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The Key to Tomorrow's Smart Cities

Economic Vitality and Systematic Planning

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— Guo Ping —
Rotating Chairman of Huawei

The United Nations predicted that two-thirds of the world's population will live in cities by 2050. Research by Oxford Economics showed that as of 2030, about 750 cities around the world will contribute nearly 80 trillion US dollars to the global economy, accounting for 61% of the world's GDP. However, new opportunities always come with challenges. The growing population will exacerbate a series of issues that cities currently face, including security, pollution, and traffic jams.

As countries reach consensus on the necessity of developing digital economies, numerous activities will be carried out in cities to improve efficiency and optimize economic structures. Information and communications technology (ICT) will act as a key driver during this process.

Smart cities will become the basis for the development of digital economies, while also becoming an important means for addressing challenges that cities face.

The digital transformation of cities is rather complicated. By referencing Maslow's hierarchy of needs, I think a city's digital transformation needs can be divided into four layers, from bottom-up:

The first layer is ICT infrastructure; the second layer is security assurance; the third layer is a supportive environment for industrial digitization; and the fourth layer is the "digital brain" for coordinated city management.

No single technology can support the digitization of cities alone. Instead, a combination of multiple technologies, which we call "digital foundation", will be required. ICT will become a key enabler for social development, supporting more and more industries in their production and management.

Huawei is now working to build the digital foundation of smart cities, including ubiquitous connectivity, a digital platform for developers (the Huawei Horizon Digital Platform), and pervasive intelligence.

This digital foundation will integrate data to facilitate data mining, analytics, and sharing. More importantly, numerous app developers will work with Huawei to build an ecosystem and the "digital brain" of cities. These will provide advanced tools for decision-making on city development, to support the digitization of domains like governance, transportation, and policing, and ultimately build smart cities that are well governed, benefit their citizens, and help businesses prosper.

Huawei is committed to bringing digital to every person, home and organization for a fully connected, intelligent world. Building smart cities is a key part of this commitment. I hope this article provides useful references about building smart cities.

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Since the concept of smart city was set up 10 years ago, its importance has been generally recognized. There are more than 1,000 cities around the world that have started or are building smart cities, the promotion of smart city is in full swing. But what we have witnessed is that the constructions of smart cities are plagued by the phenomena of "many constructions but limited effect, many attempts but less integration, many pilot projects but less massive production". Are the issues of immature technology, premature development stage, or inappropriate development model? What is the key to the future development of smart cities?

Here come the Huawei's profound thinking and systematic positions.

Through the analysis of urban development process, it is found that economy and systematicness are key to urban development. At each stage of urban development, it is the general law that roles about economy and systematicness of new technologies and other new things are reflected as stages coming from functions, to performance, and then to effectiveness. Smart cities are undergoing the same development process and have gone through performance verification in key areas and are entering the performance realization stage. The economy and systematicness of smart cities are shifting from spontaneity to self-consciousness. Since the key to the future of smart cities lies in economic vitality and systematic planning, it is necessary to strengthen our confidence and accelerate the development of smart cities by driving the economy in a systematic way.

Taking 20 typical cities in our analysis, we have sorted out the key issues concerned by 12 cities, their typical practices and digital initiatives, and analyzed the effectiveness of digital initiatives. Through the analysis of 6 typical city cases and several smart city projects, it is found that the typical models and paths of smart city economy, including two typical models and six paths of digital technology empowering urban development, two typical models of smart city services forming the new economy, and four typical models for promoting smart city projects launching. Thereby, we propose six key capabilities about the smart city's systematicness, on top of that, point out four critical initiatives to speed up the development of smart city by accelerating the economy through the systematicness as our reference.

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01 Economy and systematicness are key to urban development: From function, to performance, and then to effectiveness

1.1. City is the concentrated reflection of human beings creating a better life

People come to cities for a living, and live in cities for a better life.
 —Aristotle

From the perspective of economics, city is a network of various economic markets – the combination of housing, labor, land, transportation and so forth. From the sociological point of view, city is defined as a geographically bounded form of social organization with certain characteristics. The geography holds the view that city is a dense combination of people and houses with convenient transportation and a certain area. According to the viewpoint of urban planning, city is a residential area with non-agricultural industry and population, including cities and towns established according to the national administrative system. Based on the viewpoints of economics, sociology, geography and urban planning, **it can be found that city includes three basic elements of the population, industry, and governance**, which gathers human groups and advanced social activities of politics, economy, culture, production and living. **City is the concentrated reflection of human beings creating a better life.**

1.2. Economy and systematicness are key to urban development

Throughout the trajectory of urban development itself, urban development is the process of human beings continuously creating a better life. Civilization from primitive to agricultural and then to industrial phases, from the steam age of industry to the electrical age and then to the information age, from the primitive village, to feudal castles and then to modern cities, the basic mechanism of urban development is to seize and take advantage of the opportunities brought by technological change to substantially improve productivity, carry out urban construction economically and systematically, continuously promote industrial transition and governance upgrading, and constantly improve the adsorption and radiation capabilities of cities, which can realize the development and evolution of city scale expanding and level upgrading, and to meet living needs of continuous advancement. **Economy and systematicness are accompanied by urban development, which are the key to it.**

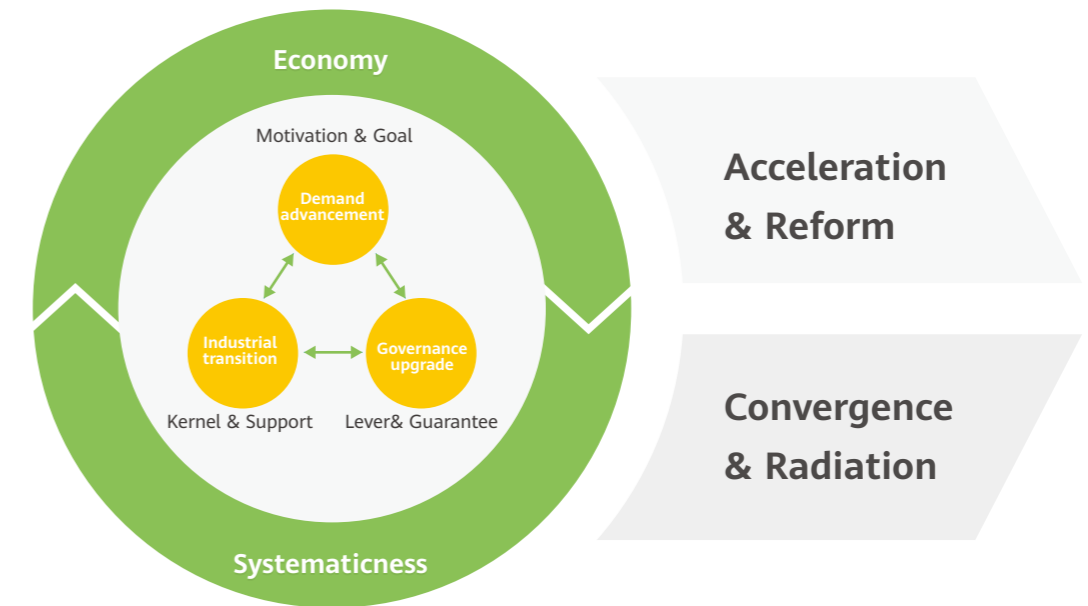


Figure 1 Key drivers of urban development

Demand advancement, industrial transition and governance upgrading are the “core”. The trajectory of urban development is the process of meeting the needs of a larger group, a larger number and a higher level. Meanwhile, there must be an industrial model and a governance model that match the development stage. Demand advancement is the motivation and goal of urban development. Industrial transition is the kernel and support. Governance upgrade is the lever and guarantee.

Economy and systematicness are the “key” promoting urban development. In order to achieve sustainability in the promotion of demand advancement, industrial transition and governance upgrading at each stage of urban development, it is necessary to integrate economy with the operation model first, that is, to ensure the acceptable return on investment (ROI), straighten out the relationship among “investment, construction and operation”. Secondly, in terms of content, the system should be comprehensive, meaning that the components of which should be comprehensive and interrelated to form an organic integrity, so as to achieve the overall effectiveness.

Urban development represents the “two effects” of acceleration and reformation, convergence and radiation. Key resources and technologies play a role of acceleration and reformation in urban development. Cities accumulate key resources, promote the innovation of key technologies, and create higher productivity, which promotes the development and evolution of the cities. As cities have the effect of convergence and radiation, they gather people, resources, export products and services. The higher the level of urban development is, the stronger its adsorption and radiation capabilities and the wider scope will be.

1.3. The role of economy and systematicness contains procedural attribute

From steam and machine technology in the age of steam to enable urban mechanization, to electric power and electrical technology in the age of electricity to promote urban electrification, and then to computer and network technology in the age of information to drive urban digitalization, key technologies have brought new ideas and schemes to promote urban development. In terms of the development of pre-industrial cities in the steam age and industrial cities in the electrical age, **the economy and systematicness of new ideas and schemes contain the procedural attribute.**

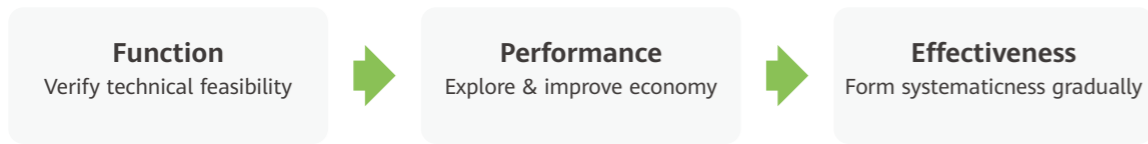


Figure 2 The function process of economy and systematicness

Function Stage: Verify technical feasibility. New ideas brought about by new technology and new schemes on a trial basis verify that whether the functions solve the problems and cast technical effects or not, so as to improve them continually.

Performance Stage: Explore and improve the economy. Emphasizing the cost and benefits of new ideas and schemes brought by new technologies, forming a more economical construction and promotion model to further expand the application scope.

Effectiveness Stage: Form systematicness gradually. Starting from the city as a whole and rolling out comprehensive promotion, it is necessary to ensure the application of technology at each point is integrated and optimized, so as to realize the systematic presentation of the technicality and economy of new technology application.

02 Economy and systematicness accelerate the development of smart city: from spontaneity to self-consciousness

2.1. Urban digitalization brings new qualitative changes to urban development

Nowadays, ICT has become the key enabler of urban development like the electricity 100 years ago. Data and information have become key resources and network services have become basic service forms, which greatly reduce the marginal cost of urban development. As a result, the capability and scope for urban adsorption and radiation expand unprecedentedly, and urban development has shifted from the real world to the combination of the real and digital world, representing the dual characters of "region" and "network". Thus, urban development is ushering in the qualitative change of "transcendence, penetrate and breakthrough".

