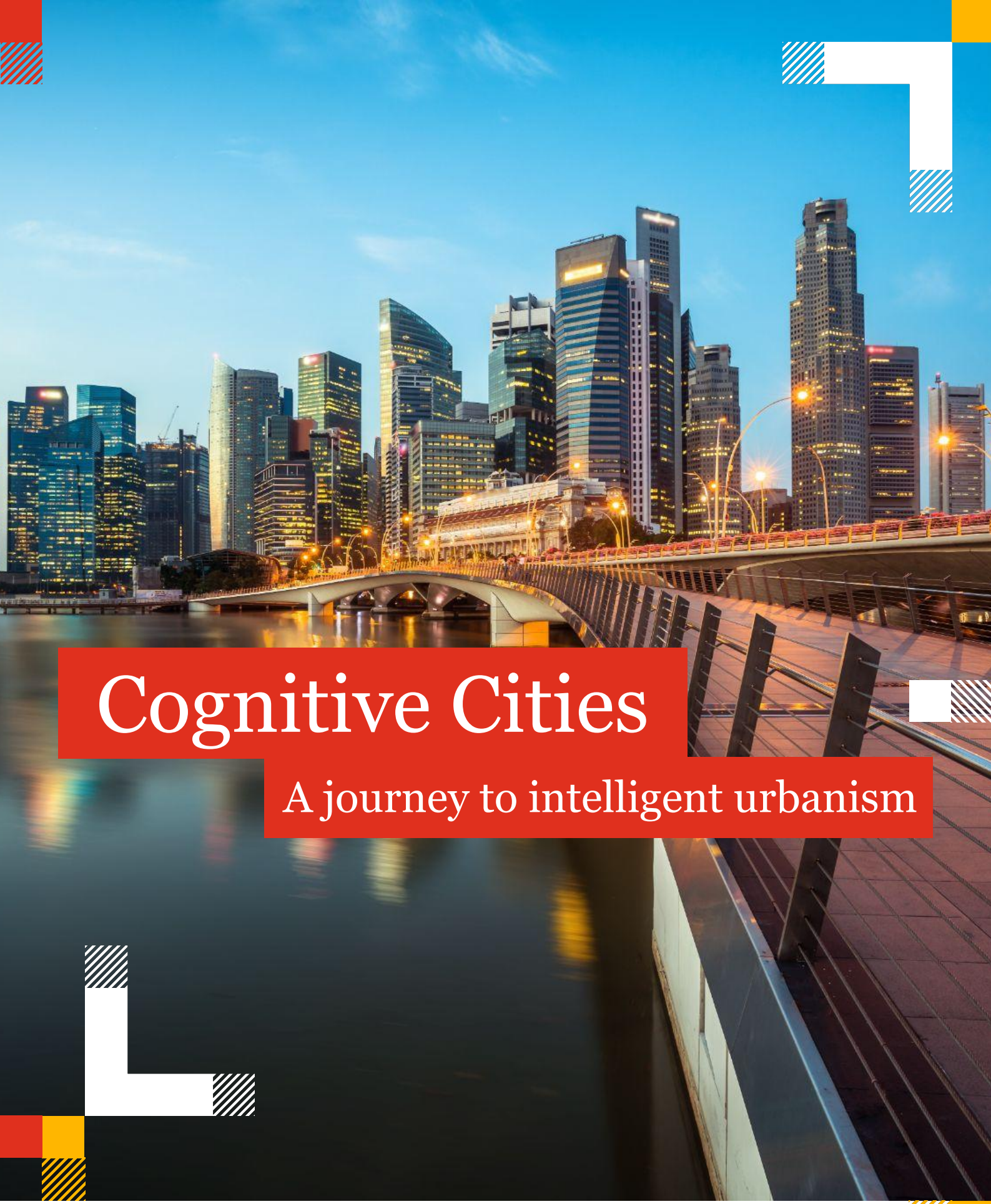

# Cognitive Cities

## A journey to intelligent urbanism

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# Foreword

## Hazem Galal

**Global Cities and Local Government Leader and Global Smart Mobility Co-Leader, PwC Middle East**

“In an era marked by accelerated urbanisation and a relentless pace of technological innovation, the concept of smart cities has taken root and flourished. However, today, we envision cities that not only embody intelligence but also exhibit the capability to think, adapt, and evolve in harmony with the dynamic needs of their inhabitants. The concept of cognitive cities represents a pivotal juncture in our urban evolution, beyond smart cities. These cities are planned and operated by insightful data, inspired by innovation, and devoted to enhancing their urban services.

This paper provides insights into the principles, technologies, and strategies that underpin the transformation from smart to cognitive cities to enhance the lives of their inhabitants, businesses and visitors.”

## Rajat Chowdhary

**Partner, Technology Consulting, PwC Middle East**

“We are in an era where we are witnessing firsthand the transformative power of technology and data in shaping the cities of tomorrow. The concept of cognitive cities, where data-driven intelligence converges with urban living, represents a pivotal moment in the evolution of our urban environments. It compels us to reimagine how cities function, adapt, and thrive in an increasingly interconnected world. Cognitive cities represent the pinnacle of our aspirations – a vision where cities become not just smart but also sentient.

Cognitive cities are an ode to human ingenuity and a commitment to building a technologically advanced and profoundly human-centric world. Together, let us embark on a journey to unlock the full potential of our urban landscapes, creating cities that not only meet the needs of today but also provide a thriving and resilient future for generations to come.”

# Contents



# 1

# Introduction

With the surge in the world's urban population, the challenges facing policymakers, municipalities and service providers to deliver sustainable, efficient, and liveable cities have become critical. As cities expand, local governments will be forced to contend with the rapidly growing demands for public services and infrastructure. The exponential technological advancements of the last 20 years have given way to cognitive cities as a beacon of innovation in urban development.

