

## Arup

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Arup has more than 40 years of experience in China with over 2,500 staff providing a full range of professional services across building, consulting and infrastructure sectors.

Arup has worked on many of the most iconic structures in China including Beijing Olympic venues, Shanghai Expo pavilions, Canton Tower, CITIC Tower, Raffles City Chongqing and Beijing Daxing International Airport and Hong Kong-Zhuhai-Macao Bridge.

## Alibaba Cloud Research Center

Powered by the massive data and business practices of Alibaba Group and Alibaba Cloud Business Group, Alibaba Cloud Research Center is committed to 'exploring new business boundaries with technology', and co-creating an open platform for cutting-edge technology and smart business. Its major research area covers cloud computing, artificial intelligence, blockchain, big data, IoT and quantum computing. Meanwhile, it actively explores technology-driven digital transformation of various industries such as retail, manufacturing, finance and energy – the possible paths and successful practice.

Over the past four years, Alibaba Cloud Research Center has delivered a full range of excellent digital services, products and programmes including Apsara Technology Review, Digital Transformation Case Library, industry digital transformation whitepapers, Chief Growth Officer Special Training, and Digital Transformation CXO Research Institute. Today it has become the 'strategic accelerator' for the digital transformation of governments and enterprises.

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## Empowering Future Urban Planning & Design with Dynamic Data

Whitepaper (abridged English version)

ARUP

阿里云研究中心  
ALIBABA CLOUD RESEARCH CENTER

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“ People-oriented design has long been hailed as the planning ideal, but until now we have had only a limited understanding of how people actually use cities. For the first time in history, we can now understand people’s collective behaviours via urban dynamic data, and use this to make better decisions that benefit millions down the road. Urban sciences can now complement design creativity in shaping better and more sustainable cities.”



**WILL CAVENDISH**  
Global Digital Services Leader, Arup

## Aim of the Whitepaper

For many years, urban planners and designers have been relying on personal experience, qualitative analyses and planning principles to formulate planning schemes that affect millions of people and billion dollars of construction investments. The data sets they can often grasp are only peak hour traffic records, decennial census data and survey responses from a thousandth of the population. Authoritative judgments and creative imagination fill the vacuum in planning techniques.

In recent years, the rapid development of digital technology has transformed one traditional industry after another. The application of new technologies such as the Internet of Things and mobile internet has resulted in an exponential growth of urban dynamic data. Lack of data can no longer be an excuse for a lack of comprehensive and objective understanding of the city. For the first time in history, omniscient observation on urban activities becomes a possibility. However, like crude oil buried deep underground, the presence of urban data does not guarantee its usability. Systematic drilling, extracting, refining, transport and storage are required to harvest its energy.

**This Whitepaper aims to explore how the urban planning and design industry can make good use of cutting-edge digital technology and ubiquitous city**

**data. With innovative planning methods and a comprehensive digital infrastructure, it can improve the efficiency and effectiveness of planning work and turn flexible and people-oriented development to a reality.**

## Current status

The rapid growth of mobile, connected devices and their associated applications have resulted in a surge in both the amount and the variety of real-time urban data. The creative use of data and digital technology has also transformed traditional industries one after another.

**This Whitepaper investigates how urban planning and design methods should transform to tap into these opportunities and make the process more efficient, evidence-based and responsive to future changes.**

In the market economy, urban planning plays a critical role in allocating 'public goods' to fulfil the need of the increasing urban population and create greater value for both the society and individuals. It goes beyond merely a building or infrastructure development. The use of dynamic data can augment this urban planning objective by stocktaking available resources more precisely and optimising their allocation based on informed decisions.

Conventional urban data sources include statistical data, survey data, remote-sensing data, existing planning parameters and data from actual implementations. The use of these data sets is faced with a number of problems including slow updates, high collection cost, low locational precision, data silos, temporal fluctuation in value and lack of dynamic attributes. They also seldom capture a city's operational performances that all plans aim to improve.

On the contrary, new data types (including open data from the government, corporations and organisations, internet data, and data from digital devices and location-based services) possess a range of advantages: diverse sources, large sample sizes, constant updates, efficient data collection and capture of people's behaviours, which ultimately contributes to the formation of timely, evidence-based, quantitative and people-oriented urban plans. Furthermore, the collection and analysis of dynamic data provide unprecedented opportunities to disentangle the complexity of the urban system and allow planners to evaluate the chain effects of an urban decision.

