides a full range of online services for passengers. With smart transportation precision push messages, we can collaborate with public transportation services and quickly respond to passengers with online smart services. Finally, the service management platform enables refined management.

**Q: Safety is, of course, the civil aviation industry's top priority. How does Shenzhen Airport use tech and management platforms to respond to safety issues?**

**Chen:** To cover every scenario, we carried out digital transformation of all zones in the airport and our front- and back-end systems, improving the precision of the big security system and implementing smarter methods. We built a dedicated modular security data room and large-capacity security cloud storage. We reconstructed more than 9500 channels of HD video, implementing 90-day storage and a smart application for video surveillance across the entire airport. We deployed smart security management and control systems and built four secondary platforms in the terminal, airside, public, and cargo areas, which formed an overall security control system with unified supervision and hierarchical monitoring. Finally, a smart video analysis platform provides active prediction of potential hazards.

### Protecting Passengers With Tech

**Q: During the coronavirus pandemic, how has Shenzhen Airport optimized and upgraded its technology to maximize the safety of passengers?**

**Chen:** During the outbreak, Shenzhen Airport has used smart technology to improve the accuracy and scientific basis of pandemic prevention, so that passengers could have peace of mind when they travel. The airport is the city's first 'line of defense' against the virus. When the pandemic started, we blocked all entry and exit. As the outbreak was brought under control in China but began to spread around the world, this required us to implement strict controls on inbound international flights and passengers. So controlling this became our top priority.

Shenzhen Airport's IOC played a major role in our response. For one thing, it helped us build a special epidemic database, so we could analyze and investigate the status of outbreaks in relation to passengers and flights, international flight trends, international route trends, passengers with fever, and quarantined passengers. At the peak, the system provided smart real-time screening and tracking of more than 700 people a day.

Data was released uniformly through the IOC platform, providing unified real-time data to various offices and departments, including the airport epidemic prevention office, airport quarantine station, provincial/municipal health commission, municipal prevention and control leading group, municipal transportation authority, State-owned Assets Supervision and Administration Commission, and the airport emergency center. This facilitated the development of targeted epidemic prevention strategies.

The IOC's scenario-based video technology supported real-time dynamic monitoring of all stands and channels on the ramp, and flight



*Building ICT infrastructure and an integration platform is a major, long-term undertaking where you don't necessarily see the immediate value, but which has long-term benefits.*

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and passenger screening, which allowed us to check all key flights, and not miss a single person or flight.

The airport is a gateway, connecting the city and outside world, so stopping the spread of the virus was a top priority. We responded to requirements from the authorities for prevention and control. We installed infrared thermal imaging cameras at the entrances of the terminal building and Ground Transportation Center (GTC), and at all jet bridges and in the arrivals area for full thermal imaging coverage. Normally staff use infrared thermometers to measure passengers' temperatures, transferring those with a reading above 37.3 °C to the pandemic prevention department for re-examination and isolation. But since infrared thermometers only have an effective range of 3 to 5 cm, this necessitates close contact between passengers and airport staff, increasing the risk of infection. Also, multiple staff are needed to check passengers one by one and keep order, so it's very inefficient.

We switched to binocular infrared thermal

imaging cameras (with blackbody correction) to detect the forehead temperatures of passengers entering and leaving the airport. Passengers passing through the camera are captured in under a second and the temperature of each passenger is displayed by color in real time on a computer screen for staff at the temperature checkpoint. The system notifies staff with audio and light warnings, so they can deal with any issues immediately, greatly increasing speed and efficiency.

Airports generally check whether passengers are wearing masks at temperature checkpoints at entrances and exits, but to detect whether they are wearing masks in all other areas of the terminal, airports have to rely on video surveillance manned by staff. Due to fatigue and lapses in concentration, accuracy and efficiency are impossible to guarantee and the inspection cycle is very slow.

We deployed smart robots to patrol the airport's security zone in mid-March 2020. The robots can inspect whether passengers and staff entering the airport security zone



*For most passengers, so-called smart airports aren't just about cutting-edge technologies. Any future smart electronic devices must provide more convenient services that meet needs and boost experience. That's the core purpose. >>*

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are wearing masks with an effective detection distance of 3 to 5 meters, with up to 98% mask detection accuracy. We can then carry out different measures depending on whether it's a passenger or a worker.

If the offender is a passenger, a voice message will be played kindly reminding them to wear a mask. If it's an airport employee, a real-time image is taken and sent to the back-end along with location information. This is transmitted via 5G to the cloud, where intelligent video analysis on edge computing devices enables backtracking and data analysis of historical data, which can be accurately linked to predetermined management and control strategies, so that personnel can then be notified in time to handle any transgression on-site, providing a more efficient and intelligent method of controlling the pandemic.

### Soaring High on the Wings of Smart Technology

**Q: How did Shenzhen Airport and Huawei build a new IT and data governance system starting with the top-level design? And what technologies can we expect in the future?**

**Chen:** For most passengers, so-called smart airports aren't just about cutting-edge technologies. Any future smart electronic devices must provide more convenient services that meet needs and boost experience. That's the core purpose.

Shenzhen Airport will continue working with Huawei to extend the scope of passenger services to all touchpoints, including public areas and airside areas; integrate offline and online resources; and expand out to new

scenarios, such as smart shopping, smart commerce, and VIP precision services. This is at the heart of creating a new passenger-centered service model.

Huawei has used algorithms to help Shenzhen Airport improve the efficiency of aircraft stand utilization. However, there are still problems, like hitting airport capacity and guaranteed resources becoming strained. We will work with our partners to digitalize resource allocation rules and allocation experience, supported by strong computing power and algorithms. This will provide smart dispatch and management of the entire resource chain, with a focus on key guaranteed resources such as check-in islands, security channels, boarding gates, baggage carousels, and ground services.

New technologies like 5G and AI will completely revolutionize digital transformation of the entire civil aviation industry, including airports. We will see 5G-based aircraft taxiing guidance, driverless vehicles in the ramp area, unmanned aerial vehicles, and even onboard wireless communications for aviation. These technologies will integrate tech with civil aviation services and increase the speed and quality of digital transformation.

Alongside the rapid iteration of digital technology, we must maintain our strategic direction and roadmaps and turn plans into reality step by step. But, we must also keep an eye on development trends and explore new technologies to ensure we stay ahead of the curve and avoid a situation where the project falls behind and becomes immediately out of date once it's deployed. That's why we will keep in mind the 'One Airport, One Dream' concept. ▲

# Shenzhen Metro Builds Industry's First Multi-Rail-Line Network Operations CDMC

By *Lei Jiangsong, Deputy General Manager of Shenzhen Metro Group*

Shenzhen Metro Group is integrating emerging technologies into construction to empower digital, intelligent metros. Cooperating with high-tech enterprises, the group is deploying Huawei's Urban Rail Cloud Solution adhering to the 'advanced smart construction concept,' which prioritizes full-lifecycle management.

In recent years, China's urban rail development has embarked on a digital journey via in-depth integration with emerging information technologies. A key milestone on that journey came in March 2020, when the China Association of Metros (CAMET) released the Program of Developing Smart Urban Rail in China. Then, in April, the National Development and Reform Commission (NDRC) issued a 'new infrastructure' policy, which included urban rail transit. Meanwhile, the whole country is promoting the construction of smart cities and large city clusters.

Shenzhen Metro Group (Shenzhen Metro) was the first in the industry to fully adopt cloud computing, big data, and Artificial Intelligence (AI) technologies. It has built a unique

Construction Digitalization Management Center (CDMC) for multi-rail-line network operations, as well as centralized management and control of more than 700 construction sites. The aim is to improve intensive and Information and Communications Technology (ICT)-based management for construction resources.

## New Challenges for Urban Rail Development

In recent years, the Compound Annual Growth Rate (CAGR) of urban rail transit construction mileage in China has been about 19%.

By the end of 2020, Shenzhen had invested more than

	Quantity	Total Mileage (km)	Number of Stations	Number of Construction Sites	Total Investment
Metros (including extension lines)	17	235	149	About 400	CNY238.8B (US\$36.6B)
Inter-city railways	5	340	37	About 216	CNY230B (US\$35.2B)
Co-constructed underground pipelines	4	84	No data	About 60	CNY25.3B (US\$3.9B)

Shenzhen Metro's urban rail development (data from 2020)



*Shenzhen Metro was the first in the industry to fully use cloud computing, big data, and Artificial Intelligence (AI) technologies. It has built a unique Construction Digitalization Management Center (CDMC) for multi-rail-line network operations, as well as centralized management and control of more than 700 construction sites.*

*— Lei Jiagsong, Deputy General Manager of Shenzhen Metro Group*

CNY490 billion (about US\$75 billion) into building a total of 660 km of urban rail lines — including metros, inter-city railways, and co-constructed underground pipelines — across about 700 construction sites.

By supporting about 100 agent-construction projects for the city, Shenzhen Metro has accelerated urban development and helped the Guangdong-Hong Kong-Macao Greater Bay Area achieve its strategic goal of building city clusters.

Because of these achievements, the urban rail development in China has evolved from conventional, single-line to complex, multi-line, and diversified — including comprehensive transportation hubs such as metros, light rails, trams, commuter rails, and Bus Rapid Transit (BRT). This trend has led to a sharp increase in the number of construction sites: The original 60 sites for single-line operations have quickly been expanded to 700 for multi-rail-line network projects, involving more than 100,000 personnel during monthly peak hours. Inevitably, this huge workforce complicates the management of urban rail construction.

Aiming to better manage the process and improve urban rail development services, China plans to reduce the conventional, labor-intensive construction mode with 'smart construction sites' that are ICT-based. A few enterprises have started to explore this concept — which means to integrate smart design, construction, Operations and Maintenance (O&M), and supervision in order to implement more efficient integrated management of the construction process.