At the core, cognitive cities harness the power of data, artificial intelligence and cognitive computing to transform cities into intelligent and adaptable ecosystems. These cities will not just be technologically advanced but also capable of learning from data, evolving to changing circumstances, proactively and autonomously delivering services and ultimately enhancing the well-being and liveability of their inhabitants. Cognitive cities aim to empower humans in numerous ways, reducing their efforts while improving their capabilities, decision-making processes, and overall life quality.

In this paper we explore the fundamental principles underpinning cognitive cities, the enablers necessary for their success, lessons learned from cities on their journey to becoming more cognitive, and the implications and opportunities for stakeholders in the urban ecosystem. We also reflect on the potential of "cognitive cities" to reshape how we govern cities for more sustainable, resilient, and prosperous futures.

# 2

# Demystifying Cognitive Cities

# What is a Cognitive City?

## From smart cities to cognitive cities

The digital evolution of cities has become synonymous with the term Smart City, an approach to city governance that endeavours to become more efficient and sustainable through the adoption of connected digital technologies. These technologies monitor and automate urban utilities and services, share real-time information with municipal administrations, service providers and city residents.

Cognitive cities go beyond the establishment of connected technological ecosystems, but integrate advanced technologies to create intelligent and responsive urban systems. Artificial intelligence and machine learning have been leveraged to analyse vast amounts of data with the aim to personalise services for residents and enable the efficient delivery of services. This is enabled through interconnected systems built on sensors, Internet of Things (IoT) devices, reasoning engines, super apps, natural language processing, human-computer interfaces, deep learning and feedback as well as learning loops, among others to perceive, reason, learn and interact with residents, decision-makers, other users in an intelligent yet secured manner. By harnessing the plethora of data and the underlying systems, cities can make informed decisions, optimise resource allocation, improve city infrastructure, and deliver more adaptive services to their residents.

> **The ideal smart city balances "economic and technological aspects with humane dimensions**
>
> - MD Smart City Index

| | Smart City | Cognitive City |
|---|---|---|
| | Reactive | Proactive |
| **Service delivery** | • Services available and accessible to city and citizens to avail when required<br>• Digital services delivered via multiple channels | • Focus on personalised, proactive, intelligent services delivery<br>• Services delivered proactively when needed by understanding city and citizen's evolving needs<br>• Leverages cross-sectoral data sharing to deliver comprehensive services<br>• Operational services become autonomous |
| **Data Utilisation** | • Siloed data; limited data sharing | • Significant amount of data consolidation and sharing |
| **Technology adoption** | • Leverages conventional technologies to deliver services (e.g. sensors)<br>• Digital infrastructure is robust to support service delivery | • Relies on emerging technologies to deliver services<br>• Powered by AI/GenAI that helps decision-making |

# Key drivers and principles for becoming a Cognitive City

Cities are adopting cognitive technologies to not only address the increasing pressures on infrastructure and urban services provision, and improvements in quality of life, but to ultimately build resiliency. As we delve into the dynamic realm of urban development, it is crucial to recognise the pivotal drivers that underpin the evolution from smart cities to cognitive cities. These drivers represent the foundational elements propelling our cities into a future characterised by intelligent and adaptable urban ecosystems. The following key drivers serve as the cornerstones in shaping the cities of tomorrow.

## Improved quality of life

Through upgraded service delivery, a Cognitive City contributes to improving the quality of life of its citizens. Citizens are able to obtain better services in a more timely and reliable manner across various domains. Additionally, a Cognitive City is a safer and more secure city, with the ability to proactively predict and reduce safety and security incidents further contributing to improvements in quality of life.

## Increased resilience and sustainability

A Cognitive City will help cities become more resilient and sustainable starting from the planning stage. A Cognitive City harnesses the power of technologies such as digital twins which allows city planners to assess different planning scenarios and objectively evaluate benefits and drawbacks.

## Enhanced city operational efficiency

City operational efficiency can be significantly enhanced through a Cognitive City transformation. City managers are able to make better decisions leveraging the vast amount of data available, supported by AI-models that can provide recommendations.

## Economic growth

A Cognitive City can contribute to economic growth, helping to unlock new revenue streams through leveraging the vast amount of data. Additionally, jobs can be created by newly established companies created to address the city's evolving needs.

Cognitive plans for a city can be based on a few fundamental principles and tenets that underpin the concept of intelligent urban living. These principles shall serve as a foundation and guiding philosophy behind the design-redesign, development-redevelopment and management of urban environments in the digital era.

## Guiding principles

### 1 Citizen-centric

Delivering inviting and attractive experience that drive user engagement and can establish a sense of community

### 2 Proactive

Using predictive analytics and data-driven insight to anticipate and address urban challenges, thus optimizing city operations and enhancing overall sustainability and quality of life

### 3 Trustworthy

Ensuring the security, privacy and ethical use of data and technology by establishing robust governance, cybersecurity measures, and transparent policies to build and maintain trust among citizens, business, and stakeholders