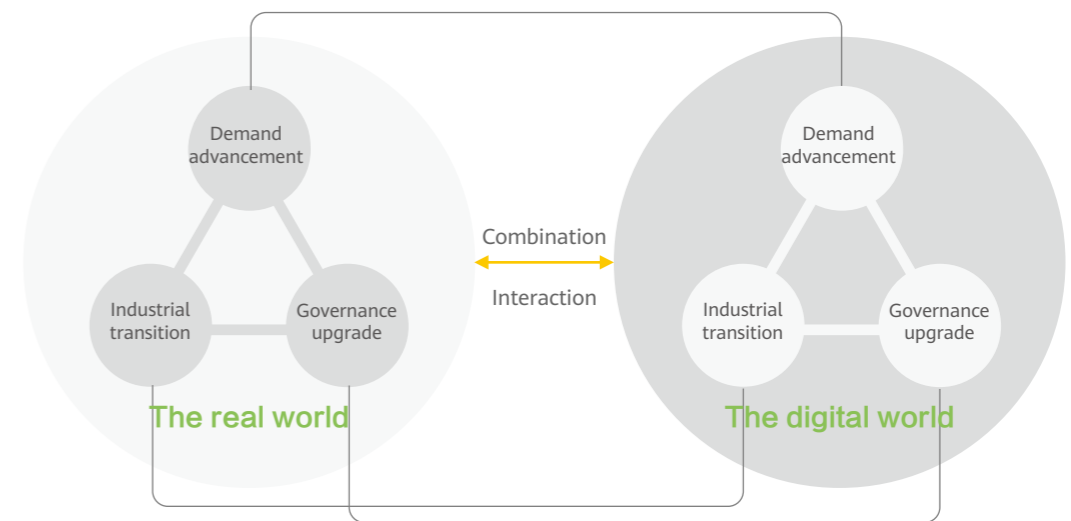


Figure 3 The combination and interaction of real and digital world

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The demand advancement presents “two transcendences”. People are not satisfied with the use and possession of local resources and their demands transcend geographical boundaries. People are not satisfied with the use and possession of physical resources and their demands transcend the boundaries of reality.

Currently, the basic needs (physiology, security) of most urban populations are guaranteed thoroughly, and more and more people have the opportunity, ability and willingness to pursue advanced demands. According to the United Nations, in 2018, there were 7.59 billion people in the world, 55 percent of whom lived in cities. By 2050, there will be 9.7 billion people, 68 percent of whom will live in cities. With the increasing number of urban population and the increasing urbanization rate, the amount of demand carried by the city expands rapidly. The living, transportation, work and recreation needs of urban residents are becoming more and more complex, and the scope of demand is from local to global, from reality to the network, and the level of demand is constantly advancing.

Industry transition needs “two penetrations”. Penetrating the property, location and ownership boundary of resources reforms the traditional production and supply model. Penetrating the ceiling of the real world opens up wider commercial space in the digital world.

In the information age, information and data have become key resources. Knowledge-based and mental work-based economic growth has become the way to go. Digital economy has become the mainstay of the economy and industrial development has ushered in a fundamental transformation. The platform economy, shared economy and other new economic models relying on digital technology transform the traditional production and supply model completely, reduce the cost of resource integration and service supply greatly, and form an economic model in the traditional uneconomic field. As the key resources, data and information create infinite possibilities for the expansion of commercial space in the digital world with extremely low marginal cost and great value creativity.

Governance upgrade needs “two breakthroughs”. To improve governance level and solve governance problems by breaking through the boundary of virtuality and reality and the combination of them. Establishing new governance rules in the digital world with breaking through the governance inertia of the real world.

As cities developed, traffic congestion, environmental pollution and other urban diseases have become more and more serious. Digitalization has provided powerful means to alleviate and solve urban diseases, optimize urban operation model and improve urban operation efficiency. For example, intelligent control of traffic lights can effectively improve the traffic efficiency of intersections and reduce the source of automobile exhaust emission, and smart security system can effectively decrease the crime rate. Meanwhile, with the deep promotion of urban digitalization, digital technology brings new urban economic and social operation models. Since traditional governance ways “fail” to govern the shared economy and network community, it is necessary for cities to establish the governance rules in the new digital world.

2.2. The economy and systematicness of smart city change from spontaneity to self-consciousness

As the new idea and scheme of ICT technology enable the urban development, smart city has been undergoing the key transition period from the function stage to the performance stage after 10 years of development. Since the partial smart city construction has achieved some effects, it is necessary for smart city to transform from “fractional smart” to “collective intelligence”, that is, the economy and systematicness of smart city is shifting from spontaneity to self-consciousness. At the same time, the coordination of networked services and the accumulation and integration of data resources put forward higher requirements for the systematicness of urban digitization. Therefore, it is the right time to systematically promote the construction of urban ICT infrastructure, digital platforms and data resources, as well as the smart application in various industries and fields, so as to drive the economy in a systematic way and accelerate the development of smart cities.

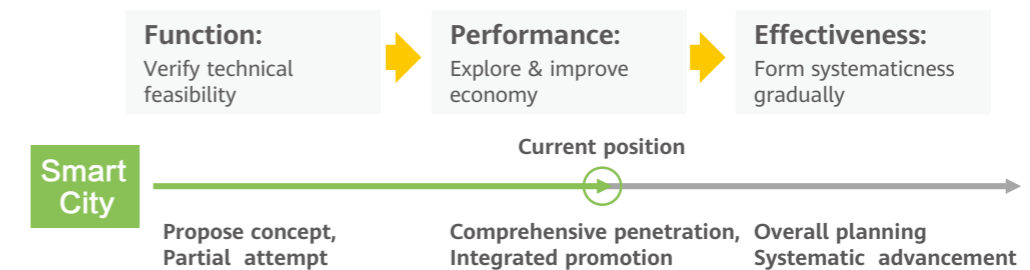


Figure 4 The function process of economy and systematicness of smart cities

Functional verification. After the concept of smart city was put forward, fractional attempts were first made in government affairs, water, transportation, energy, medical treatment and other fields to continuously improve the capability to solve the urban problems. A large number of practices have shown that smart cities have obvious effects on improving government efficiency, urban traffic efficiency, environmental pollution monitoring and governance capability. Actually, smart cities have basically completed the functional verification stage of economy and systematicness.

Performance improvement. Recently, smart city has started to penetrate into all aspects of urban social and economic development. With the development and application of cloud computing, big data, artificial intelligence (AI), 5G and other technologies, smart cities have further improved their functionality and formed “urban brain” and other comprehensive high-level applications. In the performance improvement stage, the further development of smart city puts more emphasis on input and output, and forming a sustainable construction and operation model has become an urgent matter.

Step over the development stage. After experiencing “the hottest concept”, smart city has become more pragmatic to pursue the business model consciously, and the process of economy and systematicness has further progressed. At the same time, the

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characteristics of digitalization is different from those of the electrical transformation. The value enhancement remains extremely demanding on the richness of data resources and the breadth and depth of network coverage, even if the marginal cost of data, information resources and network service are relatively low, but when the function verification has been completed, the smart city should be promoted in a systematic way to accelerate the development of economy into the effectiveness stage.

03 Select typical urban cases for research: key issues and digital initiatives, economy and systematicness

3.1. Methodology and scope

In line with the general law of smart city from function, to performance, and then to effectiveness, the development and governance of smart cities are analyzed from three aspects: urban key issues and corresponding digital initiatives, the major model of progressing smart city towards economics and critical capabilities of systematically constructing smart city.

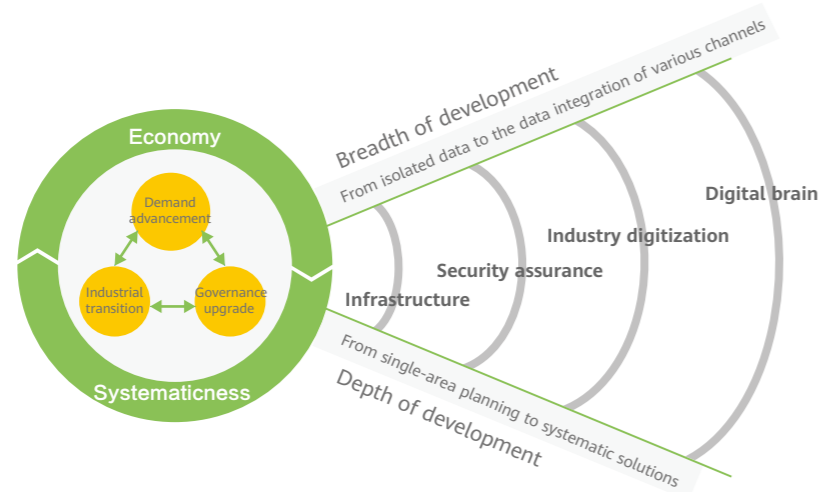


Figure 5 The methodology and scope

Key issues and digital initiatives. Key issues and typical practices are sorted out regarding demand advancement, industrial transition and governance upgrade. Simultaneously, corresponding digital initiatives are analyzed from the perspectives of effectiveness and developmental law.

Economy of smart city. Smart cities have three attributes of city, economy and project. Firstly, smart city is an important part of the city, thus contains the urban attribute. Secondly, the ICT infrastructure and accumulated data resources constructed by smart cities are the foundation of digital economic development. Subsequently, services provided by smart city help shape a new economy under the economic attribute. Thirdly, smart city with its project attribute is generally launched as a basis of projects. Thereby, it's reasonable to analyze the main model and path of progressing smart city to economics from urban, economic and project level.

Systematicness of smart city. Considering the latest progress of smart city, the key capability system requires building up, with references to the general smart city framework and six levels of infrastructure, perception, platform, service, digital space governance and security system for smart city.

3.2. Case study sampling

According to UN statistics and *The World's Cities in 2018*, urbanization rates in Europe are relatively high with a comprehensive urban governance structure. In Asia, cities are undergoing a diversified growth rapidly, including mature cities and emerging cities relying on the recourses and politics support. We choose 20 cities from Europe and Asia and conduct an in-depth research and analysis of their key urban issues and digital initiatives. Furthermore, in order to build comprehensive profiles of urban development empowered by digital technology, 6 cities are drilled down as our case study.