In recent years, Shenzhen Metro has deployed an Office Automation (OA) system and a contract management system. It has also built video surveillance, access control, and multi-line video networking systems, as well as security management and integrated engineering project management platforms, in compliance with the government-issued Smart Construction Site Standards. However, there is a major drawback in this approach: Data from the preceding information systems isn't shared efficiently. To make things worse, exhaustive — and sometimes ineffective — manual operations result in inefficient service handling. For example, the video surveillance



*Shenzhen Metro has actively engaged in the city governance system and in Digital Shenzhen's industry ecosystem. This has aided the process of constructing (smart) metros for (smart) city development, and Shenzhen Metro is becoming a leading platform-based company in the digital rail transit industry — greatly contributing to new infrastructure construction in China.*

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system still relies on manual inspection, and this can lead to missing risks or reporting risks when there are none.

By the end of 2019, Shenzhen Metro had done a great deal to eliminate obstacles and reform the systems to address these challenges. Starting from enterprise strategy planning and top-level design, it worked together with multiple high-tech enterprises — including Huawei — to delve into digital transformation solutions by signing strategic framework agreements and seeking management consulting and planning. Ultimately, Shenzhen Metro decided to deploy Huawei's Urban Rail Cloud Solution, referring to the advanced smart construction concept that prioritizes full-lifecycle management.

### Smart Urban Rail: One Map for Urban Rail Construction

The smart urban rail project is deployed in three steps:

**Step 1:** Gradually implement document-free management by promoting online operations throughout the entire rail transport lifecycle.

**Step 2:** Monitor workforce, machines, materials, methods, environments, and measurement using real-time front-end Internet of Things (IoT) sensing systems — all based on standardized and normalized processes. Refine management of safety, quality, progress, investment, and plan, and ensure the construction process is controllable.

**Step 3:** Accumulate a multitude of data and apply digital technologies — such as big data and cloud computing — to turn data assets into a basis for decision-making, implementing digital and intelligent management and

control of urban rail development, and promoting service transformation.

After intense efforts, Phase 1 of Shenzhen Metro's smart construction project — CDMC — went live as scheduled. It integrates data of various service systems and provides one rail construction map to comprehensively monitor more than 700 construction sites, as well as the investment, progress, the parties involved, safety, quality, personnel, equipment, and green construction status. The system also allows both horizontal and vertical comparisons of data in terms of time, construction unit, line, area, and site; makes core data visible and manageable; and supports auxiliary management and decision making of construction projects.

#### Complex offline document-based processes:

Shenzhen Metro integrates the industry's best practices to build a comprehensive engineering project management system that helps prevent wasted expenditure and features cloud-based planning, interworked electromechanical systems, safety and quality assurance, Metro-Common Information Management (M-CIM), Digitalization-Engineering Project Management (D-EPM), and question pool coordination. The group accelerates ICT-based management for the entire lifecycle of urban rail transit — including planning, design, construction, acceptance, and handover — and promotes document-free services. This minimizes and mitigates information-sharing difficulties during metro construction.

**On-site safety control:** Shenzhen Metro uses information technologies to implement integrated management of safety risks, hazard checks and handling, and Tunnel

Boring Machines (TBMs)-based construction. It aims to enable hierarchical management and control, dynamic monitoring, as well as risk and hazard prevention by prioritizing earlier control, precise management, source governance, and scientific prevention. Through collaboration with several other parties, Shenzhen Metro has achieved standardized, normalized, and ICT-based construction.

**Construction technology standardization:** Shenzhen Metro develops feasible and operable outlines for major operational methods to standardize the management functions of all parties involved and define specific management requirements. It also uses ICT tools for standardized and quantifiable management.

**Mechanical equipment management:** Shenzhen Metro uses front-end monitoring devices, sensors, and collection software to monitor the running status of gantry cranes, tower cranes, Power Distribution Boxes (PDBs), and TBMs in real time. Details include the load, torque, wind speed, amplitude, angle, and hoisting height of tower cranes; excavation earth pressure, main thrust force, torque, and posture of TBMs; and current and temperature of PDBs. The data obtained is transmitted to the information platform in real time for summarization and processing. When an exception occurs, a warning signal is sent to remind management personnel to deal with it.

**Material management:** Shenzhen Metro dynamically tracks material-related processes — such as supplier selection, material bidding, application, usage, and inspection, as well as unqualified material withdrawal — on an information platform. The platform carefully

monitors the entire material lifecycle to ensure early prevention, in-event tracking, and post-event tracing, avoiding quality accidents.

**Environment monitoring:** Shenzhen Metro installed environmental-monitoring devices to detect on-site particle mass concentrations, dust, noise, temperature, humidity, and wind direction and force. The data is sent to the monitoring platform in real time for statistical analysis, warning, and on-site construction guidance — reducing the negative impact of rail construction on city life and transforming the extensive management mode.

**Personnel management:** Shenzhen Metro has set up a real-name workforce platform and deployed facial recognition turnstiles on site to detect exceptions, such as untrained employees, to implement timely prevention and control. Any worker who repeatedly violates production management regulations is recorded in a list and is prohibited from entering the site.

Huawei's video surveillance and risk identification solutions enable Shenzhen Metro to access construction site videos and intelligently analyze them in a unified way. Real-time HD video sending and AI-based identification of safety hazards replace manual inspection in some situations, increase efficiency, and prevent accidents.

Previously, it took seven days for a 15-person team to inspect more than 400 construction sites, which was time-consuming and labor-intensive, and it was only possible to do spot-checks. In contrast, Huawei's Smart Construction Solution intelligently takes snapshots using AI video algorithms to automatically identify safety hazards, such as personnel without helmets or reflective vests,



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*Through years of exploration and the implementation of the CDMC, Shenzhen Metro has changed its extensive, conventional management mode, and worked toward achieving refined and ICT-based management of urban rail development services, eliminated data-sharing obstacles during construction, and promoted in-depth application of big data in the service field. >>*

open flames, smoking, geofence intrusion, and dangerous climbing. The solution improves the safety hazard identification rate by about 30%, reduces routine inspection workload by 35%, and significantly increases work efficiency by shortening the identification time from days to minutes.

As well as improving the construction safety and supervision efficiency, the solution has also deterred on-site workers from misconduct, reducing risk-concealing and false positives and negatives, and effectively regulating construction units.

Shenzhen Metro has also set up an ICT-based dispatch, command, and control system for track areas. The system generates warnings when trains are approaching or are speeding, through proper shifting and scheduling of work vehicles and personnel, reducing safety accidents in the track area by 85%. It streamlines the entire process — from incident response, to reception, to handling. If there's a safety incident, PCs, large screens, and cellphones are linked in real time for efficient response. Shenzhen Metro uses VR glasses with on-site video backhaul function for the command center to monitor on-site situations, facilitating more efficient handling.

In the future, the rail transport industry will use big data and AI to enhance the safety quality control of TBMs. Shenzhen Metro integrates AI into TBM safety management services. It has independently developed a smart big data platform for TBM construction, and created various predictive models concerning TBM safety — such as TBM selection, ground subsidence, excavation parameters, fault diagnosis, and posture correction. The platform warns about potential

accidents in the subsequent construction based on the prediction results, monitors the work environment of TBMs, and supports TBM drivers' operations — effectively ensuring the safety of construction personnel and the quality of tunnels.

The smart construction project also supports multi-dimensional statistics and display of metro construction and government supervision data, as well as associated invoking and analysis of event-related data, to provide auxiliary management and decision-making support for metro construction at the macro level. For example, the overall construction situation as well as warning analysis is available, including various indicators, such as investment trends, engineering process, and statistics of all parties, safety alarms, and rankings.

Through years of exploration and the implementation of the CDMC, Shenzhen Metro has changed its extensive, conventional management mode; worked toward achieving refined and ICT-based management of urban rail development services; eliminated data sharing obstacles during construction; and promoted in-depth application of big data in the service field — leading intelligent innovative applications in urban rail construction.

Shenzhen Metro has actively engaged in the city governance system and in Digital Shenzhen's industry ecosystem. This has aided the process of constructing (smart) metros for (smart) city development, and Shenzhen Metro is becoming a leading platform-based company in the digital rail transit industry — greatly contributing to new infrastructure construction in China. ▲

# Innovative Urban Rail Cloud: Hohhot Metro Reaps the Advantages of Being a Late Mover

*By Chen Huijuan, Global Transportation Business Unit of Huawei's Enterprise Business Group*

**R**apid urbanization and technological development go hand-in-hand. And as urban development accelerates, so too does the demand for better performing public services. Here, urban rail transit is no exception. We have, therefore, now arrived at a new, pivotal period: Technologies powered by 5G, cloud computing, and big data are being applied during the construction and operations of urban rail transit.

On December 31, 2019, Hohhot — the capital of Inner Mongolia — officially opened its first metro line, Line 1, which also happens to be the first in the world to deploy Huawei's Urban Rail Cloud, an industry-leading multi-line, multi-system cloud solution. In short, this solution provides comprehensive support for rail transit operations, in turn revolutionizing the experience for passengers.

## **Implementation of the Urban Rail Cloud**

As early as 2016, during the initial phase of Line 1's construction, Hohhot Metro proposed and subsequently followed a 'cloud computing + urban rail' guideline and model. This model encourages the use of emerging technologies, such as cloud computing and big data, to support everything from subway operations and production, to the management of the enterprise, construction and resources. An intelligent cloud platform was therefore built for the design, construction, and operations of Hohhot Metro, implementing full coverage of informatization services as well as unified Operations and Maintenance (O&M) and security control. To ensure smooth implementation for the project, Hohhot Metro adopted an

approach of 'bold planning, careful verification, testing first, and ensuring reliability,' all while using innovative technology to ensure safety and improve efficiency during construction. As the cloud solution provider of the project, Huawei has world-class technologies in the field of cloud computing, big data, Internet of Things (IoT), and emergency communications. It also has extensive experience in rail transport informatization.