### 4 Evolving

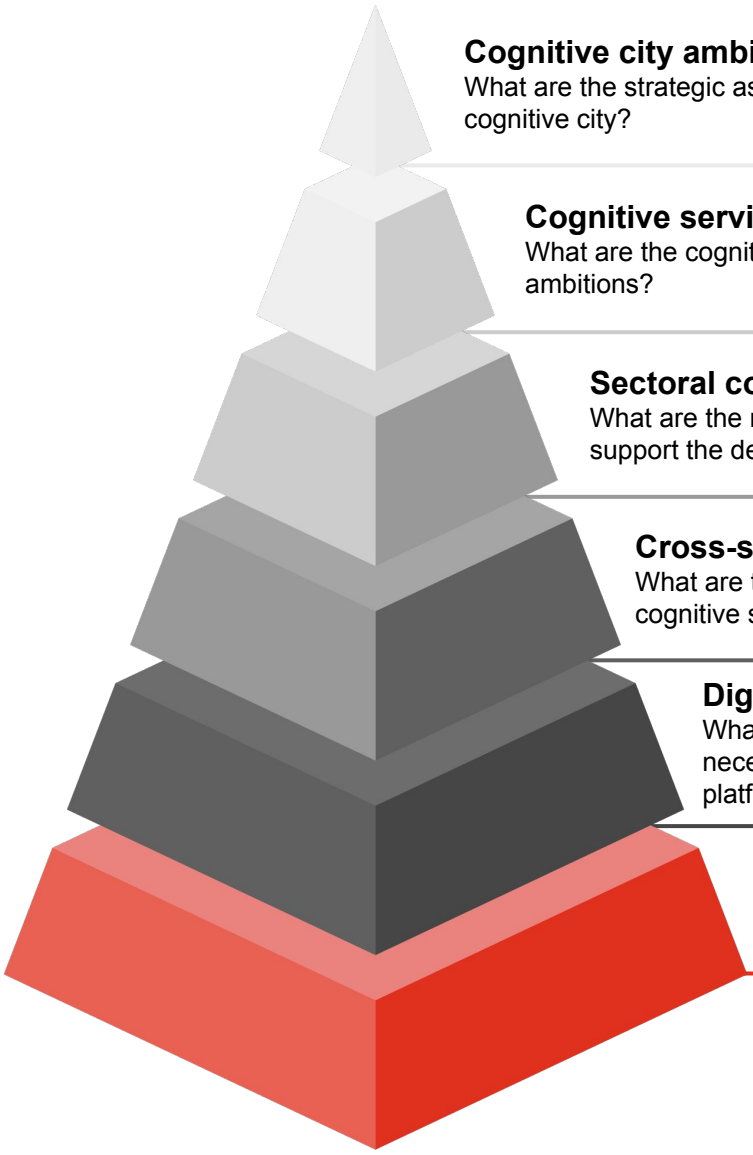
Inducing technology and capabilities that embrace flexibility and continuous learning and thereby adapt to changing technologies and requirements of a city

### 5 Coherent and integrated

Delivering seamless experience to enhance convenience and streamline, leveraging and integrating data collected from different sources to develop a comprehensive understanding of user needs

# Cognitive City framework

To advance the ‘cognitive’ journey, it is imperative that city governments and decision-makers understand the levers that will enable technology and data for their urban transformation. To guide this, local governments must develop a structured framework that involves defining the city’s strategic ambitions, the services, solutions and platforms that will enable these strategic ambitions, the infrastructures that will guide the delivery of these services, and finally the enablers that will serve as the catalyst for these elements.



**Cognitive city ambitions**
What are the strategic aspirations and future goals for a city aiming to become a cognitive city?

**Cognitive services**
What are the cognitive services to be enabled by the city to fulfill these ambitions?

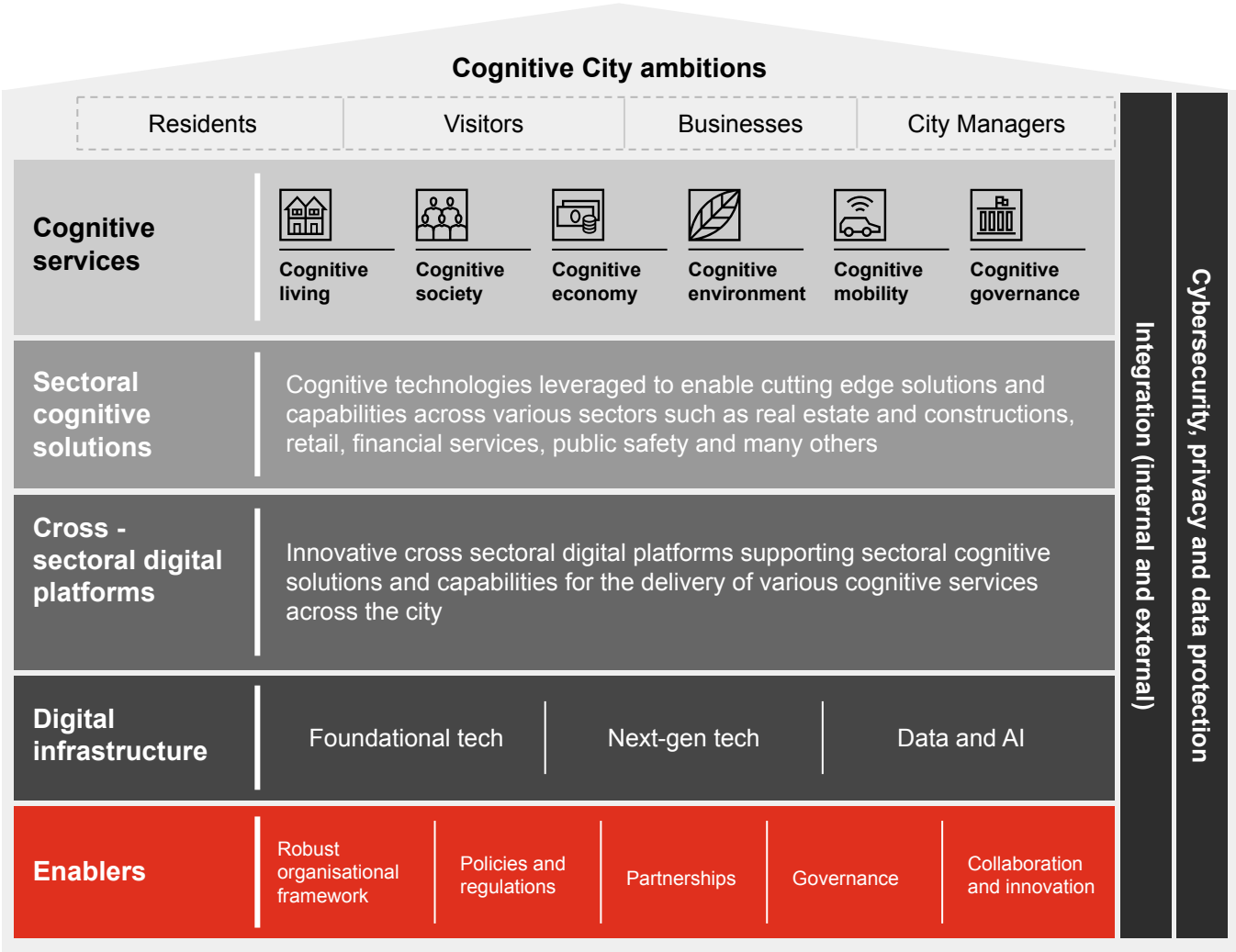
**Sectoral cognitive solutions**
What are the requirements for each sector and solutions required to support the delivery of cognitive services?