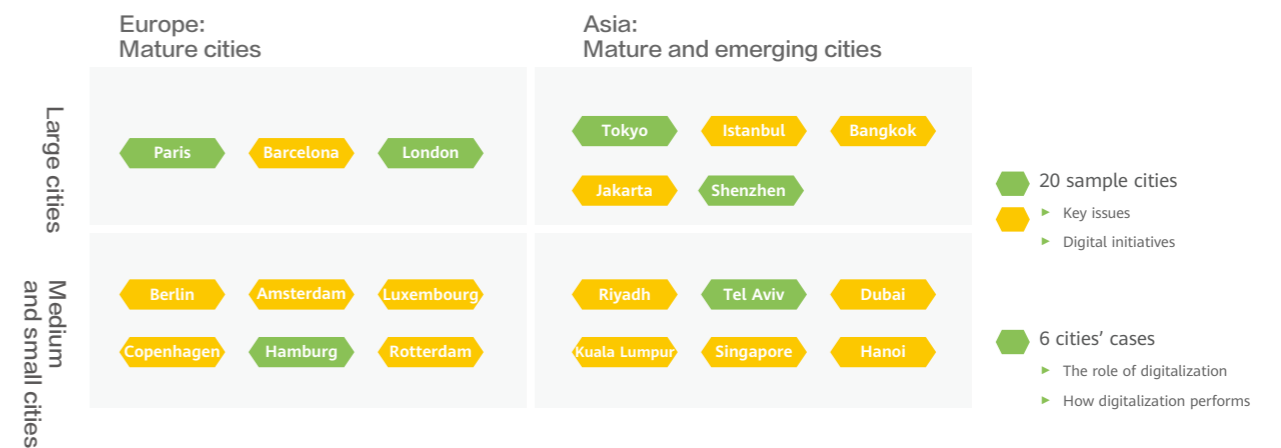


Figure 6 City samples

04 Key issues and digital initiatives: Active attempts from function to performance

4.1.12 key issues are receiving wide attention among cities

It is found that 11 key issues in 3 major areas as well as the city infrastructure issue are receiving wide attention through official documents covering 20 typical cities.



Figure 7 Key urban issues

Overall, urban transportation, industrial transformation and cluster, and convenient services are the three most popular issues. Specifically, urban transport, as the most direct “urban disease”, receives the highest degree of concern. The supply and convenience of urban public services are the most fundamental needs of urban residents, enabling convenience services highly concerned. Value density growth which is considered as the urban essence cannot be separated with industries, thus making industrial transformation and cluster a hot issue.

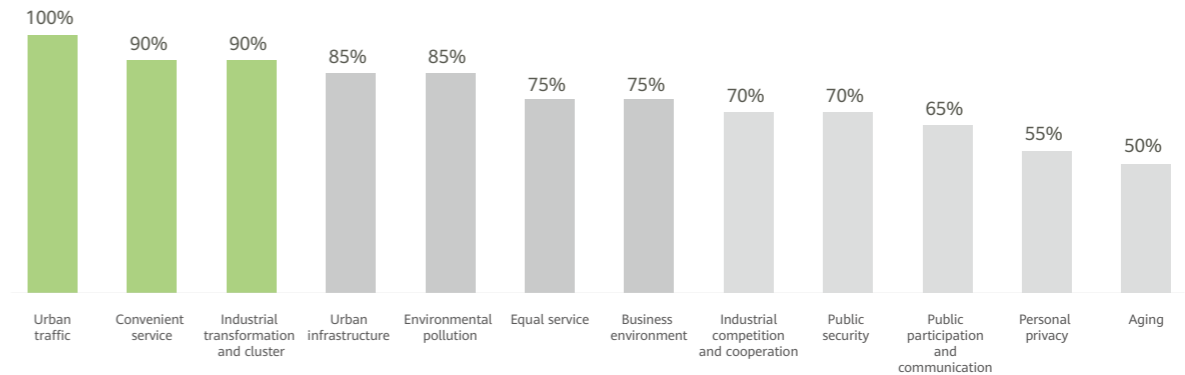


Figure 8 Degrees of attention to key issues

On top of that, urban infrastructure receives extensive attention due to the need for ICT infrastructure, emerging intelligent infrastructure construction and digital transformation of traditional urban infrastructure. Meanwhile, equal service and environmental pollution are generally concerned by mature and developing cities. Last but not the least, because of the intensified competition across cities, environmental upgrading for business has received widespread attention as well.

In the demand advancement scenario, 4 issues related to aging, convenient service, personal privacy and equal service are highly concerned. Aging represents the human's demand in the longer run, the concern of which should focus on addressing health problems of the elderly over a longer lifespan and providing appropriate jobs to them. Convenient service demand comes from a relatively larger population. Quantity and matched quality of providing public services such as education and medical treatment, etc. are within this topic. Personal privacy represents a higher level of human demand with its emphasis on tackling issues that both protect privacy as well as enhance data collection and usage. Equal service signifies the demand from more and more groups. As a result, it's necessary to provide a targeted service to a wider range of people as a priority of ensuring the equality of public services.

In the industrial transition scenario, 3 issues related to industrial transformation and cluster, industry competition and cooperation and business environment receive wide attention. Urban industrial transformation and cluster stemming from the industry and people demand for re-arranging urban districts as well as upgrading industrial-value densities, for instance, migrating core industries towards high-end spectrums, building up new towns to ease the heavy burden of population and industry and gathering emerging industries, etc. Industry competition and cooperation comply with the evolution of digitalization, where it's required to vitalize the traditional industries with digital technology and capture the core pivot for digital economy. Urban business

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environment is continuously challenged by the higher requirement of efficiency and resources proposed by the industrial economy in the information society. Thus, the environment requires to be enriched through the accumulation of high-quality human capital for the new economy, an active support of government regulations and policies with more efficient services.

In the governance upgrade scenario, 4 issues regarding environmental pollution, urban transportation, public security, citizens' participation and communication bring about a popular discussion. Environmental pollution, urban traffic and public security generate urban diseases, which underlie the urban development in the long term. However, the digital technology which can be organically embedded in the urban governance, will propose effective ways to ease and solve urban diseases as a basis of more rapid response and feedback as well as experiences of decision-making modeling in digital world for urban issues happened in the physical world. During the public governance, the public require a wider range of participation, more flexible forms and more direct expression of willingness. Digital technology provides an effective approach having the public participate collectively in the urban governance by building up an inclusive bridge connecting the public, government and city.

Meanwhile, issues related to the urban construction and digitalization of information, transportation, energy and environmental infrastructure, etc. as well as the construction of intelligent urban infrastructure are also widely concerned by cities. Under such circumstances, the improvement of basic urban infrastructure capability creates the foundation of the human's need, industrial economy development and urban governance.

4.2. Digital technology brings about new driving forces to key issues

The combination of digital technologies and key issues can meet the continuous advanced demands, accelerate industrial transition, and promote governance upgrading more effectively.

The guarantee of demand advancement: Service resources can be aggregated in a wider range at a lower cost by the networked ways. Networked, digital and intelligent service models can be adopted to reduce service costs, improve service efficiency, alleviate the shortage of service resources and provide more accurate services, so as to meet the continuous advanced demands of urban residents more effectively.

The accelerator of industrial transition: Digitalization transforms traditional production and supply models, brings about innovation of business patterns, and promotes industrial transformation and cluster. On the other side, rebuilding the traditional urban competitive advantages, reshaping the capabilities of adsorption and radiation, and regaining a favorable position in the reconstruction of the value chain of global industrial competition and cooperation can promote industrial transition.

The booster of governance upgrading: The governance of "urban diseases" such as environmental pollution, urban traffic and public safety needs more effective measures and a new model. And digitalization is the inevitable choice at present. Digitalization and networking have upgraded the way of social communication and organization, which means public participation and communication in urban governance need to be good at applying digitalization.

Specifically, pivotal demands to key issues, typical practices and digital initiatives include:

Table 1 Typical practices and digital initiatives to key issues

Issue	Demand	Practice	Infrastructure and Digitalization	
Demand Advancement	Aging	Enable the elderly a healthier and longer life and create more jobs	<ul style="list-style-type: none"> Integrate resources to improve old-age public services Guide and support the elderly service industry such as health and medical care lines 	<ul style="list-style-type: none"> Build the digital infrastructure to adapt to the aging society Create digital applications to provide more sophisticated health management for the elderly, making up for insufficient resources
	Convenient Service	Integrate and reuse public resources in a wider range as well as meet explosive service needs with lower cost and higher efficiency	<ul style="list-style-type: none"> Transform the way to provide public services Improve the administrative efficiency of public services 	<ul style="list-style-type: none"> Increase and improve the public service infrastructure and have them digitalized Promote urban information and network facilities to enlarge communication and information service capabilities
	Personal Privacy	Enhance public confidence in personal privacy protection, balance data usage and personal privacy protection	<ul style="list-style-type: none"> Introduce policies and regulations to regulate personal data collection and use Increase transparency and strengthen autonomy 	<ul style="list-style-type: none"> Improve security facilities for network and information; establish sound technologies for proprietary protection
	Equal Service	Provide equal services with low cost and high efficiency for vulnerable groups, as well as strengthen targeted services for small groups	<ul style="list-style-type: none"> Improve medical security, promote educational equality and empower survival skills Promote equal employment and promote equal pay for equal work 	<ul style="list-style-type: none"> Strengthen facility securities for basic living and promote digital transformation for service efficiency Bring low-cost and wide-covering "long-tailed" capability using digital applications so as to cover more groups
Industrial Transition	Industrial Transformation and Cluster	Transform traditional production and supply models, promote business innovation and redistribute the value density of cities	<ul style="list-style-type: none"> Promote digital technologies to transform traditional industries Lead the new digital industries 	<ul style="list-style-type: none"> Carry out the construction of the new city or new district in order to shape a smart highland Improve infrastructure such as connectivity, computing power, and platforms Compress intermediate steps digitally, transform production and supply models,
	Industry Competition and Cooperation	Reposition the industry in the value chain, reshape the adsorption, convergence and radiation of key industries	<ul style="list-style-type: none"> Integrate regional and global development systems Rely on advantageous industries, leading the development of industrial clusters Coordinate and promote technological innovation by the government 	<ul style="list-style-type: none"> Cooperate online and offline, further break through geographical boundaries and integrate the upstream and downstream resources of the industrial chain
	Business Environment	Create a fair environment, bring together talents, foster innovative genes as well as attract global companies to settle	<ul style="list-style-type: none"> Promote the urban human capital Improve the administrative efficiency and introduce favorable policies Create a fair playing field 	<ul style="list-style-type: none"> Accelerate labors' knowledge and skills, and transform the government's administrative service digitally
Governance Upgrade	Environmental Pollution	Strengthen energetic management to save energy and reduce the cost of resources' recycling	<ul style="list-style-type: none"> Enhance urban energy efficiency and promote the clean and renewable energy Promote the recycling of urban resources Monitor and track pollution so as to implement precise governance 	<ul style="list-style-type: none"> Promote energy-saving renovations and digital upgrade for urban infrastructure Perforate the circular business chain, reduce operating costs, sense environmental pollution dynamically and simulate accurate treatment programs
	Urban Traffic	Improve the efficiency of the transportation system, change the model of commuting, and reduce the intensity of using vehicles	<ul style="list-style-type: none"> Advocate for green commuting Improve the operation efficiency of transportation system 	<ul style="list-style-type: none"> Improve transportation infrastructure and take digital measures to improve efficiency Use digital technologies to provide accurate and intelligent traffic management, optimize traffic efficiency, innovate travel service models, and offer more effective commute options
	Public Safety	Improve the efficiency and capacity of public safety management and threats' response	<ul style="list-style-type: none"> Improve management and response for public safety Strengthen cross-departmental collaborations to improve resilience to major crises 	<ul style="list-style-type: none"> Promote real-time, accurate, stable and continuous perception analysis and early warning for public safety in order to schedule and coordinate resources efficiently
	Public Participation and Communication and Communication	Increase public's willingness, abilities and tools to participate in urban development	<ul style="list-style-type: none"> Develop online participation channels Encourage public participation in the urban governance 	<ul style="list-style-type: none"> Make information more open and transparent through digitalization; enhance the convenience and the efficiency of public participation, communication and receiving feedback via online channels