In the implementation phase, Huawei's project team organized leading industry experts to work onsite. Throughout the entire process — starting from the centralized deployment of a single system, developing into that of multiple systems, then ending with that of full systems — the solution was constantly optimized to meet evolving requirements. If and when service requirements changed, each and every step was carefully reviewed, ensuring smooth solution implementation.

In the testing phase, the project team performed multi-phase, multi-batch, and long-term tests together with several other mainstream service providers, all at the Urban Rail Ecosystem Lab of Huawei's OpenLab in Suzhou. Verifying feasibility was crucial and it required extensive testing, involving eight service systems, more than 30 mainstream equipment vendors, six test directions, and more than 600



*Huawei's urban rail cloud solution serves as a platform that carries metro services, laying a solid foundation for our innovations, and secure and efficient operations. Unified equipment and O&M management not only improve resource usage by 40%, but also simplify our O&M. This allows us to invest more resources and energy in service innovation and high-quality development.*

*— Liu Zhanying, Chairman of Hohhot Metro*

test cases. Huawei also set up test platforms in Hohhot itself and in Horinger County, some 60 km south of Hohhot, to perform simulations based on actual project requirements. This not only helped ensure the successful delivery of the solution, it also enabled invaluable experience to be collected — experience that can be applied elsewhere, in the future.

The solution achieved full coverage across the entire metro system, consisting of one control center, one train depot, and a total of 20 stations. All service systems — including the Integrated Supervisory Control System (ISCS), Passenger Information System (PIS), Auto Fare Collection (AFC), Access Control System (ACS), Closed-Circuit Television (CCTV), and Automatic Train Supervision (ATS) — were supported through a unified Huawei cloud platform.

At the top-level design, Huawei built three cloud platforms — for the production center, the Disaster Recovery (DR) center, and stations and depots — providing Infrastructure as a Service (IaaS) for multiple systems. This meets the existing requirements of Hohhot Metro Line 1 and Line 2 — the latter first opened on October 1, 2020 — and also reserves capacity to accommodate Line 3, Line 4, and Line 5 in the future.

All of this means that, despite being a relative latecomer, compared with other Chinese cities, Hohhot Metro is now leading the way in innovative subway construction. That's all thanks to Huawei's urban rail cloud solution. Indeed, According to the China Association of Metros (CAM), the Hohhot urban rail cloud project improved resource usage by over 50%, compared to similar projects, slashed initial investment by approximately 40%, and increased operational and management efficiency by more than 30%.

In terms of security and reliability, the 'inter-network isolation and intra-network protection' approach has improved the security of the entire platform by more than 80%. Meanwhile, the three-level assurance mechanism — based on the active center, the DR center, and the station cloud nodes — has improved service reliability by more than 50%.

On September 6, 2019, during the Urban Rail Cloud Innovation and Application Seminar held in Hohhot, more than 300 urban rail transit experts and scholars from across China visited the Network Operations Control Center (NOCC) of Hohhot Metro. The visitors were especially impressed with the multi-line and multi-system urban rail cloud.

They spoke highly of Hohhot's urban rail cloud construction, highlighting its benefits for subway construction and improving operational efficiency. They also recognized the exemplary role it is playing, leading the urban rail transit industry in China toward digitalization and intelligence.

### Benefits of the Urban Rail Cloud

At the end of the day, improving production, operations, and passenger services is the core goal of any smart urban rail construction project. Therefore, existing fragmented construction modes need to be eradicated, paving the way for new platforms that can make the most of new Information and Communications Technology (ICT) capabilities. These platforms can collect and accumulate general customer requirements, in turn simplifying the development of smart applications while also driving innovation.

To this end, Huawei developed the urban rail cloud solution with five fields in mind: operations and production, enterprise management, construction management, operation management, and asset management. In addition, a unified cloud platform architecture — consisting of a safe production network, internal management network, and external service network — was adopted to support the construction of the informatization platform, delivering five key benefits to customers in the urban rail transit industry.

**Secure and reliable service operations:** Strict compliance with China's Level-3 security protection requirements is assured. The safe production network, internal management network, and external service network were

designed for the active center, DR center, and stations and depots, respectively, implementing horizontal full coverage and vertical end-to-end security protection for metro services.

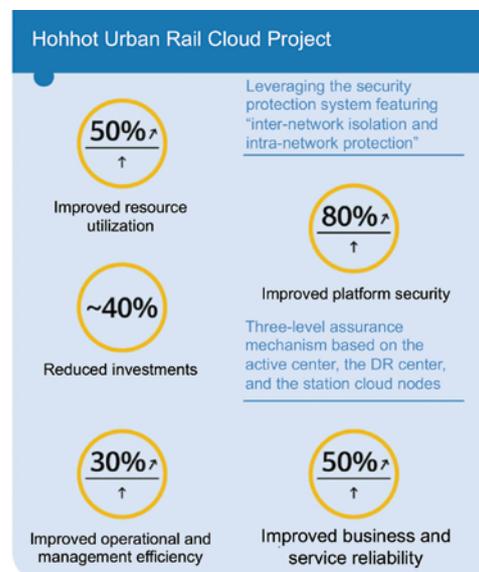
**Centralized O&M management:** The solution unifies service processes and operation guidelines, supports automatic service deployment and intelligent device status analysis, and implements visualized management and control of hardware resources. This improves O&M efficiency and reduces the need for highly trained maintenance personnel.

**Complete enterprise information architecture:** Production and operations, enterprise management, and customer service are optimized and integrated by establishing a complete enterprise information architecture. In the future, massive amounts of service data will be shared, maximizing its utility and facilitating enterprise management.



*As the cloud solution provider of the Hohhot Metro project, Huawei has world-class technologies in the field of cloud computing, big data, Internet of Things (IoT), and emergency communications. It has extensive experience in rail transport informatization, too.*

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Source: China Association of Metros



*Digital transformation is an ongoing process. The application of new technologies — such as 5G, big data, cloud computing, and Artificial Intelligence (AI) — will constantly drive the construction of smart urban rail. >>*

**Reduced initial construction costs:**

Information Technology (IT) resources and station resources such as equipment rooms, power supplies, and environmental control and firefighting equipment are all integrated, boosting overall resource utilization.

**Elastic capacity expansion and efficient services:**

The cloud platform streamlines the computing, storage, and network architectures of all lines and systems, maximizing the value of investments while maintaining high service efficiency. In addition, with the advantages of elastic resource expansion and on-demand resource allocation, the solution supports evolution to cloud databases, big data, and industry-enabled Platform as a Service (PaaS), providing strong support for new service rollout and new line construction in the future.

**Huawei's 'Platform + AI + Ecosystem' Strategy**

Digital transformation is an ongoing process. The application of new technologies — such as 5G, big data, cloud computing, and Artificial Intelligence (AI) — will constantly drive the construction of smart urban rail. 5G applications, specifically, are reshaping connectivity, providing the urban rail industry with full-service data sharing, data governance, and data analysis. Meanwhile, the future will see intelligent O&M, intelligent operations, and intelligent services develop further in the industry, thanks to the application of AI.

Huawei's contribution to the urban rail industry has been extensive, further evidenced through a joint innovation lab established with Hohhot Metro, Beijing Jiaotong University, and Traffic Control Technology (TCT) Co. Ltd. What

each division of the partnership offers is clear-cut: Huawei provides platform products and technologies; Beijing Jiaotong University provides talent cultivation and theoretical research; TCT focuses on developing segmented applications for urban rail transportation; and Hohhot Metro provides application scenarios. Thanks to the efforts, investments, and complementary strengths from all sides, the joint lab has been able to successfully integrate production and research with actual applications.

On one hand, the joint innovation lab can implement Huawei's 'platform + AI + ecosystem' development strategy, to accelerate the integration of new technologies into scenario-specific solutions. On the other, it boosts the construction of the urban rail industry ecosystem. Simply put, it makes the urban rail cloud the foundation of smart urban rail construction, meeting ever-changing industry requirements.

With clear strategies and cutting-edge solutions, Huawei has provided solutions and services for more than 170 urban rail lines in over 70 cities around the world. The urban rail cloud has become the development standard for the entire industry and a solid foundation for digital transformation.

Looking to the future, Huawei will continue to invest in the urban rail industry, promote the application of more new technologies, and deliver optimal scenario-specific solutions. Guided by the 'platform + AI + ecosystem' strategy Huawei will work with software and hardware vendors, system integrators, big data integrators, and industry application developers alike, to jointly build world-leading, future-oriented smart urban rail systems. ▲



# How a Xi'an Locomotive Depot Safeguards Railway Transportation with 5G and AI

*By Guo Qianli, Chief Architect of Railway Industry, Global Transportation Business Unit of Huawei's Enterprise Business Group  
Chen Danfeng, Senior Architect, Global Transportation Business Unit of Huawei's Enterprise Business Group*

**T**asked with ensuring the safety of train operations, locomotive experts are invaluable in railway transportation. Huawei's Smart Locomotive Solution, which is powered by 5G and AI, can free these key workers from exhaustive, cumbersome tasks and significantly improve safety assurance capabilities and efficiency — as railway transportation sets a standard for upgrading industries from person-assisted to tech-assisted operations.

China's railways supported 3.66 billion passenger trips in 2019. The safety and comfort of the passengers on each of those train rides were ensured by locomotive experts — including several specialists.

Several of those specialists are deployed at the locomotive depot at China Railway Xian Group (CR-Xi'an), which is responsible for all passenger trains departing from or passing through Xi'an — the capital city of northwest China's Shaanxi Province, with a population of about 12 million.

Those specialists include Li Xiangqian, the Chief Engineer of China Railway, who receives a special allowance from the State Council of China; Zhou Miaosheng, who holds a National May 1st Labor Medal and has been officially recognized as a

role model of CR-Xi'an and as an 'admirable railway employee during the Spring Festival travel rush'— a time when hundreds of millions of train journeys are made nationwide.

Other experts at the depot include image analysts, such as Sang Minghui, who is able to gain insight from typically under-used data and makes decisions based on video footage.