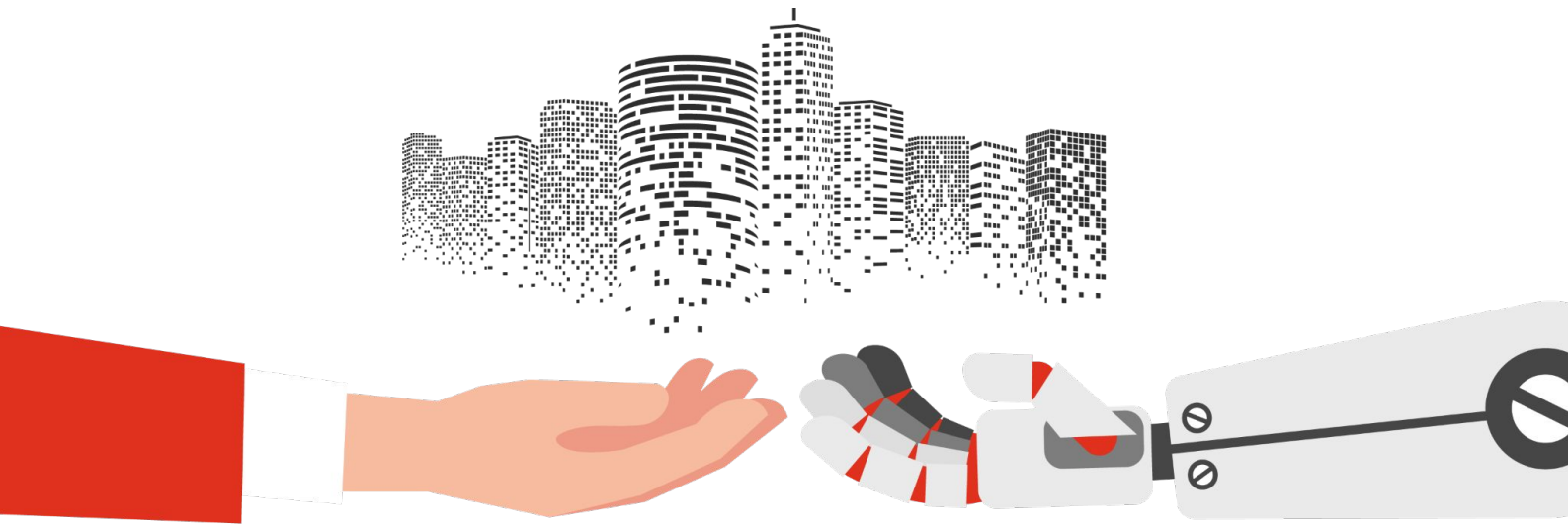
**Cross-sectoral digital platforms**
What are the cross-sectoral digital platforms that enable the cognitive solutions and cognitive services?

**Digital infrastructure**
What are the foundational digital technologies which form the necessary infrastructure for the cognitive solutions and platforms?

**Enablers**
What are the internal and external capabilities, resources and assets that are needed to enable all layers?

Having a well defined framework, supported by robust regulatory and legal tools, is essential for addressing strategic questions and guiding the governance of the cognitive transformation. Clarity in the definition of framework components can help in the realisation of a cognitive roadmap for a city.



| Framework layer | Indicative activities |
|---|---|
| 1 Cognitive City ambitions | Defining the aspirations to achieve the cognitive objectives for the cognitive city. |
| 2 Cognitive services | Designing the various cognitive services delivered to citizens, residents, businesses and governments across the city. |
| 3 Sectoral cognitive solutions | Developing the mix of cognitive and digital solutions required to enable the delivery of cognitive services across different sectors of the city. |
| 4 Cross-sectoral digital platforms | Developing/orchestrating cross-sectoral digital platforms that are designed to enable the cognitive solutions to operate seamlessly in order to deliver the cognitive services across all sectors. |
| 5 Digital infrastructure | Enabling the set of foundational technology components used to provide cognitive solutions and platforms with the required data, hardware and software. |
| 6 Enablers | Leveraging the internal and external capabilities, resources and governance needed to bring the cognitive aspirations, solutions, platforms and the underlying infrastructure to life. |

This framework can guide cities in achieving their vision of becoming cognitive and realise various outcomes while ensuring resiliency and sustainability across all aspects and improved efficiency transformed ways of doing things. In addition to the above layers, the verticals mentioned below are key to ensure interoperability and information security

| | |
|---|---|
| **Integration and cybersecurity, privacy and data protection** | Enable seamless integration between internal and external systems/entities while ensuring all data is secured, protected throughout from any threats and privacy is adequately maintained. |