4.3. The digitalization of key issues has basically completed functional verification

Cities are actively attempting to address urban issues via digitalization. For instance, regarding advanced demand, actions like online education, telemedicine, health monitoring, big data of health and remote care robotics are widely used. As for industrial transition, digital actions like intelligent manufacturing, shared economy, smart parks, online entrepreneurship service, online training and employment, etc. are connected with industries. Regarding governance upgrade, measures related to digital government, emergence monitoring, video surveillance, pollution monitoring, traffic control and command, urban brains, etc. are widely taken. Digital technologies are empowering the key issues, which reflect 3 breakthrough capabilities below:

- Resource aggregation capability:** digitalization, physical resources' dispatch and use, data resources' exploitation and usage
- Spatiotemporal extension capability:** networks, self-help, service scope and time extension
- Model innovation capability:** precision, intelligence and birth of new business

The effectiveness of digital initiatives reflects on the large impact on business improvement and strong operability to launch projects. As a result, the effect of digital initiatives to key issues is evaluated by two indices: impact on business improvement and operability.

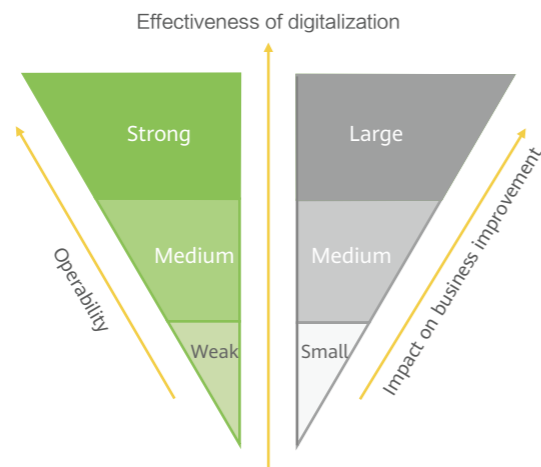


Figure 9 The efficiency analysis method of digital technology

Analyze the effectiveness of digital initiatives, it is found that digitalization has been infiltrated into core links with a good operability as well as the relatively maturation in urban governance. It is also found that digital solutions have the basic function to solve urban problems. However, it's necessary to establish a performance business model to achieve the low-cost "scale production". Additionally, integral effectiveness realization requires strengthening the systematic coordination.

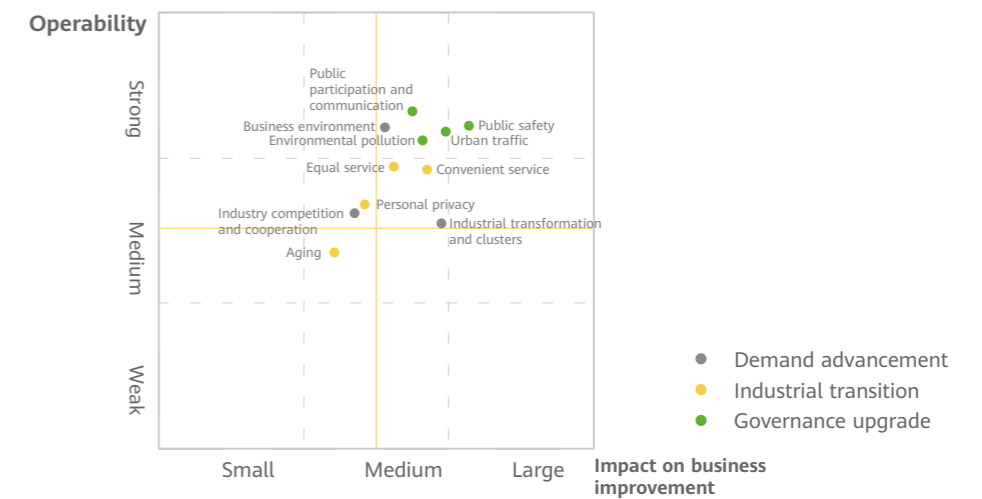


Figure 10 The effectiveness analysis of technology solutions to key issues

Fundamental functions have been built up. The highly standardized solution based on the simple customization of prototype products has been applied to the core business links, reflecting the good technical effectiveness. That is, the function of digital solutions to solve key urban issues has been initially established.

Performance realization requires an effective business model. Further enhancement on the operability and impact on business improvement require the advancement in technology or business models to achieve low-cost "scale production". That is, breakthroughs in business models are one of the current orientations for realizing the smart city performance.

Effectiveness realization still requires the systematic coordination. Attempts in separated fields have achieved the fractional intelligence. However, such fractional intelligence is not effectively coordinated with each other, where the multiple simplicities can't help to crack the bottleneck of smart capabilities, nor achieve the economic scale. That is, the joint effort needs to be put further on economy and systematicness.

Smart city has set foot into the critical transition from "fractional intelligence" to "integral intelligence", which requires accomplishing two pivotal transformations of "economy" and "systematicness". "Economy" comes to the aid of addressing economic model issues to realize "massive production", whereas "systematicness" supports to solve the systemic capacity issues to achieve "breakthroughs" of smart city capabilities.

05 The economy of smart city: Urban, economic and project level

5.1. Urban level: Two typical models and six paths of urban development empowered by digitalization

Smart city is the organic integration of digital technologies and critical urban elements. The role of smart city is achieved by digital technologies empowering urban economic and social activities and accelerating urban evolution. The core of urban development is the development of urban industries. At the urban level, the economic vitality of smart cities is mainly reflected in the combination of digitalization and industry.

Empowering urban services to meet demands advancement: Improving service level, reducing service cost, enriching service content and networked delivery make the urban service more convenient, fast and orderly. Digitalization improves the efficiency of resource allocation, reduces the cost of urban service and enriches the content of urban service by the combination and interaction of virtuality and reality.

Empowering economic development to promote industrial transition: Supporting the transformation of traditional industries, breaking through the constraints of time and space, and achieving the goal of larger scope, faster connections, stronger interactions can rebuild new competitive advantages. Generating new economic models based on the information technology will foster new economy pursuing differentiation, personalization, networking and speed.

Empowering urban management to support governance upgrading: Providing stronger means for urban governance includes digitalization of all urban elements, real-time visualization of urban state, coordination and intelligence of urban management decisions.

Through the case analysis of typical cities, it is found that there are two typical models and six paths for digitalization empowering urban development and accelerating urban evolution.

5.1.1. Digitalization empowers mature city's evolution

Represented by London, Paris, Tokyo and Hamburg, mature cities have been highly urbanized with well-developed urban functions

and diversified industries, and their developments show the characteristics of high starting point, low growth rate and slow evolution. The digital technologies help realize partial vitality activation and advantage recreation during slow urban development, which supports the evolution of mature cities.

Urban characteristics: Mature cities have a long history, high-level urbanization, well-developed functions, diversified industries, high density of population and industry, as well as continuous space expansion.

Urban development: The overall low growth of the cities requires a breakthrough and growth in diversified industries, which can make industries upgrade, space expand, and industrial value density rise constantly.

Digital technologies empowerment: Digital technologies break through the constraints of time and space, and achieve the goal of larger scope, faster connections, stronger interactions, which rebuilds new competitive advantages, enhances the value density and helps evolve in the high starting point.

Here come our opinions that micro-innovation, "experimental fields" and integrated development of industries and cities are the pivots of digitalization facilitating the evolution of mature cities. First, applications of new technology promote the existing industries to achieve "micro-innovation", which constantly enhances the value of industry. Second, in the process of urban expansion, digitalization strengthens connections between new towns and old districts further to enhance capability of old districts' service resources which can radiate to new towns. The third is creating "experimental fields" to explore the experience ahead during the process of solving urban problems so as to promote industry formation and export it.

Path 1: Digitalization supports the economy to reactivate

It is an important path for the mature cities' development, continuously promoting industrial upgrading and replacement, hence enhancing the value density of cities. Digitalization has transformed the models of resource aggregation, production and service supply, which can effectively promote the reactivation and upgrading of urban industries.

The general measure: according to the urban industry and its development characteristics, government selects the industries that need value enhancement and strengthen the organization, guidance and support. Meanwhile, government promotes digitalization to empower traditional industries by transforming the models of resource aggregation, production and services supplying to support industries reactivation.

Case: Digitalization supports the creative industry and inspires the new growth of London.

London is the world's most important cultural, educational, sports and scientific centre. Its creative industry has risen rapidly, which makes London the capital of creativity in recent years. In the late 1980s, the British government began to develop creative industries vigorously. According to the official statistics, the average value added of the creative industry is 20% higher than that of the whole industry, showing high

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economic added value. The creative industries have maintained a growth rate of more than twice of GVA since 2009, even though London's overall economic growth is low and even negative. The scale of the creative industry has exceeded 10% of GVA and is constantly increasing, realizing the "reactivation" of the economy. Thus, the "creative capital" has become another name card of London.

The empowerment of digital technology enriches the creative industry critically in addition to the active promotion from the government policy and London's cultural heritage. The creative industries present the characteristics of "creation - digitalization - industrial integration". Digital content and network communication have become important parts of London's creative industry. For instance, for WPP Group, the world's number one communications group based in London, 36% of its revenues came from digital businesses in 2014. The D&AD Festival, a 57-year-old global creative industry pageant, specially set up the awards of "digital marketing" and "digital design". The creative industries, combining creativity, culture and technology, are continuing to drive the London economy to grow again.