These experts are busy year-round, but their workloads increase sharply during the Spring Festival travel rush. The amount of work to be done is so vast that these experts are typically only able to spend Chinese New Year's Eve with their families every four or five years.

As well as being responsible for all passenger trains departing from or passing through Xi'an, CR-Xi'an's Locomotive Depot

*In the conventional mode, multiple scenarios – such as onboard data transfer, driver-related video analysis, and equipment status check and evaluation – require manual intervention. This means locomotive experts have a heavy daily workload that leads to low efficiency and causes safety hazards.*

also monitors the performance of train drivers (including drivers of high-speed railways). Locomotives and drivers are critical to ensure safe train operations, so locomotive experts start working as soon as a locomotive enters the depot, which is when image analysts monitor drivers' operations and specialists check the health status of locomotives.

### Manual Operations Limit Image Analysts' Capabilities

Because they are directly responsible for the property and safety of thousands of passengers, train drivers face a lot of pressure. Tasked with controlling safety risks, Xi'an Locomotive Depot has assigned 40 dedicated image analysts

to perform correlation analysis of video footage and train control and monitoring (LKJ) system data while trains are en route to their destinations, as well as do spot checks and record driving violations, and then implement appropriate sanctions or penalties.

Typically, each locomotive is equipped with seven cameras to record videos of the cab, mechanical room, and rail conditions when the vehicle is in motion, generating about 30 GB to 50 GB of data each time it performs an operation. A locomotive's onboard data is manually copied using USB flash drives, and the data transfer takes over 40 minutes, which is inefficient and labor-intensive.

Complicating things, manual data copy can cause various safety risks, for example, the onboard computer may be

#### Manual Onboard Data Transfer



- **Labor-intensive:** Dedicated data transfer teams and equipment
- **Time-consuming:** Low port rate; about 40 mins for data transfer of a single locomotive
- **Risks:** Damage-prone device interfaces and USB flash drives; viruses, as well as data loss and tampering

#### Manual Analysis of Video Footage



- **Error-prone:** Fatigue can lead to errors
- **Limited:** Spot checks can't cover all videos because there is so much data
- **Inefficient:** Complicated scenarios, difficult correlation analysis

#### Manual Health Evaluation



- **Need for experience and expertise:** Manual checks and analysis
- **Information silos:** Difficulties sharing data between different systems; unable to determine root causes for equipment faults because of a lack of correlation analysis
- **Poor collaboration:** No automatic service ticket association, and problem tracking is difficult

The locomotive domain suffers from a lack of informatization and intelligence, which has severely limited its service development.

infected with the USB flash drive viruses; difficult management and control of multiple intermediate links pose data tampering and damage risks; and the USB ports of onboard devices may be destroyed.

Manual video analysis can't cover massive amounts of video data and problems are easily overlooked when analysts become fatigued and their eyes are tired. Another problem is that experienced train drivers' expertise is wasted as they need to act as image analysts.

### The Urgent Need for Tech-Assisted Methods

A total of 70 specialists from Xi'an Locomotive Depot's dedicated inspection and repair team continuously check the health status of hundreds of locomotives every day. They climb on top of trains, go down to trenches, and walk around in narrow mechanical rooms. All kinds of specialists — locomotive and electrical fitters, and braking, welding, or pantograph- Overhead Catenary System (OCS) system detection engineers — need to comprehensively check each locomotive in the shed within a limited time period (20 minutes during the Spring Festival travel rush), quickly locate faults, and act fast — ensuring all locomotives can drive out of the shed on time and run safely.

Integral to locomotive efficiency and safety, running gear is roughly equivalent to a car chassis, though it's more complex. It's the lower part that guides the train to run along the tracks and transmits all the weight to the rails. It comprises the wheelset, journal box lubricators, side frames, bolsters, and spring shock absorbers.

A single set of running gear usually includes 2306 screw bolts. Using the conventional repair and examination mode, railway staff need to check whether each of the screw bolts and other key components of the running gear are working properly — either by using only their naked eyes, or by tapping on the components with a hammer and listening to the sound. This relies on the railway staff having a lot of experience of manual checking, and even that doesn't guarantee that all components will be checked effectively. In addition, workers need to perform multiple complex operations for each locomotive after it moves into the depot. Although various sensors are installed at key components, the sensor data isn't fully used, so frequent manual maintenance is required, and this wastes both manpower and material resources.

When the key components have major health issues, specialists need to take targeted measures based on the locomotive's repair process, historical problems, and symptoms, and send the locomotive to the shed or factory if necessary. More systematic and comprehensive diagnosis and specialized treatment can take weeks, which is severely detrimental to the operational efficiency of railways. Some of the more complex issues rely on specialists' experience. The transition from person-assisted to tech-assisted repair, and consistent optimization of health management for locomotives and key components, as well as repair classes and systems need to be implemented as soon as possible.

### Smart Locomotive Solution: Powered by 5G and AI

After years of involvement in the industry,



*Huawei's Smart Locomotive Solution uses world-leading 5G technologies to replace manual operations. It can lead to a ten-fold increase in data transfer efficiency and automatically obtain real, complete driver surveillance footage. >>*

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*The smart locomotive solution has raised the detection rate of faults and driving violations for image analysts. It uses 5G to transfer all driver-related video data to the intelligent analysis center through high-speed cache devices and automatically identifies violations using AI. >>*

Huawei has gained in-depth insight into railway transportation. Applying its leading communications and digital platform capabilities, Huawei and industry partners launched the innovative Smart Locomotive Solution, which uses 5G and AI. This solution reduces locomotive experts' heavy workloads, enables more intelligent operations, and better ensures railway transportation safety — helping CR-Xi'an embark on a smart journey.

This solution uses Huawei's world-leading 5G technologies to replace manual operations. It can lead to a ten-fold increase in data transfer efficiency and automatically obtain real, complete driver surveillance footage.

The solution works on the emerging mmWave band and uses beamforming (phased-array antennas, supporting fast attenuation and low interference beyond the coverage area) and intelligent tracking (ensuring the alignment between the Railway Base Station (RBS) and Train Access Unit (TAU) at all times, with stable bandwidth) technologies, to achieve high-speed train-to-ground data transfer. When a locomotive slowly enters a depot, a high-speed channel of 1 Gbit/s or above is automatically established between the TAU and RBS within 300 to 500 meters in the depot's throat section, supporting a maximum transfer rate of over 1.5 Gbit/s. About 30 GB of onboard data is generated

during each locomotive operation, which can be automatically dumped within three minutes.

The entire data transfer process ensures data integrity, and it's secure and reliable without manual intervention, ten times faster than manual data copy. The smart locomotive solution is the railway industry's first intelligent application of 5G. It will facilitate more efficient manual data copy, eliminate safety risks, improve data reliability, and tackle many other issues, providing complete video data for image analysts.

The smart locomotive solution has raised the detection rate of image analysts. It uses 5G to transfer all driver-related video data to the intelligent analysis center through high-speed cache devices, and automatically identifies violations using AI.

Huawei's AI platform — HUAWEI CLOUD ModelArts — provides industry-leading computing power, enabling partners to shorten the training duration of a single model from one week to only one to two days and supporting fast application. It is the fastest training platform certified by Stanford DAWNbench — a benchmark suite for end-to-end deep learning training and inference — setting a new record of 4 mins and 8s (it takes 18 minutes to perform the same type of model training on the AWS).

The solution also supports customized development of video-based behavior analysis algorithms based on actual scenarios. A total of 11 driving violations can be automatically, intelligently identified, such as not making gestures, using electronic devices, not operating the steering wheel or workspace equipment properly, and showing signs of fatigue. The intelligent driver evaluation mode helps

Task	Conventional Locomotive	Smart Locomotive
Data transfer	4-8 dedicated workers per depot; about 40 mins each time	Fully automatic; about 3 mins
Video analysis	Manual spot checks, heavy workload, and limited coverage	Intelligent analysis, efficient, 100% coverage
Routine examination and repair	Planned maintenance, requiring comprehensive manual checks and analysis	Condition-triggered, on-demand maintenance according to equipment status

A comparison of conventional and smart locomotives

regulate driving behavior and ensure safety, eliminating the issues caused by the inefficiency and insufficiency of manual spot checks. In the past, one employee could only check four locomotives every day; with the intelligent analysis technology, an employee can process analysis results of over 40 locomotives daily, increasing the efficiency by ten times.

The smart locomotive solution uses big data diagnosis to predict the health status of key components. Using the Huawei big data platform's integration, storage, query, analysis capabilities, as well as support for data warehouses and Business Intelligence (BI), and data connectivity and sharing capabilities of the ROMA platform, the solution streamlines multiple core service systems to build an End to End (E2E) locomotive information sharing platform.

The solution builds fault prediction and health management models for locomotive running gear based on the data of onboard sensors or concerning ground operational safety, servicing, and repair, as well as extensive expert experience and fault examples accumulated by Huawei partners. Such models implement health evaluation and service life prediction functions, and they provide a scientific basis for the reform of repair processes and systems during the transition from planned to predictive maintenance.

The big data platform supports analysis of massive amounts of historical status data of running gear sensors and health evaluation of key components. By drawing endurance curves and generating timely alarms for unhealthy components, the platform minimizes manual inspection and repair times and prevents minor issues from escalating into more difficult problems.

Big data can also be applied to detect flaws in railway axles. The health status of axles is crucial for safe train operations. Inefficient detection of axle damage causes larger and larger cracks, which can lead to disastrous consequences such as train derailment. The damaged key components, such as drawbars and couplers must be replaced in time for safety reasons. In line with regulations, any wheelset with over 2-mm holes or 0.7-mm peelings should immediately be replaced. However, damage to axles is usually very minor, and it usually takes three or four rounds of manual inspection before the damage is identified and confirmed. With big data analysis, the solution obtains the status data of axle sensors — such as temperature and vibration — to evaluate whether they are healthy, and predict fault risks and generate alarms accordingly. As well as increasing the repair efficiency, it also reduces safety hazards.