**Advantages of new data types** include diverse sources, large sample sizes, constant updates, efficient data collection and capturing human behaviours – all contributing to the formation of timely, evidence-based, quantitative and people-oriented urban plans.

"The 50-year cycle of traditional urban development strikes a stunning contrast with the 5-year cycle of digital technology, resulting in an incompatibility between static urban planning and dynamic urban living. Today, as a living artificial organism, a city can form a super 'neural network' with the help of data, AIoT and cognitive applications. With digital planning, a city can evolve into an orderly growing smart organism, making the development of people-oriented, harmonious coexistence of man and nature a new possibility."

**LIU SONG**

Vice President, Alibaba Group



## Our vision

We envision that future cities will grow and fulfil their people's needs by better allocation of resources rather than their ever-increasing consumption, hence achieving sustainable development.

Despite the limited resources available, cities will continue to expand under the natural urbanisation process in developing countries and the people's expectation on better living standards. Urban planning, being the process of "comprehensively prepare, tangibly arrange and practically manage a city's socio-economic development, land uses and spatial arrangement during a defined period of time", works alongside the market to allocate these resources.

We envision that the physical and digital infrastructure will be deeply integrated in future cities.

Such a complex system allows the operational experience of a city to be fed back to its planning and design process so that the physical plan can be optimised and adapted to emerging needs through time. In fact, the current use of mobile apps to order and pay in restaurants, and the intelligent traffic control for ambulances have already demonstrated that physical-digital integration is underway. We advocate to go a step further to close the loop between the

planning and operation stages of an urban lifecycle by systematising the use of dynamic data on the former.

Under this conception, planning practices will transform in multiple dimensions:

1. Given the integration of the digital and the physical worlds, the digital infrastructure will be an integral part of an urban plan. Both the framework of data flow and the associated physical network and devices will be planned alongside with physical development.
2. Dynamic data becomes a new resource for the planning process to make the analysis more robust and comprehensive, enabling evidence- and experience-based planning. It follows naturally that planning techniques and procedures will also be modified. Preliminary assessments can be continually and automatically done such that warning can be sent for anticipated problems.
3. Given the volume and ubiquity of urban data, the need of a powerful, stable, safe and reliable digital infrastructure would be essential to materialise the above vision. On top of the sensing, network, computation, operation and application layers that any smart city warrants, a digital twin of the physical city will be required to provide dynamic urban data with a centralised and integrated platform where spatial analyses can be performed.

# How will the planning practice transform?

The digital infrastructure will be an integral part of an urban plan.

Dynamic data becomes a new resource for the planning process, driving the change of the planning techniques and procedures.

A powerful, stable, safe and reliable digital infrastructure will be essential.

## Four strategic propositions

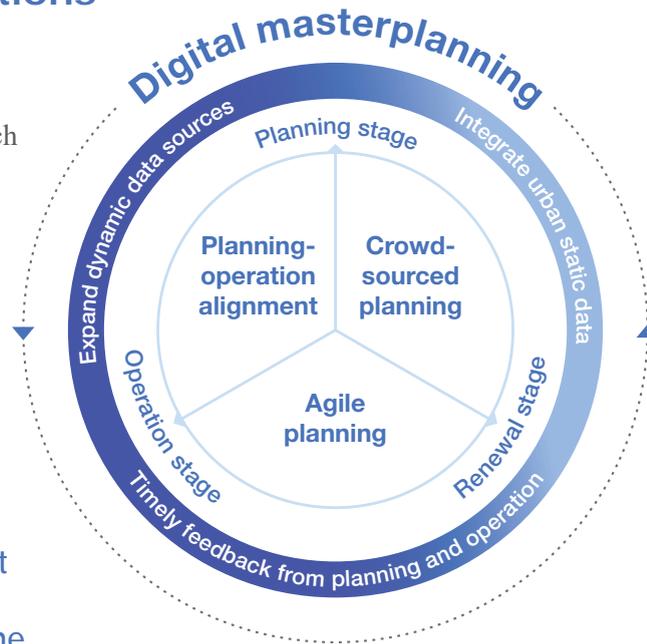
This Whitepaper puts forth four propositions to guide our thinking towards this transformation, from which planning mechanisms can be derived to fully tap into the benefit of the abundant data resources in cities.