# 3

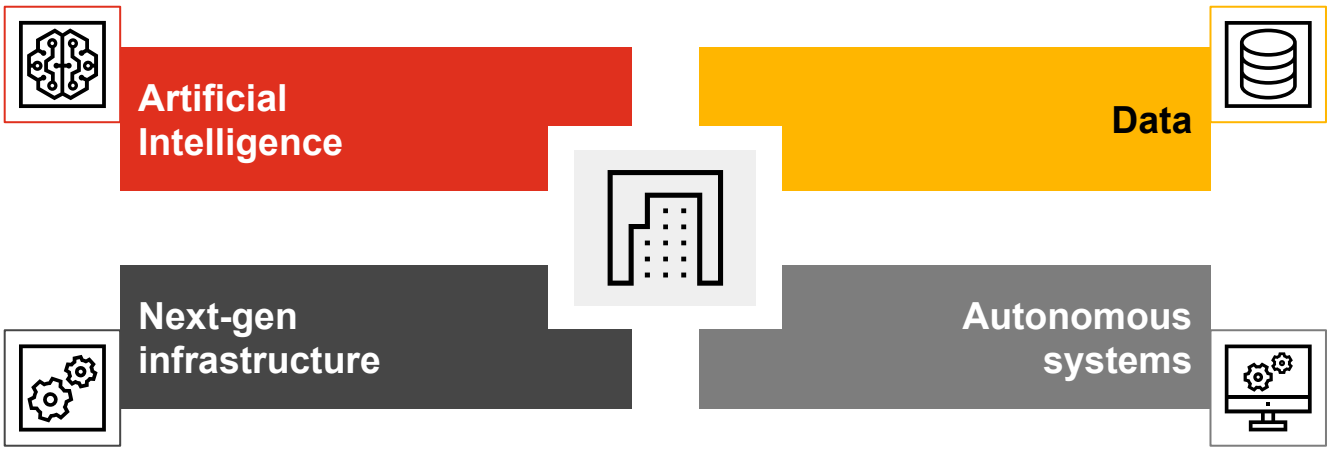
# Unfolding the tenets of Cognitive Cities

# How to make a city cognitive? Going beyond technology

Our perspective on smart cities has emphasised the significance of non-technological elements alongside technology, a view that extends to cognitive cities, recognizing their dependence on both technological and non-technological facilitators.

## Key technology enablers for Cognitive Cities

By leveraging emerging technologies, Cognitive cities can become proactive, intelligent and adaptive ecosystems that enhance the quality of life for their dwellers. Cognitive cities generate and harness vast amounts of data from diverse sources, including sensory systems, IoT devices, mobile apps, social media, and public services, such as transportation, healthcare, education, traffic cameras, utility metres, etc. using real-time data processing to gain valuable insights into urban dynamics. The data collected through a trusted mechanism can be orchestrated for the city to learn, conduct reasoning, adapt and make autonomous decisions across city services, creating a more  efficient and responsive urban ecosystem.




### Artificial Intelligence (AI)

Artificial Intelligence (AI) is the pivotal force propelling the advancement of cognitive cities. Its capacity to process intricate real-time data facilitates proactive pattern identification, optimising operations and swift action implementation across diverse use cases. Many cities are employing AI-driven chatbots for public services and exploring autonomous systems, like decision-making robots, independent of direct human involvement. Cognitive cities can also enable a ubiquitous use of AI across sectors to transform city planning and operations across various use cases, such as traffic management, wayfinding, autonomous last mile delivery, public safety, quick citizen services, emergency response, autonomous transportation, urban planning and many others. For example, an AI-based emergency response system can detect sudden changes in the environment to anticipate and prepare for possible natural disasters.

## Data

Data technologies are crucial in supporting Cognitive Cities by enabling the collection, processing, analysis and utilisation of data to generate and visualise insights from various sources across a city. Data collected from multiple city sources is processed and analysed for energy demand forecasting, user verification, travel suggestions, secure health data sharing, and more. These applications utilise cognitive solutions like intelligent energy management, end-to-end journey planning, and health data management. For instance, personalised travel recommendations can be generated based on user preferences, transactions, and real-time location data, including suggestions for dining, shopping, and sightseeing.

## Autonomous systems

Cognitive cities leverage autonomous systems across the city that can enhance the delivery of cognitive services. These autonomous systems will make decisions without direct human intervention by performing tasks and functions independently, relying on sensors, algorithms, and AI to perceive their environment, process information, and execute actions. These systems are designed to help increase efficiency, ensure maximum safety, and execute tasks accurately across various use cases. leveraging various cognitive solutions to manage and operate autonomous systems, such as robotics, cooking automation, construction management, delivery management and transportation management. For example, users placing requests on e-commerce websites can get packages delivered to doorstep by drones. These drones communicate with robots inside homes to retrieve the package, unpack it, and deliver the product to the user without explicit instructions.

## Next-gen infrastructure

Cognitive cities employ innovative platforms and systems to drive experiences and services across the urban landscape. Next-gen infrastructure serves as a foundation for connectivity, data, equipment and cutting-edge technologies, moving away from siloed platforms and systems approach to an integrated collaborative ecosystem. It will also support city governments and managers to efficiently plan, manage and monitor the deployment of new platforms and systems through on-demand models essential for the new initiatives and services planned for the city. The next-gen infrastructure technologies support the technology themes and their components by providing various supporting and as-a-service capabilities, such as advanced and domain-specific computing, high-speed low latency connectivity and dynamic communications, high-end intelligent sensor equipment, robust security, resilient and scalable systems, customisable configurations and others.