### **Smart Locomotive: From Person-Assisted to Tech-Assisted**

The application of Huawei's 5G- and AI-based Smart Locomotive Solution reduces the safety issues that occur while locomotives are running by more than 10% and leads to an over ten-fold increase in the data collection and analysis efficiency, saving millions of CNY (CNY1 million is about US\$153,000) in operational costs per locomotive depot per year and greatly reducing safety risks.

The solution allows locomotive experts to spend time with their families during national holidays, while safeguarding the travel of the potential 1.4 billion train passengers who live in China. ▲



*The application of Huawei's 5G- and AI-based Smart Locomotive Solution reduces the safety issues that occur while locomotives are running by more than 10% and leads to an over ten-fold increase in the data collection and analysis efficiency. >>*

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# Enabling Digital Transformation with Port Intelligent Twins

*By Wang Tiangang, Chief Engineer of Water Transportation Solutions of Huawei's China Government & Enterprise Transport Business Dept.  
Chen Huijuan, Senior Marketing Manager of Huawei's Global Transportation Business Unit*

For thousands of years, ports have been all-important transportation hubs. In recent years, with the continuous growth of the business volume, ports have new requirements for digital transformation using new technologies and concepts.



Located on the west shore of the Bohai Bay, on China's northeastern coast, Tianjin Port is the sea portal of the Beijing-Tianjin-Hebei region that connects Beijing and Tianjin — two of the biggest cities in the northeastern part of the country — with Hebei, one of its largest provinces. This area includes

the Xiong'an New Area — a state level new area that's a development hub for Beijing, Tianjin, and Hebei. It's also the sea-land intersection of the Belt and Road Initiative, an important node of the economic corridor of the New Eurasian Land Bridge, and an international hub offering customers a

*As a key port in the northern China, Tianjin Port Group hopes to apply advanced technologies — including Artificial Intelligence (AI), big data, cloud computing, and 5G — to core production business, enabling scientific operations at the port, improving operation efficiency, and reducing operations costs.*

full range of services. The port trades with more than 800 ports in over 200 countries and territories around the world, making it one of the world's top ten ports in terms of cargo volume for many consecutive years.

As a key port in northern China, Tianjin Port Group hopes to apply advanced technologies — including Artificial Intelligence (AI), big data, cloud computing, and 5G — to core production business, enabling scientific operations at the port, improving operation efficiency, and reducing operations costs. This is how the group aims to establish the port as a world-class international hub that features smart, green, and secure services.

To meet that objective, the group devised a strategic goal: By 2028, the container throughput will exceed 30 million Twenty-foot Equivalent Units (TEUs), and the port will gain a firmer foothold as an international hub, provide services with global-leading efficiency, and become a world leader in smart port construction.

### Traditional Ports: Unable to Meet Service Development Needs

Inventory turnover — selling and replacing stock — is an important service for traditional terminals. In recent years, large- and medium-sized ports have constructed new terminals and berths to meet increasing inventory turnover requirements. Existing terminals, meanwhile, need intelligent, automated, and refined means to improve their operation efficiency. In this process, Tianjin Port faces several challenges.

- **Vast Staffing Requirements**

Tianjin Port has an annual container throughput of 18.35

million TEUs. Its employees total 20,000, including many operators on the terminals — such as container truck drivers, yard crane operators, dispatchers, and tally clerks — as well as on-site security supervision staff.

Following years of automation-oriented reconstruction, Tianjin Port completed the remote control reconstruction of yard cranes and the testing and launching of unmanned container trucks. Now that its automation processes have improved, Tianjin Port needs a horizontal transportation system to ensure better coordination and effective use of automatic equipment.

- **Improving Automatic and Intelligent Scheduling**

Every day, dozens of ships dock at the port, hundreds of container trucks travel back and forth, tens of thousands of containers are loaded and unloaded, and tens of thousands of external container trucks enter the port to collect containers. All of these operations require port planners to formulate plans manually. Although some of Tianjin Port's terminals have improved the operation efficiency through the use of technology and effective work methods, including the use of equipment such as quay cranes, the port still urgently needs to use the latest technologies, such as AI, to implement intelligent scheduling and planning.

- **Managing Port Operations**

Ports are difficult to manage: They're closed areas filled with people, vehicles, goods, and ships; they also involve a lot of energy consumption, maintenance, and operations. To ensure everything is running smoothly, the operation status of each terminal needs to be reported to the upper level in the form of monthly, quarterly, and annual reports. Meanwhile, mid- and senior-level leaders need to access multi-dimensional and

accurate operation data from the entire port group and each terminal in real time, so that group leaders can understand the operation status and provide sufficient support for future operation decision-making.

To manage terminal production activities and labor and energy consumption, engineers need data about the personnel, equipment, and energy consumption of the entire port and terminals. Meanwhile, the resource consumption data of each ship, each container, and each quay crane is required; in this way, the data can be precisely analyzed to further reduce the port's operation costs.

### **A Need for Intelligent Management Methods**

More than 10,000 cameras have been deployed in Tianjin Port, ensuring full coverage without blind spots. Most of the cameras are traditional, though, so security staff must be assigned to each of the port's

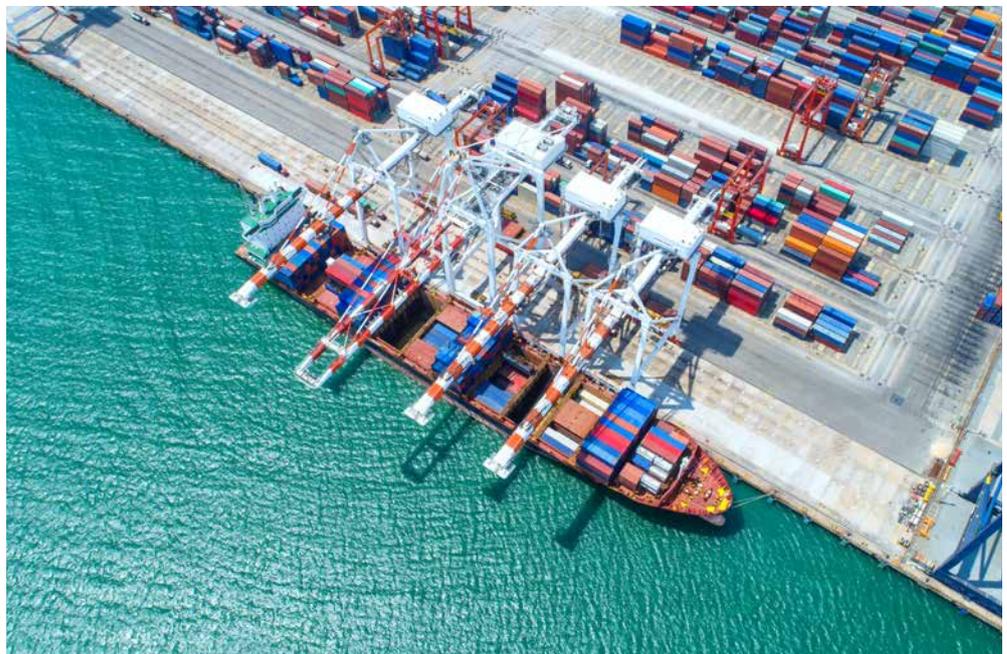
terminals. The port urgently needs proactive security protection to improve the inspection efficiency and efficiently detect violations, such as illegal parking of trucks, speeding, and unauthorized access to restricted areas.

### **Port Intelligent Twins: Enabling Tianjin Port's Digital Transformation**

At the 4th World Intelligence Congress in June 2020, Tianjin Port Group and Huawei signed the Strategic Cooperation Agreement at the Intelligent Transportation Summit.

By cooperating on information-based top-level design and smart port construction, the two parties aim to build a port demonstration project, set an industry benchmark, and build a world-class hub that's green and smart.

Tianjin Port worked with Huawei's team to plan 14 implementation projects in six fields:



ships, goods, container trucks, security protection, operations, and equipment. The concept of Port Intelligent Twins was proposed, with a vision to create an intelligent twin of the port that requires no manual intervention and operates logically, scientifically, and optimally.

Huawei Port Intelligent Twins consist of four intelligent aspects: applications, a hub, connectivity, and interactions.

**Intelligent applications:** The port's core production system is comprised of its intelligent applications, which include the intelligent Terminal Operating System (TOS), production auxiliary system, horizontal transportation system, and logistics management system, which can help make the port service system smarter.

**Intelligent hub:** As the core of the port, the intelligent hub is the operation and decision-making center, consisting of AI, data analysis, intelligent video, and autonomous driving modules, and provides decision-making support for the running of smart applications.

**Intelligent connectivity:** People, vehicles, ships, objects, and goods of a smart port can be connected to the virtual world through 5G, Wi-Fi 6, and microwave technologies to achieve full connectivity of the port. In this sense, connectivity essentially acts as the nerves of the port.

**Intelligent interactions:** Sensing and interaction equipment such as the videos, sensors, Global Positioning System (GPS), and radars are involved, facilitating real-time data collection of the entire port and data exchange.

Based on the main pain points in the smart port construction process, the two parties planned and partially implemented intelligent scenarios such as a horizontal transportation system and intelligent port scheduling.

### • Horizontal Transportation System

The joint commissioning of unmanned container trucks was completed for the no.1 berth at the intelligent container terminal in Section C of the Beijiang Port Area (the Northern Port Area of Tianjin Port). After five months of design and verification, this solution integrated smart port products, such as unmanned track cranes, unmanned electric trucks, and unmanned container cranes under remote control, featuring

significant breakthroughs in multiple key technologies. Huawei provided infrastructure products and solutions such as the intelligent horizontal transportation system, cloud platform, data middle ground, network, Intelligent Vision (Huawei's machine vision product series), and data center — enabling Tianjin Port to take a critical step forward in digital transformation and intelligent upgrade.