Path 2: Strengthen multi-centre synergy via digitalization

New town construction is a common practice that mature cities cope with population expansion and industrial expansion. The new town can share the resources of the core district through digitization and networking and realize the seamless connection between the old and new cities in the digital space, effectively supporting the multi-centre synergy.

The general measure: the government overall plans new town construction, and promotes population, industry, resource reconfiguration of new and old districts. Networked services promote the urban core ability to extend to the new town more effectively and integrate the industries and urban services while at the same time, promoting the construction of intelligent and digital city actively with the standard of the digital age.

Case: Digitalization promotes the development of new town in Paris to achieve multi-centre synergy and urban expansion.

Paris is one of the most important international metropolises around the world, urban area is only 105.4 square kilometers in traditional towns. With the expansion of urban population, industrial agglomeration and unbalanced development brought by spontaneous suburbanization, Paris launches new city construction. And its "multi-centre" synergy model has been widely referenced to. The population of the Paris urban area has remained at about 2.1 - 2.2 million, and the population of the Paris Region has increased from 9 million to more than 12 million. Taking Marne-la-Vallée as an example, it has successfully integrated into the Paris multi-centre system. The new town has a 20-minute subway line to downtown Paris, and 17,000 companies, including the French headquarters of IBM, ANPE and others, as well as 50+ research centres and 20+ higher education institutions.

Digitalization is the stabilizer and accelerator of new town development. On one hand, digital and networked means promote new town to connect with the high-level resources of core district, enhance the attraction of new town. Service resources of core district in the construction process of new town, like deploying digital art exhibitions, implementing the "Open Data Proxima Mobile" project to improve government service level and integrating telemedicine issue into the common law to promote the development of telemedicine. On the other hand, they actively embrace digitalization to build smart new town, including integrating the concept of "accessible city" into the construction of the new

town, using digital technology to patch up the disconnected districts, constructing the 3D transportation system, encouraging pilot and industrial incubation programs for smart power grids, smart light poles, and driverless cars in new cities to promote high-level and dislocated development of new cities.

Path 3: Forming new industries in the process of puzzles solving

Traffic congestion, pollution and aging are "urban diseases" of mature cities that must be alleviated and solved currently. The application of digital technology has become an important means to solve such urban diseases. At the same time, it can be practiced locally and then introduced to the world.

The general ways: In terms of typical "urban diseases", it is necessary to strengthen government guidance and promotion, switch perspectives in the industrialized way and explore the crisis solutions behind "urban diseases", in order to form, testify and improve new solutions with digital means in the local environment, and then establish industrial capabilities for outward expansion.

Case: ICT technology empowering aging industry, turns "threat" into "opportunity" in Tokyo.

Declining birth and increasing aging make Tokyo the super-aging society ahead of other cities in the world. The elderly over 65 account for more than 25% of the total population in Tokyo. According to the National Institute of Population and Social Security Research, such number will increase to more than 30% in 2030. Tokyo adopts the idea of "local trial-industrial output" to combine coping with the aging problem with industrial development and explore the way of "threat" and "opportunity" transformation in the aging metropolitan area. On one hand, the government enacts laws and policies, constantly improving the social security system such as old-age care, medical care, and nursing as well as encouraging to form a joint societal force for addressing aging issues; on the other hand, it builds an intelligent aging and nursing care industry with ICT technology and then introduces it to the world.

The 5.0 Strategy of Japan Super-smart Society integrates "efficient service, lifetime on-the-job" as an important content, combining digitalization and coping with aging as the national strategy. According to the Report of *ICT Super-age Society Vision Conference* published by Mizuho Bank, the ICT endowment industry will bring about twice of economic growth compared to traditional pension industries. ICT technology has empowered the "Japanese model" of pension industry. Tools like the ICT-based health prediction and prevention system, the medical information collaborated-platform, the Robot X and the ability improvement of ICT application for the elderly, etc., comprehensively promote the aging industries to embrace digitalization, which helps to realize dual growth of direct and indirect societal benefits, as well as the great potential to introduce to the world in the future.

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Path 4: Reconstruction of urban traditional competitive advantages

In the long-term, mature cities generally need to rely on their locations, resources and other aspects to form their traditional advantages. With the globalization and digitalization, urban traditional industries which are challenged need to be reconstructed to maintain their competitiveness via digitalization empowerment.

The general ways: Revitalize the traditional advantages under the government promotion. In the process, digitalization integrates the upstream and downstream industrial chains as well as innovates the production and service model, which extends industries, updates businesses, amplifies adsorption and radiation capabilities, expands the content and scope of services, in order to empower the core capability and form the new competitive advantages.

Case: Digitalization rebuilds the competitiveness to achieve the 2nd revolution of Hamburg Port

Hamburg is located in the estuary of the German Elbe River and famous for its port trade. It used to be the distribution hub of Europe's core commodity. Hamburg experienced a slump in container and bulk handling during the 2008 economic crisis. And then, Port of Hamburg has embarked on a second transformation from container and bulk cargo distribution hub to a service-oriented diversified port. On one hand, actively building the world's advanced container port as well as improving its production efficiency and capacity is to consolidate the leading position of container and bulk cargo distribution hub; on the other hand, improving the port comprehensive service system is to exploit the market potential of service chain of port logistics, promoting the development of related service like energy, raw materials, ship-building and certification of shipping goods and shipping finance.

In the process of economic transformation of Hamburg port, the construction of smart port actively endows the port economy with new vitality. On one hand, the digital technology can improve the production efficiency of the port. After the western expansion and digitalization of the port of Waltershof, the capacity of the port has increased by around 2 million TEU per year. On the other, regarding improving the port services, digitalization empowers the formation of efficient multi-modal transportation of railway, water and land. Currently, logistics processes around rail, water and road traffic are 95% digitalized, and more than 2,000 companies have connected to the automatic data collection and analysis system, which help improve the logistics of Hamburg Port. In addition, establishing a first port floating power plant "Hummel" in the world provides smart energy and enables the green development, which supports the sustainable development.

5.1.2. Digitalization speeds up emerging city's rise

Emerging cities like Shenzhen, Tel Aviv and Dubai, etc., have a short urbanization period, of which urban functions are gradually improving synchronous with the diversified industrial structure taking shape. The characteristics of low starting status, high growth rate and rapid rise are reflected in their developmental patterns. These cities have been seizing the opportunities of emerging technologies to achieve quick rise, during which digitalization is playing an important role.

Urban characteristics: Traditional urban advantages such as natural resources and location are not prominent or relatively poor. Cities have a short history and are encouraged vigorously by the government. Urban development is less burdened by the history.

Urban development: Cities has seized the critical historical opportunity of changing industrial chains. Under the vigorous encouragement of the government, they have developed knowledge-dependent industries such as high-tech, art and culture to improve the urban functions and areas.

Digital technologies empowerment: The rise of emerging cities is the result of seizing the digital opportunities. The automatic combination of digitalization pushes cities to realize urban elements' digitalization, industries' high-end transformation as well as synergy and intelligence of management.

We believe that continuously leading new technologies and fully embracing digitalization are key to digitalization accelerating the rise of emerging cities. First way is to build an innovation and entrepreneurship ecosystem in the field of new technologies and introduce talents ahead. Meanwhile, strengthening the R&D and innovation are also vital to master core and emerging technologies and occupy the high-end links of the value chain. Second way is to actively explore the emerging technology to transform cities and promote the applications of urban development. On top of that, it's essential to establish new supervision mechanisms to appropriately improve fault, trial and error tolerance so as to encourage and support first attempt.

Path 1: Break through purposely to maintain differentiation advantages

Seizing the high-value links of new technology, encouraging innovation and entrepreneurial activities and maintaining the continuous leading position can be considered as important paths for the rise of emerging cities.

The general ways: During the high-value transformation of the high-tech industry, the government plays the major role in encouraging and promoting, introducing and training of high-end talents as well as introducing and cultivating high-level enterprises, so as to adopt a single breakthrough to form the differentiated competitive advantage, select key urban industries and maintain the leading position of innovation continuously.

Case: Tel Aviv- The city is founded by the high-tech innovation and entrepreneurship

Tel Aviv is concentrated by most of Israel's high-tech industries, known as Silicon Wadi. As a global entrepreneurship centre, the contribution of the technology industry exceeds 90% of GDP. Since the founding of Israel in 1950, entrepreneurship and innovation in the high-tech field have brought about a leapfrog urban development in just 70 years. The government plays an important role in achieving such accomplishments, for instance, continuously introducing high-tech talents, developing leading academic and scientific institutions, attracting mature tech giants to set up local centres as well as providing financial support for the research of innovative and ground-breaking technologies. The government takes the burden of risk of R&D incubation and builds up the complete business system for innovative products, in order to explore the trading market of the technology and speed up its realization.

Tel Aviv has become a global entrepreneurship centre due to encouraging the development of high-techs and innovations greatly. According to *2019 Global Entrepreneurship Ecosystem Report*, Tel Aviv ranks 6th. In addition, Tel Aviv ranks 3rd in artificial intelligence

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and 2nd in cybersecurity over the world. Eytan Schwartz, CEO of Tel Aviv Global, says among all the start-ups, 30% and 40% of them are developing products for smart city applications, where high-tech permeates urban development naturally. For instance, radar system named Magos, security cameras and panic buttons, the data sharing platform "Open Data TLV" and intelligent classrooms, etc.

Path 2: Seize opportunities to progress comprehensively

The core of urban competition comes from the division of labor in the urban industry chains. The holistic urban progress can be realized in ways of seizing opportunities of globalization and digital transformation and pushing urban industries to the middle and high end of global industrial chains.

The general ways: The city captures opportunities brought about by industrial transformation and combines the capacity of location, demographic dividends, policy dividends, and resources, etc. The government concentrates on promoting the upgrading of industrial chains through empowering the digitalization and developing information technology industries, so as to step towards mid-and-high end industrial chains from introduction, to imitation, and then to independent innovation.

Case: Shenzhen- The city is rising alongside its industrial upgrade from low end to high end of industrial chain

Shenzhen has created a world-famous "Shenzhen's Speed", which has grown from a small fishing village to a modern, international metropolis in just 40 years, and becoming a global economic and technological centre. Its GDP has grown from 179 million yuan in 1979 to 2.4 trillion yuan in 2018, surpassing Hong Kong. Over the past 40 years, Shenzhen has seized the opportunity of global industrial chains' transformation, applied policies and demographic dividends to develop rapidly. The leading industry has developed from three types of processing plus compensation trades: OEM, electric information industry to strategic emerging industries, which has upgraded from the bottom of the global industrial chain to the top in such a process. The development promotes Shenzhen developing from agricultural economy into an export-oriented traditional industry, from incremental expansions to stock optimizations and from the single innovation to the regional coordination. At present, it has been given the mission of building a pioneering demonstration zone for socialism with Chinese characteristics.