### Proposition 1: Planning-operation alignment

Different from the traditional prescriptive planning, planning-operation alignment is a performance-based planning method based on the real urban life experience and the needs of citizens.

Data sets generated by end-users and the subsequent collection and processing of them allow planners to trace how urban spaces are actually being used. This opens up the possibility of using actual performances rather than prescriptive rules to formulate and assess a planning/design proposal. Unlike in conventional planning practices where prescriptive planning standards and guidelines serve a proxy for ‘good’ planning outputs, the current data technology reveals a direct relationship between a planning/design scheme and its ultimate end-user behaviours or experiences. Some ‘key performance indicators’ for planning and operation can therefore be unified.

To achieve the above, an Activity Information Modelling (AIM)



Four major changes in urban planning driven by dynamic data

environment will be necessary to enable behaviour-based planning empowered by data availability. Complementing Building Information Modelling (BIM) and Geographical Information System (GIS), AIM captures dynamic data by providing data ‘containers’ for anticipated urban activities (e.g. pedestrian and vehicular movements, clustering of people) such that these data sets can be stored, visualised and analysed with geo-references. Mobility Mosaic, a mobile app produced by Arup, follows the logic of AIM and has facilitated the Transport for Victoria to capture the passengers’ performances to make the right planning decisions.

### Proposition 2: Agile planning

Agile planning allows the planning design and parameters to be adjusted within a certain range based the actual performance of the urban operations.

The availability of data reflecting end-user behaviours also creates opportunities for fine-tuning the original plan during the operation stage. Due to changes in external circumstances and unavoidable deviations in the original predictions/simulations, the original plan often fails to fully meet the ultimate operational needs. Instead of relying on a complete plan revision to reconcile the differences, ‘agile planning’ can be introduced to allow part of the plan to be prescriptive with the rest being adjusted based on the actual performance during the operation.

A hybrid planning system, together with consensus on thresholds that can trigger planning adjustments, will be required to put the above idea into practice. Taking a business park as an example, the allowable floor area of the Phase II development can be a range rather than a fixed quantity – the upper end can be

granted if the actual traffic demand is significantly less than predicted while the office space demand is stronger than expected.

A mechanism to trigger adjustments would further enhance planning agility in fulfilling the evolving needs of the society. A framework to ‘sense-check-warn-adjust’ can be established – automatically collecting data related to key performance indicators, analysing to check against acceptable thresholds, providing warning for exceedance and recommending directions for adjustment. ‘Dynamic planning’ has been advocated by organisations such as the Energising Kowloon East Office in Hong Kong which released five versions of ‘conceptual master plans’ within five years. The use of dynamic data will complement efforts of this kind by providing more evidence for changes within a shorter response time.

“To bring urban data alive, we need to design the right ‘containers’ that facilitate data processing, visualisation and analyses. The Digital Twin will seamlessly connect the ‘physical’ and ‘digital’ worlds and enable us to continually refining our city based on the latest evidences. It is envisioned to be an indispensable part of future ‘urban infrastructure’.”

**BRUCE CHONG**

East Asia City Advisory Leader, Arup



### Proposition 3:

## Crowd-sourced planning

Urban data generated from multiple sources can potentially be used to inform better planning decisions.

Traditionally, most if not all data for planning analyses are provided by the government. With the growth of location-based services and other online-to-offline activities, urban data generated from multiple sources can potentially be used to inform better planning decisions. Dynamic data from the government, corporations and organisations together with those shared by the general public can be consolidated to provide a snapshot of the current status of a city.

In conventional planning practices, policies, previous plans and professional judgements are combined with site survey and/or interviews to form the planning basis. With the availability of data technology and third-party data, the plan-making process should also begin by reviewing the data landscape to ensure that no relevant third-party information is being missed. It can be obtained by active means such as data sharing, issue reporting, and rating for open spaces and public facilities. It can also be obtained via passive means such as text analytics on public online opinions and ratings on points of interest (POIs).

Many city governments have been implementing open data policies under which urban data without sensitive issues are required to be made public. Such a

concept has been extended to private businesses which are closely linked to public interest. For example, the State of Massachusetts has passed a law to require rideshare companies to share data with the state government, and cities including Boston have been using such data to inform planning decisions. On the other hand, private entities should also be allowed to submit their data, comments and recommendations to open platforms to enable more evidence-based planning. It is necessary to establish a mechanism such as ‘urban data trust’ to allow the crowd-sourced planning being practiced safely and properly.