# Non technology enablers for Cognitive Cities

It is imperative to recognise that technology alone cannot accomplish cognitive city ambitions. Non-technological enablers, including great leadership, governance and engagement must be considered to help facilitate the delivery of cognitive solutions.

## Leadership

Without strong leadership cognitive cities are unlikely to succeed. Cognitive city transformation starts with local government commitment, clarity of vision and objective, aided by long term thinking focused beyond the immediate gains of short term projects. This leadership requires practising foresight, facilitating collaboration, and building alliances and partnerships, to better the lives of urban residents. Top-down political endorsement serves to further empower local governments and cognitive city leadership to drive transformative change in urban governance.

Leaders must be adept at not only developing a culture of innovation but nurturing this culture to deliver sustained innovation. This goes beyond just enabling and financing Research and Development, but creating an entire ecosystem whose shared culture is one of innovation. For example, establishing Living Labs in partnership with research and academic institutions can provide an open-innovation ecosystem that iterates and tests cognitive solutions. Living Labs operate as intermediaries between citizens, research organisations, private companies and government agencies using real-life environments to rapidly prototype, test and scale-up innovations, while focusing on co-creation, wherein solutions are shaped and designed using the input of users and consumers (ENoLL).

# Effective governance

## Data governance

Given the immense generation of data and the need to access these great volumes of data, data governance is a crucial element in the development of a Cognitive city. Identifying entities involved in the management, provisioning and utilisation of urban data (like IT system administrators, data owners, data policy coordinators, data stewards, and data policy officers), and the interactions among these entities is critical. These interactions are included in the decision-making process for data access management, data quality management, general data lifecycle management, and management of metadata in an urban environment. Cognitive city governance frameworks can guide the management and sharing of data within and across organisations of the Cognitive city ecosystem. Further, the usage and usability, integrity and security of data must be based on established standards and policies that balance both private and public interests, and are guided by the governance framework

## Institutional governance

Local governments must ensure the establishment of an enabling environment that provides regulatory structures, instruments and institutions to balance private and public interests regarding data access and use (OECD, 2023). The establishment of a dedicated, centralised office, at either the local or national level, can ensure the alignment to Cognitive City strategy, while the distribution of initiatives across a municipal government, signals decentralising leadership to deliver collaborative projects and programs. Lastly, forming partnerships with private organisations can help drive the targeted delivery of smart city solutions that are at the forefront of advancements in industry. Rallying the entire ecosystem around the identified objectives, closely integrating know-how with planning and execution, and adapting to the ever-changing technological landscape.

Cross-functional committees consisting of stakeholders involved in the governance of cognitive services must be established to improve coordination, streamline decision-making and ensure effective policy resolution. Designated task forces or working groups, for example technology-related working groups, citizen-experience working groups and data ethics working groups, composed of experts and specialised entities with a clear mandate can facilitate the delivery of the Cognitive City aspirations.

## Robust regulation

Given the personalised urban services underpinning Cognitive cities that are aided by vast data collection, data handling and data privacy necessitate the establishment of robust regulations. Data legislation and regulation can help cities ensure compliance to policies concerning data management, protection and sharing, and are needed to clarify how, when and what types of data should be collected and shared. Local governments must enact and adhere to legislation that ensures the adequate protection of personal data, in the case that personal information collected can identify individuals, to avoid breaches in data safety. This is of particular concern given the technological advancements in advanced analytics (specifically the use of Artificial Intelligence) that necessitate more guidance on data protection. Furthermore, Cognitive city initiatives are further subject to specific regulations depending on the domain of operation whether within the transport, telecoms, water or energy supply domains (OECD, 2023).

## Funding and financing

A cognitive city transformation requires funding and financing in order to conceptualise, develop and operate cognitive solutions. Cities cannot rely solely on traditional forms of financing such as government funding. Cognitive solutions can be implemented using innovative financing means, leveraging the large amount of data that can be collected and made available. Cities can build revenue sharing and data monetization into their service delivery models for certain services with the private sector to ensure timely roll out of the solutions

## Citizen engagement

In order to achieve citizen-centric urban development and create citizen-centric services, citizens and community stakeholders must be regarded as key stakeholders in the design and implementation of Cognitive City initiatives and programmes. Citizens will only provide and allow access to personal data when there is established trust in actors in charge of data management. Residents must be provided mechanisms through which they can engage with their local authorities and governments. This may be through open data platforms that allow citizens to both make use of municipal data and share their own data, enabling a more granular understanding of residents' needs. This may also take the form of regular forums or citizen committees that enable an open dialogue between city officials and those who will ultimately benefit from enhanced urban services.

# 4

# Exploring model cities and real-world applications of cognitive urbanism

# How to make a city cognitive? Going beyond technology

## Cognitive use cases and success stories

The impact of cognitive technologies on urban life spans various industries, promising significant transformation. In our rapidly changing world, these technologies serve as powerful tools, revolutionising numerous aspects of urban living. By enhancing decision-making and automating tasks, they offer groundbreaking solutions across spheres of urban living including agriculture, banking and finance, business management, community and social support, culture and entertainment; education, energy, health and wellness, housing and property, nature and environment, public safety, retail and dining, tourism and hospitality, and transport and mobility. Specific use cases within each sector illustrate how cognitive technologies redefine urban interactions and address challenges and opportunities in urban living.

### Agriculture

- **AI in agriculture:** AI optimises crop production, improving resource management, and sustainability.

  For example, China's Ministry of Agriculture implements AI-powered crop management systems to enhance crop yields and resource efficiency.

- **Robotic farming**: Robotics automate farming tasks like seeding, spraying, and harvesting, increasing efficiency and reducing labour.