Today, digitalization has become an important part of Shenzhen. According to *The Shenzhen IT Industry Development Report* released by Shenzhen's Science and Technology and Innovation Committee, the output value of Shenzhen's IT industry reached 2.41 trillion yuan in 2018, becoming the global manufacturing centre in communication products, computer products, digital products and LEDs. According to *The Global Financial Centre Index Report* jointly published by the UK think tank Z/Yen Group and China (Shenzhen) Development Institute (CDI) in 2019, Shenzhen ranks top ten in the world in "Financial Technology Service Index". On August 10, 2018, the first blockchain electronic invoice was issued by Shenzhen. Additionally, urban services in Shenzhen are also actively creating "Shenzhen Speed". For instance, Shenzhen Airport has achieved "one pass clearance" in its domestic flights with the ID card, instead of the boarding pass.

5.2. Economy level: Two typical models of smart city services forming the new economy

The new economy relies on information technology and pursues differentiation, individualization, networking and speeding. Under the impetus of digital technologies, it reduces the cost about the resources' aggregation and supply of urban services. At the same time, industry service helps form the new economy. Based on the analysis of project cases, it is found that two typical models of smart city industry services form the new economy.

5.2.1. Platform economy improves urban services

For urban convenient services such as commuting, distribution and agent activities, digital technology enables forming the service model of shared and platform economy. The shared economy model, from the supply side, optimizes the allocation of usage rights of urban service resources. The platform economy increases the supply of quality goods and services to better meet the people's growing needs for a better life. Supporting urban convenient services and developing platform and shared economy require cities to build a friendly regulatory and business environment, stimulate innovation and implement inclusive and prudential supervision.

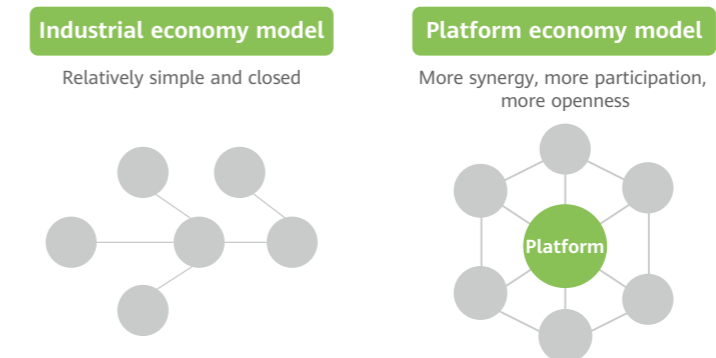


Figure 11 Schematic diagram of platform economy model

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Case: Shared e-scooters

Shared e-scooters as an emerging and convenient short-distance vehicle in 2018, provide an effective solution for the "last mile" of urban traffic. Shared scooter receives rapid and wide popularity as it meets the short-distance traveling needs and effectively alleviates the urban congestion. According to data from American traffic data analysis company INRIX, driving distance to destinations in the United States is 46% less than 3 km and 30% of private-car users are willing to replace cars with electric scooters. Furthermore, 27% of users are willing to use electric scooters as the public transportation tool. At the same time, shared scooter companies are favored by the capital. In 2018, Lime and Bird are the first two American companies to reach the valuation of \$1 billion. Besides, five companies in Europe have raised more than \$150 million.

Source: Adeyemi Ajao, *Electric Scooters and Micro-Mobility: Here's Everything You Need To Know*

Case: Dallas Traffic IoT

Connected Urban Transport in Dallas relies on IoT technologies and provides services to the traffic application service providers, so as to achieve the organic combination of governmental supervision platforms and business service platforms. Projects stem from the government's demand of improving the traffic management, of which the services are usually purchased by the government. The government enacts policies and regulations requiring various traffic applications to connect to IoT management platform uniformly under the rules, which forms the core integrated unit of urban traffic data and management and satisfies the demand of government's precise monitoring and management of urban transportation. At the same time, the government authorizes and supports the platform construction and operation providers, and actively explores the way related to the provision of data, information and other services to traffic application service providers based on the platform. The project is scheduled to be put into operation in 2020.

Source: *Intelligent transport without limits: The City of Dallas Case Study*

5.2.2. Upgrade platform of business management

For the business management platform with public service attributes such as the transportation IoT, it can be promoted as a business service platform and an industry platform. While safeguarding the business management, it provides information and data services to the market, taps revenue potential and develops into the industry platform. In terms of upgrading business management platform to business service platform, it requires the government's coordination and promotion to establish an open platform system, so as to set up the unified standard initially, and then coordinate decentralized underlying IoT devices to access the platform. The platform is operated by the professional teams with its services purchased by the government. At the same time, application service providers provide more standardized capabilities for open services.

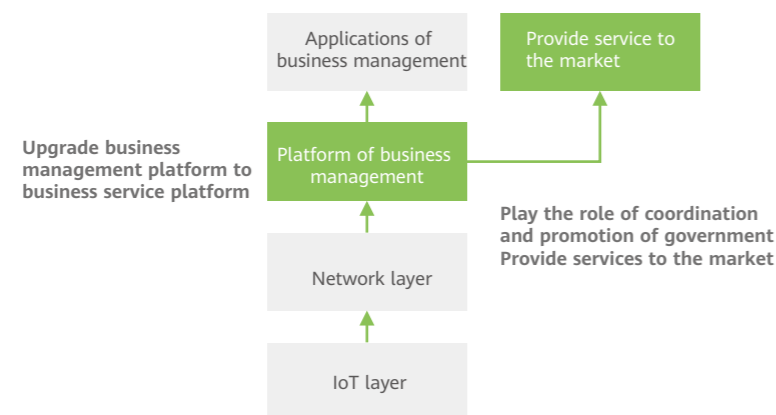


Figure 12 Business management platform upgrade model

5.3. Project level: Four typical models of promoting smart city launching projects

Smart city is a systematic project that requires government-enterprises cooperation and joint efforts and participation from multiple parties. Government promotion and investment, as well as appropriate construction and operation model are important guarantees for the rapid landing and continuous operation of smart city projects. After the analysis of typical project cases, it is found that there are four typical models for launching smart city projects with government-enterprises cooperation.

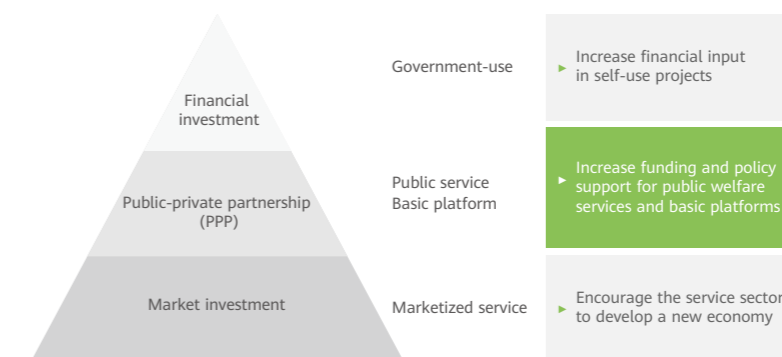


Figure 13 Smart city project investment pyramid

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5.3.1. Government investment model

The government is always the investor for the project of public safety and government management, which is applicable to government investment model. With project-based operation model, the government initiates procurement and then enterprises provide products, technology and conduct implementation. When the construction is completed, the government takes the inspection to decide whether to accept the project or not. If accepts, the government usually entrusts the construction party or other third parties to account for the operation and maintenance. In addition, the government can propose demands, come to a purchase-service agreement with enterprises and allow enterprises to invest, construct and maintain. Eventually, the government purchases the service as agreed.

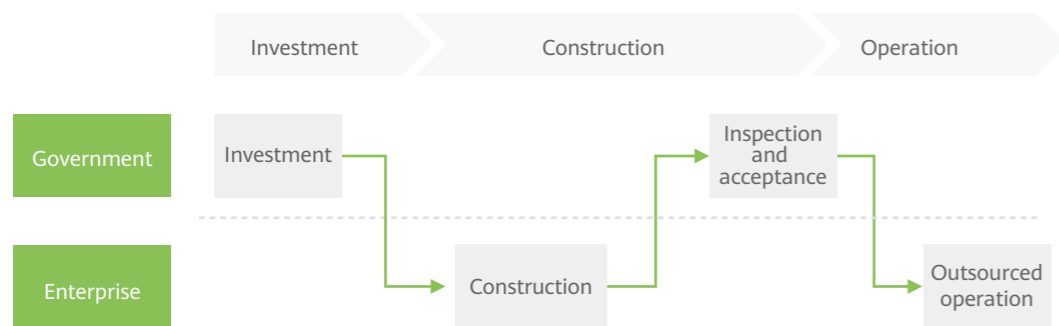


Figure 14 Government investment model of smart city project

Case: The Bristol City operations centre

In 2016, Bristol launched the construction of the city operation centre, which integrated three independent service centres previously focused on traffic control, CCTV in public places and telecommunication services to establish an integrated management, service and collaboration centre. The program is incorporated to the *Capital Plan of Council Budget* to obtain rolling investment support from the government finance. Currently, the Phase I has been completed with a total investment of 11.26 million pounds. After the completion of phase I, it has integrated traffic, CCTV and telecommunication services departments, managed about 700 surveillance cameras and networks, monitored 200+ intersections, and managed nearly 40 traffic and information signs. By integrating three separate service centres and closing offices, it could save £2m a month in operating fees.

Source: According to the Bristol Council Budgets report

5.3.2. Public-Private Partnership model

Smart city development and public service projects with clear operation targets can explore public-private partnership model, in which digitization can reduce the overall cost and create the higher value. Within such a model, the government puts funds, lands and policy support, etc. The enterprise provides funds, talents, technologies and other resources. The government and the enterprise jointly set up an operating company or other entities which takes charge of the investment, construction and operation of the project.