### Proposition 4:

## Digital master planning

Digital master planning provides a framework to realise planning-operation alignment, agile planning, and crowdsourcing planning. It’s an integral part of the urban planning process.

A digital infrastructure is needed to collect, store, exchange, process and visualise dynamic data effectively for uses in both the planning and operation stages of urban development. Such an infrastructure will need to be planned in advance alongside with the physical set-up. We therefore propose that digital master planning be an integral part of the urban planning process. To justify the cost of setting up such a digital infrastructure, it should serve the needs

of both urban planning and urban management so that the value it creates would be substantial enough. It also ascertains the richness, authenticity and timeliness of the data and align planning and operational objectives as advocated under Proposition 1.

To facilitate digital master planning, the digital twin plays an indispensable role in bridging the digital and physical worlds. Through the digital twin, real-world dynamic data can be recorded and simulated in the virtual model with spatial and temporal considerations. It becomes possible that the trajectories of people, objects and events can be predicted, which enables evidence-based urban decisions.

Full integration of the digital and physical spaces is achieved through a digital infrastructure comprising seven layers: the sensing layer, the network layer, the computation layers, the operation system for urban data (including the data platform, the business platform and the application support platform) and applications for urban businesses.

Moreover, institutional design is as important as tangible infrastructures in enabling the use of dynamic data for urban planning and design. This includes establishing data standards and refining planning regulations and procedures.

The Development of a Common Spatial Data Infrastructure - Built Environment Application Platform (BEAP) Feasibility

Study commissioned by the Hong Kong government and delivered by Arup is creating a data infrastructure with 10 prototypical applications for handling urban planning, infrastructural engineering and environment assessment tasks. At the same time, the ‘City Brain’ developed by Alibaba further provides an integrated solution to collect, process/analyse and visualise urban data, and instantaneously generates solutions that improve urban operations.

## Three application scenarios

Based on the four propositions, we further explore the use of dynamic data in three planning endeavours that are of high demand in recent years. They are campus planning, urban regeneration and the new form of statutory plan in China called the territory spatial planning.

### Campus planning

A campus is an ideal place to implement digital urban strategies as it is often developed and operated by a single entity who is motivated to invest in innovation during the development phase to improve operational efficacy.

A ‘campus’ generally refers to an urban functional area with a clear theme and development-cum-operation boundaries as exemplified by business parks, tech

parks, university campuses, etc. Because a campus is often developed and operated by a single entity, this is an ideal place to implement digital urban strategies. Since the developers will also serve as the operators, they are motivated to invest in innovation during the development phase to improve operational efficacy. The cost-benefit can therefore be justified more easily when a system is created to serve both urban planning and operation. The advantages of pursuing planning-operation alignment (Proposition 1) and agile planning (Proposition 2) become apparent in this case.

Taking business park planning as an example, with the help of dynamic data from traffic routes and people movements, the traffic intensity and attractiveness, the number of visits, and road congestion in the park can be regularly monitored. Timely adjustments can be made to the plan to enhance the overall mobility and accessibility of people for future phases of the development.

Many business parks offer spaces and services that compete head on with each other. Dynamic data on the business nature, staffing and performances of existing tenants can help business parks refine their development strategies and corresponding facility provisions with solid evidence. At the same time, based on dynamic information on competitions, relocation trends and new investments of companies, the clustering phenomena of different industries can be identified and the positioning of the campus can be refined to secure its continual competitiveness.

## Urban regeneration

**Urban regeneration is, by nature, to re-allocate spatial resources and improve the living quality of urban dwellers. This requires more fine-grained planning based on their actual needs and also reveals the importance of crowdsourcing planning.**

With the maturity of their urban centres and caps on annual land disposal, some Chinese cities are shifting their focus from greenfield to brownfield development. Demand for planning services for urban regeneration is therefore expected to surge. Since by nature urban regeneration is to re-allocate spatial resources and improve the living quality of urban dwellers, this requires more fine-grained planning based on their actual needs. Dynamic data sets contain vast data reflecting individual behaviours that allow the needs of small groups to be understood and fulfilled. Crowdsourced planning (Proposition 3) will be highly conducive to such needs in urban regeneration.