  The Japanese Ministry of Agriculture, Forestry, and Fisheries are adopting robotics and autonomous systems for farming in Japan.

### Banking and finance

- **Chatbots for financial education:** Chatbots provide financial education and guidance, making financial information accessible and understandable to citizens. Governments can deploy chatbots and virtual assistants powered by natural language processing (NLP) to provide citizens with financial education and guidance.
- **AI-powered credit scoring:** Government agencies can use AI and machine learning algorithms to assess citizens' creditworthiness, especially those with limited credit history.
- **Digital wallets for government benefits:** Governments can develop digital wallets or apps for citizens to receive and manage government benefits, such as welfare payments, subsidies, and pensions.

## Business management

- **Blockchain-based marketplaces:** Blockchain-based marketplaces incentivise small businesses to grow and scale internationally, allowing safe and secure transactions through smart contracts.

  Estonia's government collaborates with blockchain companies to support small businesses.

## Culture and entertainment

- **Metaverse-based entertainment and cultural events:** Metaverse-based events enable residents and visitors to attend virtual concerts and museums, offering unique experiences and entertainment options. Korea is hosting concerts of popular artists using this technology for its public.

## Community and social support

- **Cognitive citizen engagement platforms:** Cognitive citizen engagement platforms that allow citizens to propose ideas, interact, debate, and vote for action, enhancing civic participation and government responsiveness. Advanced natural language processing is used to automatically classify and track preferences and opinions, identifying stand-out citizens and recommending additional ideas and solutions.

  Estonia is known for its e-governance and agencies like e-Estonia who are at the forefront of developing digital platforms for citizen engagement.
- **Cognitive counseling engagement platforms:** Cognitive counselling support platforms analyse resident profiles and connect them with suitable activities, improving mental health and community engagement.

  The Mental Health Commission of Canada has been involved in developing AI-based counselling and mental health programmes.

## Education

- **AI in education:** AI-powered personalised learning platforms adapt to individual student needs, enhancing learning outcomes. Finland's schools use these platforms to provide tailored content and assessments.
- **Cognitive tutoring:** Cognitive tutoring analyses student performance data, identifies learning gaps, and provides targeted recommendations, supporting students' individual learning journeys. Schools in the US use these systems to improve educational outcomes.
- **Cognitive agents for students:** Cognitive agents personalise coursework and support students by considering their aptitude, abilities, interests, and learning styles, fostering personalised learning experiences. Schools in the US offer AI-powered cognitive agents for grading assignments and personalising coursework.
- **Co-teaching with collaborative bots:** Collaborative bots enhance teaching, learning, and student engagement by providing hands-on experiences and simulations. Japan has integrated collaborative robots into educational environments to improve learning experiences

## Energy

- **AI-driven energy management:** AI-driven energy management systems optimise energy distribution, minimise wastage, and reduce costs, enhancing energy efficiency. France uses these solutions to optimise energy consumption and distribution.
- **Digital twins for water and wastewater management:** Digital twins for water and wastewater management actively monitor data sources to improve plant operations and ensure efficient resource management. Sweden employs digital twin technology for water and wastewater plant management.

## Health and wellness

- **Epidemics monitoring:** Epidemics monitoring gathers data on patients, predicts behaviour, and enables preventive action in hospitals, such as isolation plans and remote treatment. The United Nations uses data-driven monitoring to track and respond to epidemics and pandemics globally.
- **Rehabilitation robots:** Rehabilitation robots provide physical and mental health therapy, guiding patients through targeted exercises and tracking their progress, improving recovery after injuries or surgeries. Switzerland uses rehabilitation robotics to guide patients through targeted exercises and track their progress

## Housing and property

- **ML-based incident response:** ML-based incident response continuously monitors environments, detects anomalies, and triggers timely alerts for enhanced safety and security. Sweden employs video surveillance with ML analysis for enhanced security incident response.

## Nature and environment

- **Computer vision-aided waste management:** Computer vision-aided waste management analyses waste patterns and provides recommendations to improve waste management processes, promoting environmental sustainability. BlueCity, a city in the Netherlands, optimises waste management using this technology.
- **Automated materials recycling facility:** Automated materials recycling facilities use AI to efficiently sort, process, and recycle various materials, reducing contamination, minimising manual labour, and contributing to sustainable waste management and resource conservation. Finland employs AI to efficiently sort and recycle various materials in recycling facilities.
- **Disaster early warning systems:** Disaster early warning systems utilise ML and data analysis to predict and provide timely alerts for natural disasters, helping mitigate the impact through swift response, evacuation planning, and resource allocation. The Netherlands uses machine learning and data analysis for early warnings.

## Public Safety

- **Intelligent emergency response systems:** Intelligent emergency response systems analyse sensor data and incoming reports to identify and prioritise incidents, facilitating rapid response and resource coordination. Germany uses intelligent fire emergency response systems to analyse data and prioritise incidents.
- **Drones and AI-powered video surveillance:** Drones and AI-powered video surveillance systems use computer vision to detect and alert authorities of potential security threats or criminal activities, enhancing security and safety. China uses drones and AI-powered video surveillance solutions for monitoring and tracking potential security threats or criminal activities.
- **Natural language processing-based systems:** Natural language processing-based systems monitor and identify public safety risks through social media and online platforms, enabling timely responses to threats, protests, or emergencies. France utilises these systems to analyse social media/online platforms to monitor and identify potential public safety risks.