### • Intelligent Port Scheduling

Based on in-depth research, Tianjin Port has planned scenarios, including creating a container Crane Work Plan (CWP), berth allocation, single-ship intelligent stowage, and intelligent container yard plan. These plans aim to implement efficient port scheduling based on the port's initial restrictions, AI technologies and models, and the experience data and simulation system of existing stowage personnel, as well as machine learning and self-training. These scenarios are being developed and will be gradually implemented in 2021.

**Container crane work plan:** Introducing the CWP concept will spur a major reform of the terminal production mode. By referring to the successful experience of advanced ports at home and abroad, the port will make a change from the control-centered mode, and precisely manage plans and control to focus on both efficiency and benefits.

**Berth allocation:** The intelligent berth planning solution involves integrating berth resources, container crane resources, ship-to-port dynamic information, port machinery, and manpower information; optimizing algorithms based on the operation; and providing operation management personnel with decision-making support for intelligent berth planning to improve the comprehensive efficiency of port resources.

**Single-ship intelligent stowage:** With AI algorithms, an intelligent single-ship planning solution will be implemented to replace manual operations. This way, the port can ensure sailing safety, enhance the loading and unloading efficiency of ships, and improve economic benefits of marine container transportation.

**Intelligent container yard plan:** The main points of the container yard plan are: **Decision-making on container yard space allocation:** Arrange stack sections and slots of



*Tianjin Port and Huawei will work together on port automation and intelligent fields to build Port Intelligent Twins, and improve security, efficiency, and experience. >>*

containers to minimize the moving distance of loading and unloading machines. **Decision-making on stack collapse:** Formulate a stack collapse solution in the container yard under a given ship loading and unloading sequence to minimize the rate of stack collapse.

Phase 1 of Tianjin Port and Huawei's solution was successful. And by optimizing and iterating Phase 1 of the solution, the two parties have started cooperation on Phase 2, including smart building, smart port, smart energy management, smart control platform, and video platform projects.

**Customer Business Indicator Improvement: Displaying the Business Value of Solutions**

Through the implementation of the Phase 1 project and long-term blueprint planning, Huawei and Tianjin Port aim to support better labor structure, ensure higher efficiency and lower costs, and enable safer port operations.

**• Better Labor Structure**

Traditional terminals, being labor-intensive, regard frontline operators as of paramount importance. By adopting digital transformation measures, automation, informatization, and intelligence will improve the port's productivity. With the help of unmanned container trucks, the number of truck drivers can be decreased by 90%, and the driver-truck ratio can be reduced from 1:1 to 1:6. Digitalization helps resolve recruitment difficulty and contributes to improvement of the working environment in the port, facilitating the transformation from the labor-intensive industry to the technology-intensive industry.

**• Lower Costs and Higher Efficiency**

Based on the automatic and intelligent smart port solution, Tianjin Port will improve the following business indicators: Shorten the container crane work plan from two hours to 10 seconds; improve the work efficiency by more than 10%; increase the direct berthing rate by 5%; reduce the average loading or discharge time of external container trucks by five minutes; optimize port resource allocation through refined management and reduce the overall operation costs by 10%; further enhance the operation capability of the port without needing to build new terminals or berths, and reduce costs and increase benefits through digital transformation.

**• Safer Port Operations**

Planning of the smart port and smart buildings will facilitate smarter management of the port. The security incident identification efficiency is expected to increase by 30% through proactive security protection. Intelligent video surveillance will be deployed for 108 security check projects in the port, reducing the number of manual inspections that are needed. Meanwhile, the port's energy consumption information will be collected precisely, and data analysis models will be adopted to exercise scientific control on energy.

Over the next three to five years, Tianjin Port and Huawei will cooperate on autonomous driving in the port, to build a commercial autonomous driving solution for the port industry. They will work together on port automation and intelligent fields to build Port Intelligent Twins, and improve security, efficiency, and experience. ▲



# Beijing Halosee Develops Intelligent O&M for Urban Rail Transport

*By Wu Zhiqiang, General Manager of Beijing Halosee*

In recent years, the growth of China's urban rail transit network has accelerated. By 2020, 223 lines were operating, spread over 44 of the nation's cities, and there are now more than 6000 km of metro or subway lines sprawling across the country's urban areas.

This rapid growth of the urban rail transit network in China poses significant challenges to the industry's traditional Operations and Maintenance (O&M) system. To address those challenges, Beijing Halosee partnered with Huawei, aiming to

build all-round collaborative intelligent application systems that would support China's urban rail transport industry. Railway equipment is one of ten key industries in the nation's 'Made in China 2025' strategy, and rail transportation is crucial to both



*In the digital era, independent, controllable, secure, and trustworthy technologies have become critical for the digital transformation of enterprises. >>*

China's goal of establishing the country as an innovative manufacturing powerhouse and the success of its Belt and Road initiative.

In recent years, the scale of China's urban rail network has grown exponentially. Urban rail transport has become the main mode of transportation for people in urban and suburban areas, leading to a rapid increase in the number of trains in use. With huge numbers of trains and a tremendous transportation capacity, there's a need for constant and complex O&M and regular repairs. To ensure secure train operations and improve O&M efficiency, the urban rail transit industry urgently needs an intelligent O&M system and innovative service models.

### **Urban Rail Transport Calls for Intelligent O&M**

To ensure a safe and comfortable passenger experience, there are increasingly stricter requirements on the operational quality, security, and reliability of urban rail trains, which in turn leads to higher demands on train O&M services.

Train O&M costs account for over 30% of urban rail systems' overall operational costs. Facing these enormous O&M costs, metro operators must continuously refine their processes.

Typically, train O&M systems focus on planned maintenance. The low train usage and high repair costs — because of either insufficient maintenance or the need for very frequent maintenance — mean that these systems no longer meet the service quality and efficient response needs of the vast numbers of trains now in use.

In the digital era, independent, controllable, secure, and trustworthy technologies have become critical for the digital transformation of enterprises. Integral to China's 'New Infrastructure' plan, the urban rail transit industry must be transformed and upgraded, using secure and trustworthy self-developed technologies.

As a leading rail transport solution provider in China, Beijing Halosee is committed to the research and development of technologies that are integral to that aim, such as 5G, Artificial Intelligence (AI), big data, Internet of Things (IoT), and cloud computing. The company focuses on providing solutions for the rail transport industry with independent, controllable, secure, and trustworthy products and technologies. To support the development of the urban rail transit industry, Halosee partnered with Huawei to develop an intelligent O&M system for the industry.

### **Working with Huawei to Build an Intelligent O&M System**

With years of experience in train

#### **Partner Testimonial**



In the digital era, independent, controllable, secure, and trustworthy technologies have become critical for the digital transformation of enterprises. As a core field in China's 'New Infrastructure' plan, the urban rail transit industry must be transformed and upgraded using secure and trustworthy self-developed technologies.

— Wu Zhiqiang, General Manager of Beijing Halosee

## Beijing Halosee Develops Intelligent O&M for Urban Rail Transport

maintenance, Halosee has unique strengths in this area. Huawei, meanwhile, has the cloud-based Horizon platform, which optimizes and integrates new Information and Communications Technology (ICT) and data, enabling customers to achieve service collaboration and agile innovation.

Applying their respective strengths, Halosee and Huawei jointly built an integrated 'platform + service' solution. By innovating the train O&M model, the solution ensures secure operations, improves O&M efficiency, and has made breakthroughs in the following fields:

**Intelligent trains:** Based on the real-time collection of the status and running data of key components on trains using the IoT technology, Huawei's train-to-ground wireless communications solution transmits data in real time and uses AI algorithms to accurately determine train health status. This enables online fault diagnosis, fault prediction, and sub-health prediction — promoting train management

to a new, intelligent level.

**Intelligent monitoring:** Based on the AI algorithm and real-time monitoring data from track-side detection devices, the solution can accurately determine the train's surface status, shape, and temperature. Information about the status of key train components can be used for real-time train monitoring and fault predication, effectively reducing the workload of manual inspection, improving the accuracy and real-time performance of train fault monitoring, and providing data support for efficient operations.

**Intelligent overhaul:** Traditional overhaul focuses on planned maintenance and repair and relies on the skills and experience of the maintenance personnel. The intelligent O&M platform uses nine-axis sensor inertial navigation and image-assisted identification and positioning technologies to locate and track maintenance personnel.

To monitor the operation process in real time, image recognition technology is applied. The solution can take photos





*A scenario-based urban rail intelligent O&M solution deployed in a major Chinese city's metro network has helped the operator slash O&M costs by more than 60%. >>*

of key overhaul positions and upload the pictures for image comparison and analysis, as well as supervising key overhaul phases to control the repair process and implement post-event tracing. This significantly improves the standardization and intelligence level of train overhaul operations.

**Intelligent O&M system:** There's an integrated support system for metro operators, covering passenger services, O&M services, operational management, and collaborative O&M. The system can comprehensively control the operational status of passenger services and enterprise operations, providing intelligent guidance for enterprise operational decision-making, and accelerating their digital transformation.

The extensive cooperation between Huawei and Halosee has led to the development of a scenario-based urban rail intelligent O&M solution, which has been deployed in a major Chinese city's metro network. The solution has helped the metro operator slash O&M costs by more than 60% and halve the number of frontline O&M workers.

### **Improved O&M for an Intelligent Future**

The intelligent O&M system is an integrated train O&M service cloud platform that uses various new information technologies to support train operations, inspection, and repair. It integrates and processes multi-source heterogeneous data; monitors train operations; handles emergency faults; diagnoses and predicts faults; evaluates and manages train health; and performs key component life evaluation and management.

The intelligent O&M system — key to optimizing passenger experience as well as an effective way for train operators to reduce costs and improve efficiency — is an integrated O&M support platform built upon various technologies. It changes the traditional manual O&M mode from planned repair to status-based repair. This means that the train repair plans are more targeted, which improves train usage and reduces maintenance costs.