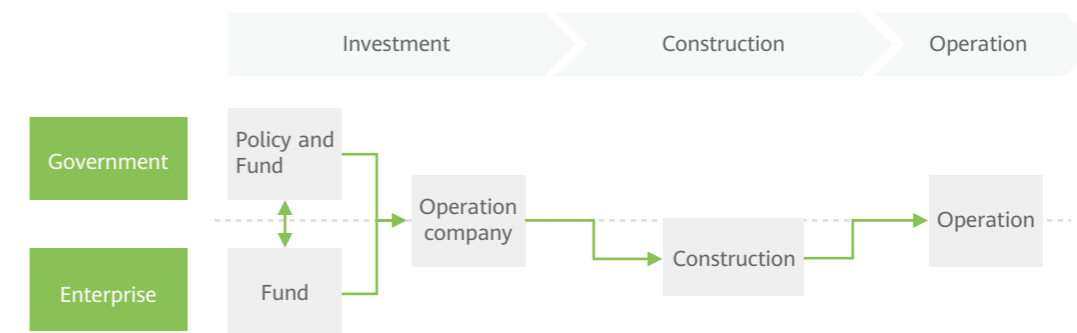


Figure 15 Public-private partnership model of smart city project

Case: the Abu Dhabi telemedicine centre

To alleviate the burden of local medical system, the Abu Dhabi government cooperates with Medgate, Switzerland's leading telemedicine provider to establish the Abu Dhabi Telemedicine Centre. The Abu Dhabi health authority HAAD is responsible for supervision and certification, and Medgate is responsible for training and providing expertise. National insurance provider Daman works with telemedicine centres to provide direct and rapid insurance claims for telemedicine services. Thus, the connected business chain ensures the rapid development of telemedicine centres. According to the official data of the Abu Dhabi telemedicine centre, more than 90% of patients are satisfied with telemedicine consultations, about 1/3 of patients are from remote and rural areas, which improves convenience of medical service.

Source: According to the Abu Dhabi telemedicine centre website <http://telemed.ae/articles data compilation>

5.3.3. Franchise

Projects related to urban governance or public service with the potential of charge and operation are applicable to the franchise

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model, in which digitalization can increase production efficiency, reduce operating costs, and expand users' coverage and aggregation. It can charge for management and service objects or to make profit in the way of backward operation. Within such a model, the government selects the cooperated enterprises and grants a franchise right for a certain period. The enterprise carries out investment, constructions and operations in the scope of franchise rights. And when the enterprise benefits from the project, the government can share the franchise benefits from the operation.

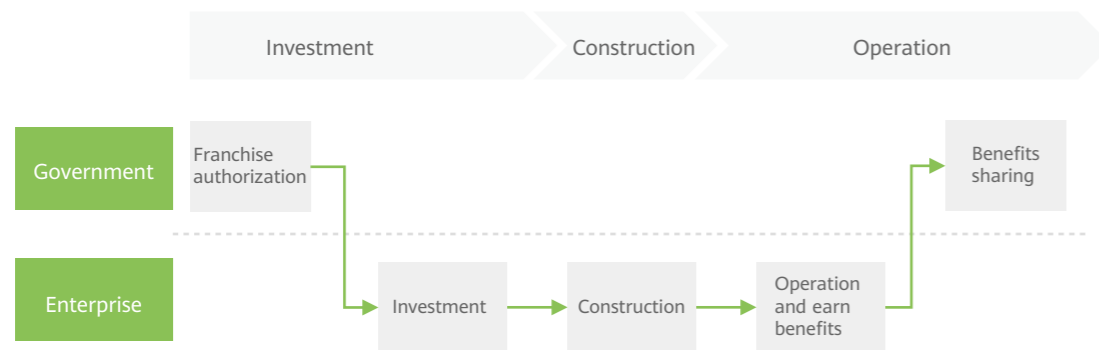


Figure 16 Franchising model of smart city project

Case: New York Link NYC free Wi-Fi service station

In 2014, New York authorized City Bridge to franchise Link NYC service stations to replace old telephone booths. Link NYC provides free Wi-Fi service to the public through advertising benefits. By sharing advertising profits, the government can get a minimum fee of at least \$17.5 million, or 50% of total revenue. The project has attracted large companies, including Qualcomm and Alphabet, to form an alliance of technology, media and experts. Up to September 2018, there were more than 5 million registered users. It is estimated that by 2022, 7500 Link NYC kiosks can be installed, and will generate the revenue of \$500 million to \$1 billion in the next 12 years.

Source: According to Link NYC official site <https://www.link.nyc>

5.3.4. Interest aggregation

Public welfare projects can reduce costs and improve efficiency through the aggregation of relevant parties' interests, and are suitable for the interest aggregation model. Low-cost aggregation of resources and users, and service enable the non-operational projects to turn into operational ones through digitalization. Generally, the government usually provides policy support and fiscal subsidies. The government or public welfare organizations play as the main entity of the project and integrate multi-party interests.

Financial support will be provided by key beneficiaries. At the same time, technology and products will be provided by professional enterprises on a paid or non-paid basis. Eventually, the project entity takes the responsibility for operation.

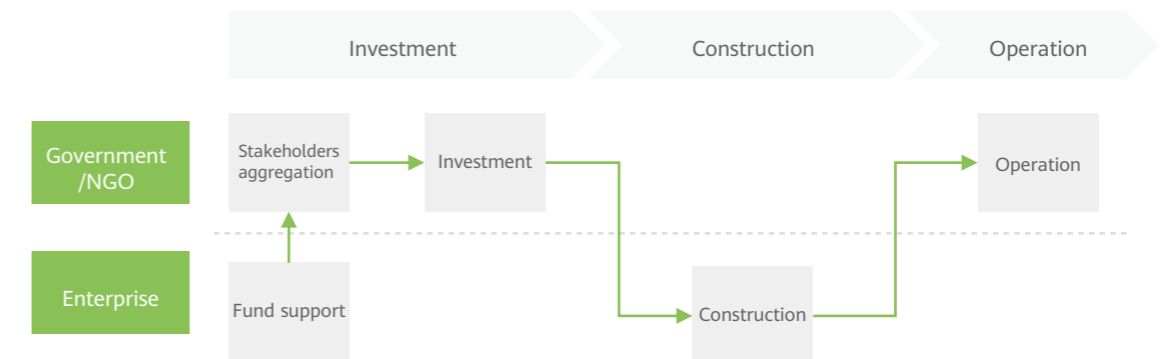


Figure 17 Interest aggregation model of smart city project

Case: the recycling of urban architecture in Amsterdam

Faced with the problem of too many construction wastes in the city, Amsterdam creates an operation model of "urban building recycling chain", which has aggregated the needs from both supply and demand sides using the method of combining e-commerce and IOT, reducing the high cost of urban building materials treatment with the idea of circular economy. The government sets up an online and offline "secondary trading market" for the construction waste and the enterprises collect the recyclable construction wastes on the government platform. As a result, plastic processing, concrete processing and organic material processing plants have joined the circulation for further extending the industrial chain. The project significantly reduces the government's financial input in the supervision of construction waste disposal. With this platform, demolition enterprises can reduce the waste disposal cost while obtaining sales revenue, and temporary buildings also realize recycling of building materials.

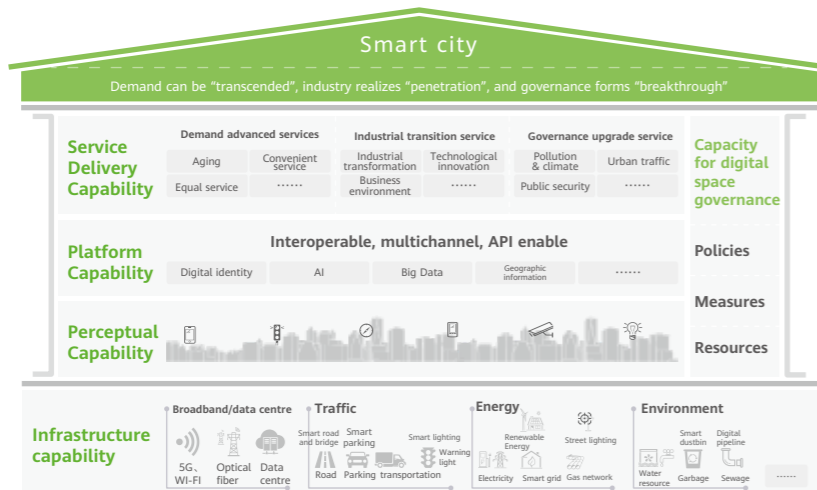
Source: According to CIRCLE ECONOMY, FABRIC TNO, Gemeente Amsterdam study report CIRCULAR AMSTERDAM

06 The systematicness of smart city: Six key capabilities to build the capability system of smart city

6.1.The framework

A smart city is a new form of city, where the physical and the digital world map and interact with each other. Under the new form, the traditional industry and digital technology are deeply integrated, and the digital industry is cultivated and developed to create higher value-added industries which realizes the industry's "penetration". Relying on the digital technology, the combination of digitalization of all urban elements, visualization of real-time status of urban operations, synergy of urban management decisions and intelligence of urban services realizes the "breakthrough" in governance. In the intelligent and personalized service process, human labor force will be further released, and the pursuit of high-level personal development will be satisfied, which can achieve the needs to transcend.

It is the right time to drive the formation of economic vitality through systematic planning and construction, so as to accelerate the development of smart cities. We believe that a systematic smart city needs six key capabilities, including the capability of organization and promotion, infrastructure, perception, platform, services and governance in digital space.



Source: Huawei - Based on EY smart city framework - 2019

Figure 18 Key capabilities framework for smart city

6.2.The key capability

6.2.1.Capability of organization and promotion

The capability of organization and promotion is the overall driving factor for the construction of smart city. The constructors of smart city need to have good organization and promotion capability to define the clear vision and blueprint, set up the systematic framework, coordinate the resources and allocate capital reasonably, so as to guide the construction of smart cities towards the established vision and blueprint.

Organization and personnel setup: The government sets up the agency for smart city organization and promotion with professional teams, and personnel assigned corresponding responsibilities, authorities and resources to coordinate and promote the construction of smart cities.

Capital input and use: The construction of smart city requires the active participation and coordination of the government and society, as well as the stable special financial investment from the government and more social funds.

Systematic planning and design: From the perspective of overall urban development, the government organizes the formulation of strategic planning, top-level design and action plans, forms the general outline to promote systematic construction of the smart city.

6.2.2.Infrastructure capability

The capability for infrastructure can be treated as the "foundation" and "soil" driving the urban development. From the perspective of smart city, urban infrastructure usually consists of ICT infrastructure and traditional infrastructure like buildings, road, etc. The systematic construction of smart cities requires not only the construction of complete ICT infrastructure capabilities, but also the enhancement of digital capabilities of traditional urban infrastructure.

Construct the ICT infrastructure: Establishing a complete "connection" infrastructure covering 5G, Wi-Fi, optical fiber, etc.to form the ubiquitous information transmission channel capability. Besides, building powerful computing and storage infrastructure to effectively support the operation of smart cities and the construction of digital space.