Urban regeneration is often motivated by unleashing the latent land value and its equitable redistribution among stakeholders. Therefore, it's critical to make accurate assessments for the economic feasibility covering demolition costs, development intensity and market acceptance of proposed developments. Meanwhile, analyses on dynamic data capturing adjacent property values, competitive real-estate products and

customer preferences can further improve land-use and design decisions by the urban redevelopment entity.

## Territory spatial planning

**The territory spatial planning opens up an opportunity to practise digital master planning, integrating mechanisms for urban data usage in the overall planning process.**

Chinese cities are formulating territory spatial plans to unify the various kinds of urban plans that are currently being produced to achieve 'a single blueprint' for land planning and management. The process will completely change the technical approach, management method and development trajectory of planning services in future, and it opens up an opportunity to practise digital master planning (Proposition 4), integrating mechanisms for urban data usage in the overall planning process.

Among all initiatives under the new system, 'dual evaluations' and the 'monitoring and evaluation' are the two initiatives where the use of dynamic data

can create most value. 'Dual evaluation' requires large amounts of background data including land resources, water resources, marine resources, environment, ecology, disasters, meteorology and climate.

Dynamic data such as existing land uses deduced from remote-sensing, air quality monitoring data, mobile map APIs usage can be used to supplement conventional data provided by the government. For 'monitoring and evaluation', the use of dynamic data will allow direct evaluation of the effect of plan implementation on end-user experiences and operational performances rather than merely plan compliance. When it comes to city emergencies such as COVID-19, the digital master planning enables cities to react quickly and properly based on the dynamic data.

"The city carries the human society, like a container. If we look at cities from a digital perspective, there are three key elements: scenarios, data and computing power. The future digital city will undoubtedly be evolving with the synergy of these three elements. Digital creativity will be one of the essential and frontier fields of urban design and planning."

**XU SHIJUN**

General Manager of Smart Government Division, Alibaba Cloud



## The way forward

Currently, factors hindering us from fully tapping into the benefit of dynamic data include inconsistent data format and quality, data silos between government departments and large corporations, lack of supportive regulations, and limited talents who master both urban and data analyses. Another major obstacle is finding ways to cover the data cost as the conventional planning/design projects do not provide for the cost of handling dynamic data and its benefits are not immediately seen.

To unleash the full potential of dynamic data in enhancing urban planning and design, we advocate for the following immediate actions:

- Re-establishing the role of urban planning in the reallocation of spatial resources;
- Building a complete and modularised digital architecture;
- Fostering collaborations between data owners; and
- Developing new planning approaches for the data-rich environment.

It is generally agreed that the technology for deeper digital transformation is already available. However, technology can do its job only when the public accepts it and the required institution set-up is in place. This report therefore highlights the importance of data security/privacy and sustained interest of data users and contributors and explores possible solutions for these two focuses.



## Protecting data security and privacy with 'urban data trusts'

An independent third-party agency called the 'urban data trust' can be established to monitor urban data availability and determine whether urban data is collected, stored and used in a secured and lawful manner, and to reach agreement with data contributors and users with the latter obtaining permission from the data trust. Advanced technology such as blockchain can also be deployed to secure the authenticity and anonymity of data being used as attempted by Alibaba Cloud in the Wenzhou Personal Data Treasure project.



## 'Gamification' continues to attract data contributors and users

Continual maintenance and upgrade of urban data platforms requires keen involvement by its users and contributors to justify such investment. 'Gamification' is increasingly regarded as an effective means to enhance user experience and level of participation. Applying it to urban planning, the public can continuously encourage users to share and use urban information through mechanisms such as online collaborations, task completions and submission of suggestions on draft design schemes in a fun and user-friendly environment.

Urban planning has evolved from being a subject for derision to becoming widely accepted today as a tool to guide the direction of urban growth and manage land development especially in East Asian cities. Such status is established through continuous advancement in techniques, profession knowledge and institutional mechanisms. It is hoped that the abundancy of dynamic urban data and its proactive usage will enable another leap in the scientific development of urban planning and design practices.

This is an abridged English version. Scan the QR code or [click here](#) to read the full report in Chinese.



"What prevents urban data from unleashing its full potential is often the lack of trust and sustained interest and not the underlying technology. It is time for the industry to put serious effort in institutional setup and UX design, so much so as the effort being invested in building the infallible cloud system and ubiquitous IoT coverage."

### SANKAR VS

East Asia Digital Services and Products Leader, Arup