Intelligent O&M is also indispensable for urban rail operators to shift from a model that only focuses on operations to an 'operations + service' model, which puts equal emphasis on operations and providing additional and proactive services.

The shift toward an 'operations + service' model is integral to the transformation of the urban rail transit industry, and the intelligent O&M system is key to implementing this model.

Intelligent O&M is also critical for the digital transformation of urban rail operators. The integrated, intelligent O&M support system integrates multiple new technologies. It comprehensively monitors trains, passengers, and enterprise operations, and it provides powerful support for transparent management, data-based decision-making, and O&M automation — facilitating digital transformation for urban rail operators.

Halosee and Huawei will continue to collaborate on urban rail transit's supply chain, smart manufacturing chain, service chain, and technical chain. They will combine their services and technologies to build intelligent application systems for the urban rail transit industry. ▲

# BYD and Huawei: Creating Intelligent Rail Transportation O&M

*By Chen Guofang, President of the Information Engineering Research Institute, BYD Signal & Communication Company Limited*

**T**he rail industry is digitally transforming. Urban rail transportation has rapidly developed in recent years, and the latest trend among enterprises in this evolving field is building secure and efficient rail transportation Operations and Maintenance (O&M) systems to improve the passenger service experiences they can offer.



*During the digital transformation of rail transportation, the data platform is the basis for the interoperability of advanced applications, and intelligence determines the amount of room for improvement for security and user-friendly experiences.*

Enterprises are applying technologies such as cloud computing, big data, and Artificial Intelligence (AI) to drive the information-based, intelligent, smart, and digital transformation of urban rail. The process of smart construction of rail transportation needs a standard data collection and storage management system and a rail transportation data management platform to realize data-sharing between functional systems, which is crucial to improving the Operations and Maintenance (O&M) efficiency as well as the passenger service level.

### **Smart Urban Rail: Facilitating Digital Transformation**

The urban rail industry suffers from three main pain points. One of those pain points is the siloed functional systems of traditional rail lines hindering data integration and interoperability. Devices of different systems are poorly coordinated, the response speed is slow when passenger flow fluctuates and faults occur, and the overall efficiency of metro transportation is unsatisfactory, making it hard to implement collaborative dispatching that is driven by passenger flow.

A second pain point is that passengers can't access up-to-date, comprehensive, and accurate travel information.

Finally, the status detection, diagnosis and decision-making, and maintenance of many metro devices and facilities are still performed manually. Because they lack intelligence and have insufficient in-depth maintenance data mining and analysis capabilities, it's difficult to implement status forecast and warning or optimize the full-lifecycle maintenance policy. The maintenance mode is mainly fault-triggered and plan-based, the linkage between device O&M and asset management is

insufficient, and the attributes recorded in the system aren't consistent with the actual attributes of the equipment — making asset management difficult.

To address these problems, the rail industry requires technologies such as cloud computing, big data, and AI, to establish a smart rail O&M system and prioritizing solving problems related to smart urban rail networks in order to facilitate digital transformation of the rail industry and to improve the O&M efficiency and passenger service level.

Data is accumulated throughout the entire lifecycle of devices and is analyzed based on big data and AI-empowered deep-learning technologies. This helps optimize the O&M process, improve the self-diagnosis and self-recovery capabilities of devices, and maximize the device usage efficiency throughout the lifecycle.

### **Data Platform: Building a Solid Foundation for Intelligence**

During the digital transformation of rail transportation, the data platform is the basis for the interoperability of advanced applications, and intelligence determines the amount of room for improvement for security and user-friendly experiences.

The construction of rail transportation involves functional systems such as vehicles, rails, signals, communications, electromechanics, and security protection. With the rapid development of the rail transportation network, the types and quantity of devices are increasing. The fault detection and maintenance assurance of devices that have been running for a long time lead to higher requirements on maintenance personnel.

Intelligent technologies can reduce manual maintenance costs and improve the accuracy and efficiency of device maintenance. Each functional system collects device data mostly by adding sensors. Data accumulation, data analysis, and device modeling are long-term tasks, and a smart urban rail system integrating multiple functional systems can serve as an important enabler for building data analysis models.

Devices use data collection tools to monitor device health status. The data analysis models of the devices need to be integrated into a unified data platform, to perform comprehensive analysis based on common basic data and tools, and provide association analysis results for functional application scenarios. This way, a new unified rail transportation data platform can be established — creating a solid data foundation for maximizing the value of data.

Based on the Urban Rail Cloud, Huawei has developed the Horizon Digital Platform for Urban Rail, which targets industry scenarios, coordinates various new technologies, and streamlines data. With the unique cross-cloud and consistent cross-platform experience and multi-technology convergence, the platform supports the quick development and flexible deployment of upper-layer applications, and streamlines bottom-layer connections, achieving synergy among the cloud, pipe, and device layers.

Huawei Horizon is a critical part of the urban rail digital base, and it enables data aggregation and data intelligence to implement digital transformation. Both enterprise customers and ecosystem partners can use the platform to lower the threshold

for using new technologies. Through quick system integration, they can also achieve collaboration and sharing of data and resources and improve the quality and efficiency of services and operations.

To facilitate its digital transformation and improve the O&M efficiency as well as the level of services available to passengers, BYD Signal & Communication Company Limited (BYD Signal & Communication) has established a smart rail O&M system — with 'smart urban rail' as the core — based on Huawei's Horizon Digital Platform for Urban Rail.

BYD Signal & Communication is a wholly-owned subsidiary of BYD. It's committed to providing fully automated smart operation solutions for rail transportation. By integrating core technologies, such as dispatching, network, and control, BYD Signal & Communication provides digital intelligent solutions, engineering implementation, and operation and maintenance services — to guarantee secure, intelligent, and efficient products and ensure comfortable experiences for passengers.

BYD Signal & Communication and Huawei have completed a solution for smart station and intelligent O&M, passed the interoperability test, and released the solutions online — another achievement since Huawei and BYD signed a comprehensive strategic cooperation agreement to explore the rail transportation domain.

In this solution, Huawei Horizon helps break the siloed IT architecture, implement efficient cross-department data sharing, capitalize on the value of vast amounts of data, and support quick development and flexible deployment of upper-layer applications to enable agile innovation of various services. With the help



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*The intelligent O&M system is the core system of rail line operators and is also a necessary information-based means to ensure the availability, security, and cost-effectiveness of vehicles and devices.*

of Huawei Horizon, BYD Signal & Communication can quickly deploy upper-layer intelligent applications. Based on BYD's smart station and intelligent O&M system data processing technologies, such applications can be used by sub-systems connected to Huawei Horizon in real time. As well as efficiently resolving enterprise customers' pain points and meeting their needs, this solution reduces customers' time, labor, communication, production, error, and maintenance costs.

### Smart Station Application Practice

While rail lines can meet the needs for common services — such as O&M, passenger services, and ticketing and charging — issues still abound: Sub-systems operate independently, causing low O&M efficiency; massive fragmented data generated by systems can't provide efficient data support for O&M decision-making; traditional ticketing and charging services fail to satisfy passengers' smart travel service needs; and device maintenance and emergency linkage still rely on manual operations.

With the continuous upgrade and reconstruction of urban lines and the design and planning of new lines and networks, stricter requirements are imposed on O&M and design and planning. O&M organizations put greater demands for upgrading and reconstructing the integrated intelligent system; design and construction organizations also provide overall intelligent system solutions during line design and planning. Participants in the transportation industry — such as passengers, telecom carriers, and bus operators — also raise requirements for service convergence. In this context, the construction of smart stations is imperative.

From the aspects of passenger, operation, and construction, the smart station solution aims to implement user-friendly services and intelligent operations. The solution enables comprehensive information display, automatic operation, and emergency handling to build an efficient smart operation and management system that can help quickly handle emergencies, build an efficient smart O&M mode, and improve passenger experience.

**User-friendly service:** As well as meeting the basic operation requirements of railway stations, the highly intelligent Passenger Information System (PIS), broadcasting system, and intelligent recognition and ticketing system also introduce functions such as new retail, sharing service, smart logistics, and lost and found, and apply technologies such as solar energy and big data to make services more user-friendly.