Digitalize the traditional infrastructure: Digitalizing traditional infrastructure like buildings, road traffic, pipelines, establishing sensing and adjusting control terminals and digital models, deploying intelligent hardware infrastructure such as smart light poles can improve the service level and the carrying capability.

6.2.3. Perceptual capability

Perceptual capability is regarded as the “sensory organ”, enabling smart city to operate from statically to dynamically. The urban operational status can be monitored and fed back in real time when constructing the perceptual capability, so that the urban delicacy control and operational management can be greatly improved. The construction of perceptual capability includes:

Sensing terminals: Urban data such as transportation, environment and public security etc. will be comprehensively collected. At the same time, structured or unstructured information will be gathered to provide feedback. Terminal sensing helps form ubiquitous, multi-disciplinary and efficient information resources.

Transmission networks: Using the wired or wireless IoT network, the public IoT network and the wireless local area network (LAN) comprehensively, data will be collected and transmitted in real time to establish the connection between the sensing data and the platform or applications.

IoT empowering management platform: Building a public and basic IoT platform will uniformly manage the related sensing terminals, aggregate all varieties of sensing data. Such a platform provides tools to monitor and share the basic data, meanwhile plays a vital role in supporting the upper smart applications.

6.2.4. Platform capability

Platform is the core resource for the smart city stepping to the future. The fundamental, comprehensive and strategical capabilities of new technologies such as big data, artificial intelligence (AI), geographic information system (GIS) and video analysis, etc. in empowering the smart city require establishing urban digital platforms, collecting and unifying all related data resources in the urban level. Platform capability includes,

Big data: Collection and acquisition of data recourses at the urban level, as well as the services of integrating data collection, processing, exchange and analysis.

AI: The intelligent self-learning and decision-making services such as image analysis, semantic analysis and human-computer interaction, etc.

GIS: The unified geographic information services are provided based on geographic information, loading the urban operation data such as transportation, environment and public services, etc., which make it possible to visualize and simulate the urban operational status.

Video analysis: It enables video sharing and provides capabilities of massive video analysis and processing for a variety of smart applications.

6.2.5. Service capability

Service capability is the exhibition to show the usage and results of smart services towards the government, residents and enterprises. The service capability is established based on infrastructure, perceptual and platform capabilities, which covers every aspect of urban planning, construction, management and services. Such service capabilities help form the sustainable development ecosystem, which can be divided into three categories, including mastering governance, benefiting citizens and thriving industries.

Capabilities of mastering governance: Integrating big data, IoT and AI etc., into the area of traffic, environment, public security and urban emergency etc. deeply can improve the degree of delicacy and smartness of governance as well as promoting the formation of a synergy of governance resources.

Capabilities of benefiting citizens: Relying on the mobile Internet and big data, providing the citizens with personalized, real-time and ubiquitous living services is to improve the quality of urban life and meet the progressing demands of human beings.

Capabilities of thriving industries: Creating a fair and efficient business environment is to accelerate the digital transformation of traditional industries, empower the development of digital industries and stimulate the new vitality of innovation and entrepreneurship, which helps transform the industries and improve the urban value density.

6.2.6. Governance capability of digital space

Governance capability of digital space is an important guarantee for the safe and orderly development of smart cities. The goal of realizing a safe, orderly and clear digital space is based on the high-quality data, which requires protecting the privacy and legal rights, regulating the behavior in digital space, combating and resisting illegal activities, as well as applying comprehensive security protection technologies and mechanism. Besides, governance of digital space requires strengthening the cross-city collaboration.

Data governance: Developing data standards and specifications, standardizing data collection, usage, sharing mechanisms as well as clarifying the data protection and update mechanisms, can improve data quality and availability.

Privacy and rights protection: Improving laws and regulations is to resist the illegal behavior of data usage, fully protect privacy, digital identities, digital asset, digital copyright and other legal rights, so as to regulate the behavior in the digital space.

Security of digital space: Establishing the comprehensive protection measures in the security aspects of terminal, network, data and application is to ensure the safety of digital space and normal operation.

07 Huawei's key positions: Four key actions to promote smart city as urban basic services

7.1. Adapt to the new situation, shift the role of government to accelerate the construction of smart city

Clarify the stage and enhance the confidence: Profoundly treat the smart city as the future development direction of cities. Precisely identify the current situation as the phase from "function" to "effectiveness". Firmly believe that smart city is the basic urban service, the basic means of urban governance, and the fundamental content of the emerging economy, which requires advanced layout and systematic planning.

Shift the role and coordinate to drive forward: The government plays the critical role as a unified coordinator and progressing organizer, as the construction investor that increases the financial investment into the areas of self-use, public welfare and basic things, and as the environment builder that improves policies and regulations, creates a fair business environment that attracts global professional companies to participate in.

Improve the publicity and foster the atmosphere: Taking service projects as a breakthrough point, it requires maximizing the participation of the public into project planning, construction and operation, and continuously improving the service experience as well as the reputation of smart cities.

7.2. Driven by economy, enhance the economic vitality of smart city with appropriate models

Promote the integration of smart city into urban development and enhance the economic vitality of smart city: Referring to the practice of different cities, select the models and paths that can be referenced to, which combines ICT technology with the development of key urban industries and the solution of key problems, so as to enhance the economic vitality of smart cities. Key industries can be reactivated through the digitalization of the model about resource aggregation, product production and service supply. The expansion of urban space can be enriched with high-level urban services through digital and networked means. Urban disease can be addressed by integrating ICT technologies, and even evolved into new smart industries through local pilots. Competitive advantages can be rebuilt through digitalization, which even brings about the new competitive advantage. Emerging cities can grasp the opportunities in the era of digitalization and globalization, where the government strongly encourages the

industrial chain links to breakthrough directionally or upgrade comprehensively.

Encourage and support the development of the new economy around smart city industrial services: Build a friendly development environment, implement inclusive and prudent supervision, encourage and support urban convenience services to develop shared and platform economy. Construct and improve the operation mechanism. Regarding the business management platform with public service attributes, while safeguarding the business management, explore the value of data and platform capabilities, promote the development of the business service platform, which can be further promoted into the industry platform. Improve laws and regulations, establish standards and norms, actively promote government data resources to open to society in accordance with regulations, encourage and support enterprises and individuals to carry out commercial development and utilization of data.

Advance the implementation of smart city projects with appropriate construction and operation models: Projects regarding public security, government management and other government usages require increasing government financial investment, and rationally choosing models about self construction and operation, agent construction, purchasing services, commissioned operation, outsourcing operation and maintenance, etc. Projects regarding public welfare services and basic platforms, require strengthening the government financial support. Establish and improve the rules and regulations for smart city joint ventures, franchising, etc., actively try and promote the use of land development rights, project operation rights, tax incentives and other means to innovate construction and operation models, as well as strengthen the implementation of government-enterprises cooperation projects. Encourage and support public institutions to explore the interest aggregation model of public welfare projects.

7.3. Systematic planning to build a complete smart city capability system hierarchically

Strengthen top-level guidance: According to the urban development strategy and practical basis, formulate targeted top-level planning, establish guidelines for systematic promotion of smart city construction, and continuously update and improve them.

Integrate ICT infrastructure into construction of urban infrastructure: Integrate ICT infrastructure into urban infrastructure planning; promote the simultaneous construction of communication pipelines, machine rooms, and towers; continue to improve facilities such as networks and data centres to raise the level of "connectivity" and "computing power".

Actively promote the digitization of traditional urban infrastructure: Introduce policies and measures to support and reward the digitalization of traditional infrastructure and improve its efficiency. In the construction and renewal process, the integrated intelligent infrastructure hardware should be actively adopted to build digital urban infrastructure.

Embed the perceptual capability into the city comprehensively: The government organizes and formulates regulations for the construction of the urban IoT, and promotes the building of the connected perceptual capability through government projects. Government projects take the lead, guide the projects in public utilities, energy conservation, emission reduction and other key areas to follow up, which promotes to embed the perceptual capability into the city synchronously.



The Key to Tomorrow's Smart Cities Economic Vitality and Systematic Planning

Speed up constructing platforms and build new urban infrastructure: Regarding the construction of ICT infrastructure as platform capability, the government should increase investment, innovate investment and financing models, construct the city-level digital platform and accelerate the construction of “middle-end” capabilities in smart cities. Besides, the government takes the lead to organize the construction and operation of data resources, promotes integration of data resources and opens application of platform.

Strengthen government-enterprise cooperation to improve diversified service capability: Establish the construction list of smart city projects, arrange common development of projects for profits and for public welfare through methods such as trading of “market” for “resources”. With the platform as the support and the specific urban needs as the guidance, it can build a comprehensive and high-level service capability covering “good governance, benefiting the people and promoting development”.

7.4. Efforts should be made in various aspects to consolidate the basic guarantee for sustainable development of smart city

Set up organization and institution: The government shall construct a professional institution for smart city construction, operation, organization and management, set up professional team and personnel with corresponding responsibilities, authority and resources to promote and coordinate the construction of smart city.

Maintain investment: Incorporate smart city construction investment and operation improvement into the regular government budget to ensure sustainable financial support. Various investment and financing methods should be adopted simultaneously to guide and encourage the participation of social funds.

Build governance capability: Improve laws and regulations, strengthen privacy protection. Enhance cross-city cooperation, establish rules for the protection and management of rights and interests in digital space such as digital identity, assets and wealth, establish norms of conduct in digital space, and jointly resist and punish activities endangering society in the digital space.

Strengthen security guarantee: In addition to improving network information security policies, regulations and standards, we should take the application of security technology as a basic requirement, strengthen the promotion and application of security technology, and ensure the security of digital space.

Improve the professional level: Introduce professional technology enterprises and enterprises clusters to participate in, to guarantee the professionalism of smart city construction with professional technical strength and promote the development of smart city to form ecosystem.

08 Conclusions

Like electrification of cities in the electrical age, urban digitalization is now undergoing an evolution from functional enhancement to performance realization and then to the exertion of effectiveness. Currently, we are witnessing a process with “many constructions but limited effect, many attempts but less integration, many pilot projects but less massive production”, which is an inevitable phase of development for smart cities.

At present, development of smart city has gone through performance verification in key areas and will enter into the performance realization stage. The economy and systematicness of smart city are shifting from spontaneity to self-consciousness, meaning that it is the right time now to accelerate the development of smart cities by systematical construction promoting economic growth. We shall identify the current development stage, enhance confidence, plan as a whole and increase investment to welcome an era of full effectiveness of smart cities.