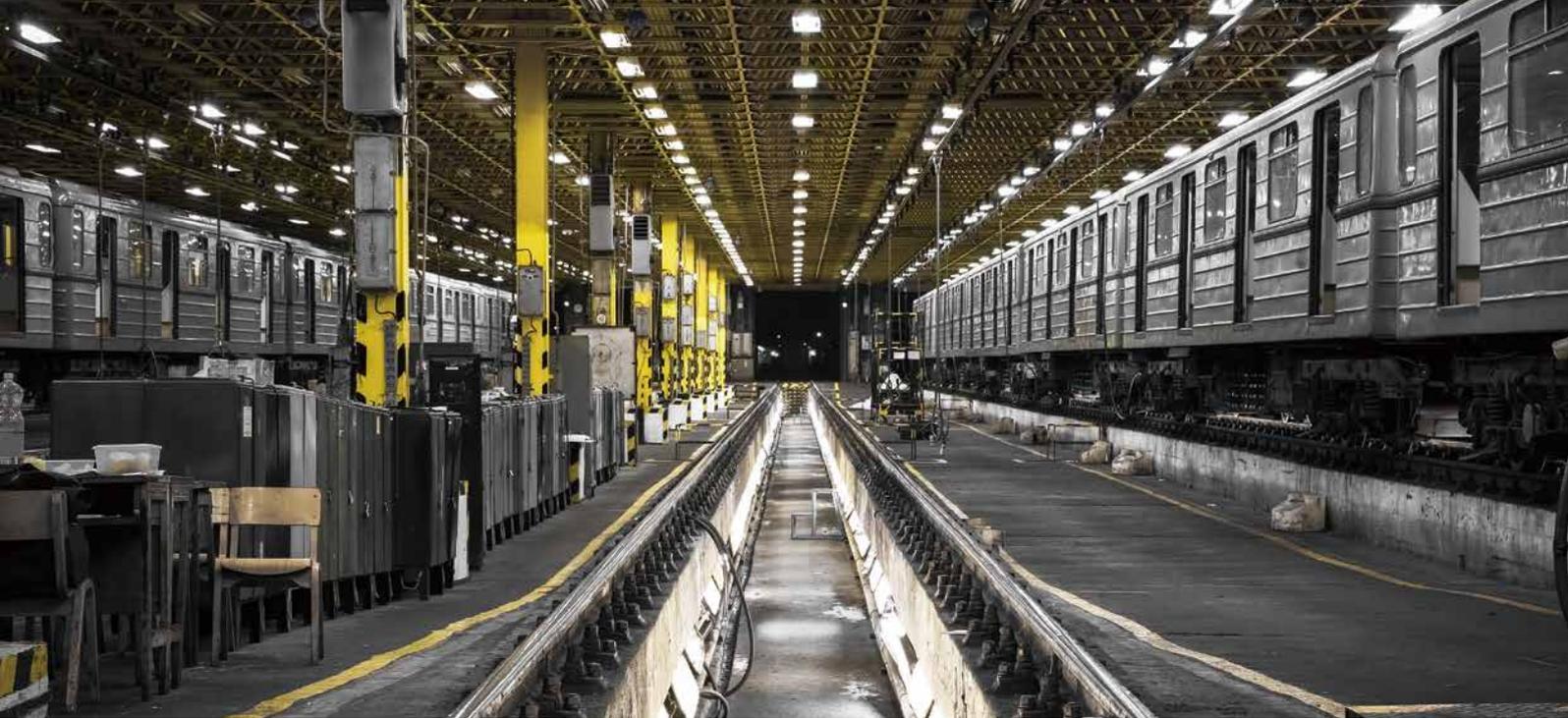
**Quick and imperceptible station access services:** Include efficient and accurate security check and imperceptible ticket check-through; reduce the queuing time; and improve travel efficiency.

**Real-time and efficient customer services:** Include quick-response online services and flexible offline services; expand the channels for customers to seek for help.

**Customized and accurate information services:** Include linkage release of information on multiple platforms, dynamic signs, and sign-based active guidance; realize customized information interaction and enrich the information content.

**Diversified travel experience:** Offer vehicle reservation, station business, logistics, entertainment, and other value-added services.

**Intelligent operations:** All devices at stations are designed and produced in compliance with unattended requirements.



Passengers can enjoy intelligent recognition-based access as well as self-help goods purchase and shared services, while line operators can significantly reduce labor costs with the help of highly intelligent devices. Meanwhile, the fault diagnosis sub-system can efficiently detect device faults and automatically report the faults to related personnel for rectification, ensuring the normal and secure running of devices.

**Real-time holographic perception of the running status:** Cover the passenger flow, train, facilities, and environment.

**Remote intelligent management and control:** Include device control, passenger flow control, dispatching and transmission, and emergency command. Solve the problems of low efficiency, high intensity, and high cost of manual management and control.

**Passenger flow-centered operation organization:** Break down data barriers between systems; achieve the adjustment and matching of the traffic capacity and volume of the road network driven by the passenger flow; and resolve the problems of poor data interconnection, difficult management and control, and complex command interaction caused by scattered systems.

**Active identification of security risks:** Solve the problem of passive response to abnormal cases, and difficulties in risk prediction as well

as active checking and elimination of risks.

### Intelligent O&M Application Practice

The intelligent O&M system is the core system of rail line operators and is also a necessary information-based means to ensure the availability, security, and cost-effectiveness of vehicles and devices. BYD's intelligent O&M system manages the entire lifecycle of rail line assets, and tracks device repair and maintenance work orders. It also conducts self-checks for system functions, reports function status, and combines with manual inspection to achieve the purpose of point inspection. What's more, it establishes a construction management module to control the repair process and approval.

The system is based on asset management and focuses on device maintenance. It integrates functions such as device operation monitoring, asset lifecycle management, device maintenance, device inspection, on-site construction scheduling management, and station management. This way, the system provides a device management information platform for O&M through information linkage and in-depth integration — helping reduce manual operations, improving management efficiency and reliability, and making full use of resources.

**Online sensing:** Use new technologies such as sensing, IoT, and edge computing to collect device and facility health data in real time to improve the intelligence and efficiency of sensing.

**Condition-triggered repair:** Deeply explore sensing data; analyze the deterioration mechanism and evolution rules of facilities and devices; and optimize the repair policy for the entire lifecycle — implementing the transformation for diagnosis and decision-making from experience-based to data-based.

**Intelligent operation:** Replace the on-site manual operation mode with the intelligent unattended maintenance equipment and remote maintenance mode. In addition, evaluate the operation quality in the later phase to implement intelligent condition-triggered repair.

**Asset association:** Unify the granularity of facility and device management as well as asset management to streamline O&M data and asset status data, ensure the consistency between asset value attributes and physical attributes, and support the full-lifecycle management of assets.

Based on the Software as a Service (SaaS)

layer, the intelligent O&M platform is scalable, comprehensive, and modernized. It consists of intelligent devices and cloud components, including edge computing, IoT, cloud platform, and service applications. These devices and components collect data from intelligent front-end devices, transmit data through various network standards, and use technical means — such as AI, big data, and IoT — to integrate, manage, and associate service systems. This way, the platform can provide secure, efficient, and smart O&M and service management.

BYD and Huawei started cooperating more than 20 years ago. As the two companies have grown, they've collaborated on projects spanning electronic products, intelligent and connected vehicles, smart driving, smart transportation, and smart campus.

In January 2018, BYD and Huawei launched a driving system — the world's first single-track autonomous driving system with 100% proprietary intellectual property rights. The two parties have since cooperated further, proposing joint solutions for smart station and intelligent O&M, applying and verify the solutions in digital platforms, and facilitating the cooperation based on joint interoperability solutions to lay a solid technical and application foundation for smart rail construction.

In the future construction and development of smart urban rail, the two companies will work together to develop more smart solutions, to provide better technical support to improve the urban rail operation efficiency and passenger service level. BYD Signal & Communication is committed to becoming a driver and leader in digital rail transportation and to working with Huawei to create a better future. ▲

### Partner Testimonial



BYD Signal & Communication is committed to becoming a driver and leader in digital rail transportation and will work with Huawei to create a better future and embrace the intelligent upgrade of rail transportation.

— Chen Guofang, President of the Information Engineering Research Institute, BYD Signal & Communication Company Limited

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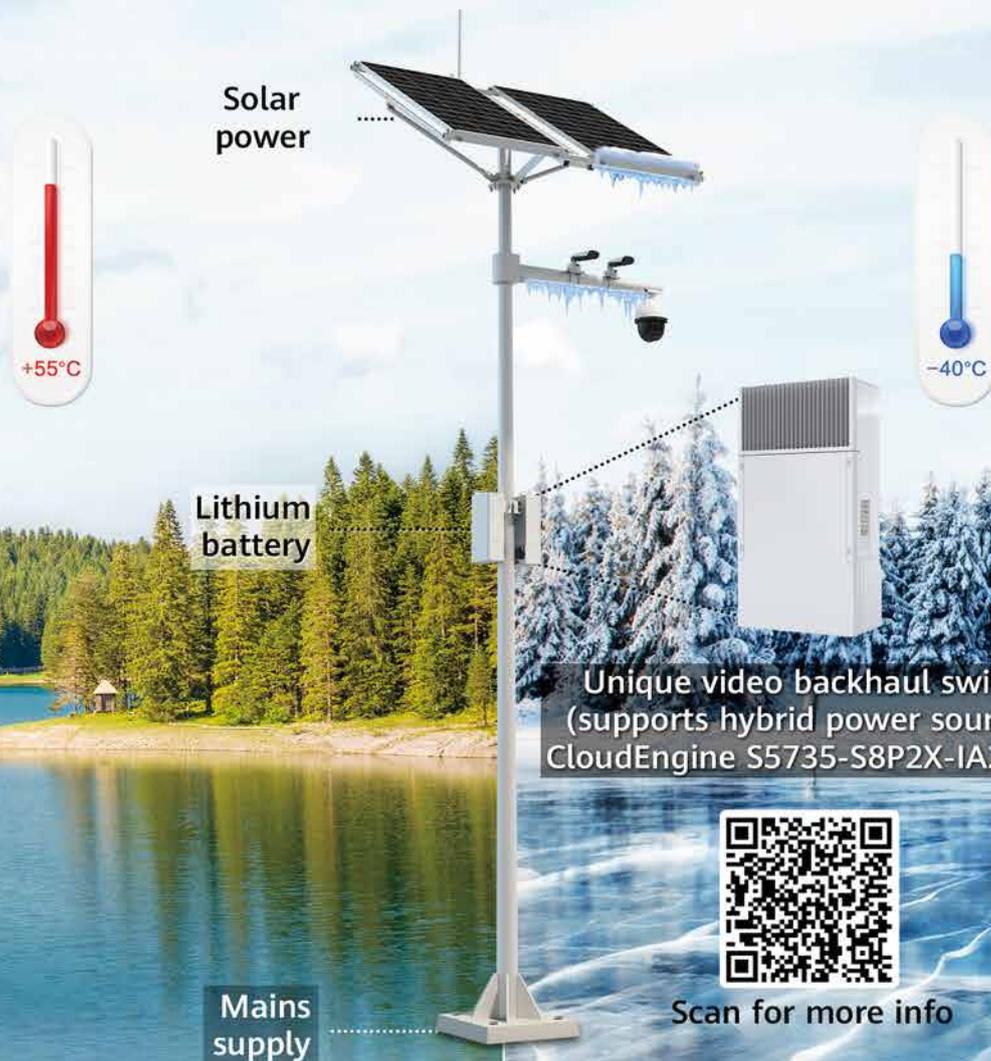
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