## Housing and property

- **AI-managed food waste:** AI-managed food waste reduction uses data insights to optimise food production and distribution, reducing food waste, and its environmental and economic impact. The UK employs AI-driven food waste management solutions.
- **Intelligent customer feedback systems:** Intelligent customer feedback systems use AI and data analysis to capture and interpret customer feedback from multiple channels, providing insights to enhance products and services. France uses these systems to conduct sentiment analysis and pattern recognition for business improvement

## Tourism and hospitality

- **Comprehensive guest profiling:** Comprehensive guest profiling collects guest data from various sources to deliver personalised experiences, delighting guests while preserving their privacy. France uses data to create comprehensive guest profiles for personalised experiences in their hotels and resorts.

## Transportation and mobility

- **AI in transportation and mobility:** AI-powered traffic management optimises signal timings, reroutes vehicles, and alleviates congestion, resulting in smoother traffic flow and enhanced mobility. Germany employs AI for traffic management.
- **Cognitive public transportation systems:** Cognitive public transportation systems use machine learning to analyse passenger data, optimise schedules, and predict demand, improving the efficiency and reliability of public transit services. London's local government body employs cognitive technologies for public transportation optimization.
- **Intelligent intersections:** Intelligent intersections dynamically respond to factors like traffic and pedestrian flows, optimising traffic management, reducing waiting time, and enabling efficient traffic flow.The USA uses intelligent intersections for enhanced traffic management.

These use cases illustrate how cognitive technologies can revolutionise urban life in diverse sectors, fostering efficiency, safety, and personalisation, in alignment with the vision of Cognitive Cities.

# Model cities for cognitive urbanism: Approaches to cognitive transformation


Numerous cities across the world have embarked on an ambitious journey to become cognitive urban centres, where cutting-edge technology and data-driven solutions converge to enhance the quality of life for residents. The benefits, however, are not limited to the residents and visitors of the city alone, but also help policymakers and city managers attract investments, businesses, talent and resources. These cities are poised to become role models for other global cities as they lean towards becoming cognitive. This transformation has been approached in two different ways across the world – greenfield development, which involves creating entirely new cities from scratch with cognitive principles at their core and focus on innovation in design and sustainability; and brownfield development, which involves the revitalisation, redevelopment and transformation of existing urban areas.

Greenfield cities refer to new urban areas developed from scratch, and it's examples are:

## THE LINE, Saudi Arabia

THE LINE is planned to be a zero-carbon Cognitive City stretching across 170 kilometres and housing nine million people within 34-square kilometres. This city aims to redefine how future cities operate by leveraging technological advancements predicting the needs of humans and nature first. Some of the critical areas where THE LINE is redefining urban living include:

- Uniting AI, robotics, IoT, and blockchain to customise services by identifying future needs.
- Developing the world's initial AI-based platform to streamline data transfers and city communications.
- Analysing over 90% of city-generated data for personalised experiences and empowering citizens through a consent management platform.
- Creating a unique digital twin metaverse prioritising human needs for THE LINE.

## Telosa, USA

Telosa is a planned city spanning 150,000 acres, with a projected population of five million by 2050. Its core focus lies in setting a global standard for inclusive and equitable urban living, implementing the 'Equitism' model, ensuring sustainability and equity. Land ownership remains with a resident-managed foundation, allowing for potential plot sales and leases to generate funds for vital services like education, job training, and healthcare. Key initiatives include:

- Utilising advanced technologies like 3D printing and AI to enhance services, minimise waste, enable autonomy, and foster transparent community engagement for proactive issue resolution.

Brownfield implementation involves transforming existing urban centres into cognitive hubs by integrating emerging technologies, adapting established infrastructures, institutions and regulation to enable the delivery of adaptive urban service. It’s examples are:

## Singapore

Singapore is recognised as a global technology leader, known for its enhancing efficiency and livability. Projects include smart transportation systems, intelligent housing solutions, and implementing an extensive sensor network for city monitoring. Key initiatives include:

- Establishing a centralised open digital platform (ODP) integrating smart city solutions, digitising and centralising district operations.
- Implementing 'Virtual Singapore,' an integrated data platform creating a 3D digital model with real-time data for simulations and future planning.
- Improving public transportation via continuous analysis of public open data for transport planning, reducing congestion, and facilitating mobility for elderly and disabled residents through autonomous fleets.

## Barcelona, Spain

Barcelona has emerged as a model city for transformation, leveraging technology advancements, focusing on sustainability and citizen engagement. It has implemented various use cases, such as smart street lighting to reduce consumption, smart irrigation to reduce wastage of water, as well as smart waste management, smart parking and smart tourism. Key initiatives include:

- Creating CityOS, Barcelona's operating system, to analyse citywide data, anticipate needs, and enhance citizen services.
- Establishing an open-source platform for sensor interoperability, fostering efficient data management and sharing.
- Encouraging citizen engagement through a digital platform for idea suggestion, debate, and voting on government matters.

## Seoul, South Korea

Seoul prioritises data-driven next-gen initiatives, showcasing technological advancements in urban development. The city's smart city master plan includes a comprehensive smart city platform integrating city data and services for improved citizen experiences, IoT-based shared parking, AI cabs, and smart surveillance. Key initiatives include:

- Introducing 'Metaverse Seoul,' a virtual replica of the city, enhancing public services and citizen engagement with accessible administrative functions.
- Implementing AI-driven surveillance for real-time detection of anomalies, incidents, and security threats.

## Helsinki, Finland

Helsinki has set a precedent for its efforts in continuous digitising across multiple domains, including planning, construction and maintenance. Key initiatives include:

- Establishing a digital twin of the city and simulating various activities such as traffic management.
- Enabling open access to the city’s data for citizens and residents – from health statistics to 3D models of buildings – via an open data portal to assist in creating more inclusive citizen services.
- Promoting residents’ well-being using AI to monitor and forecast air quality in real time, alerting residents to take precautionary measures when air quality is predicted to fall is predicted to worsen

## Hong Kong

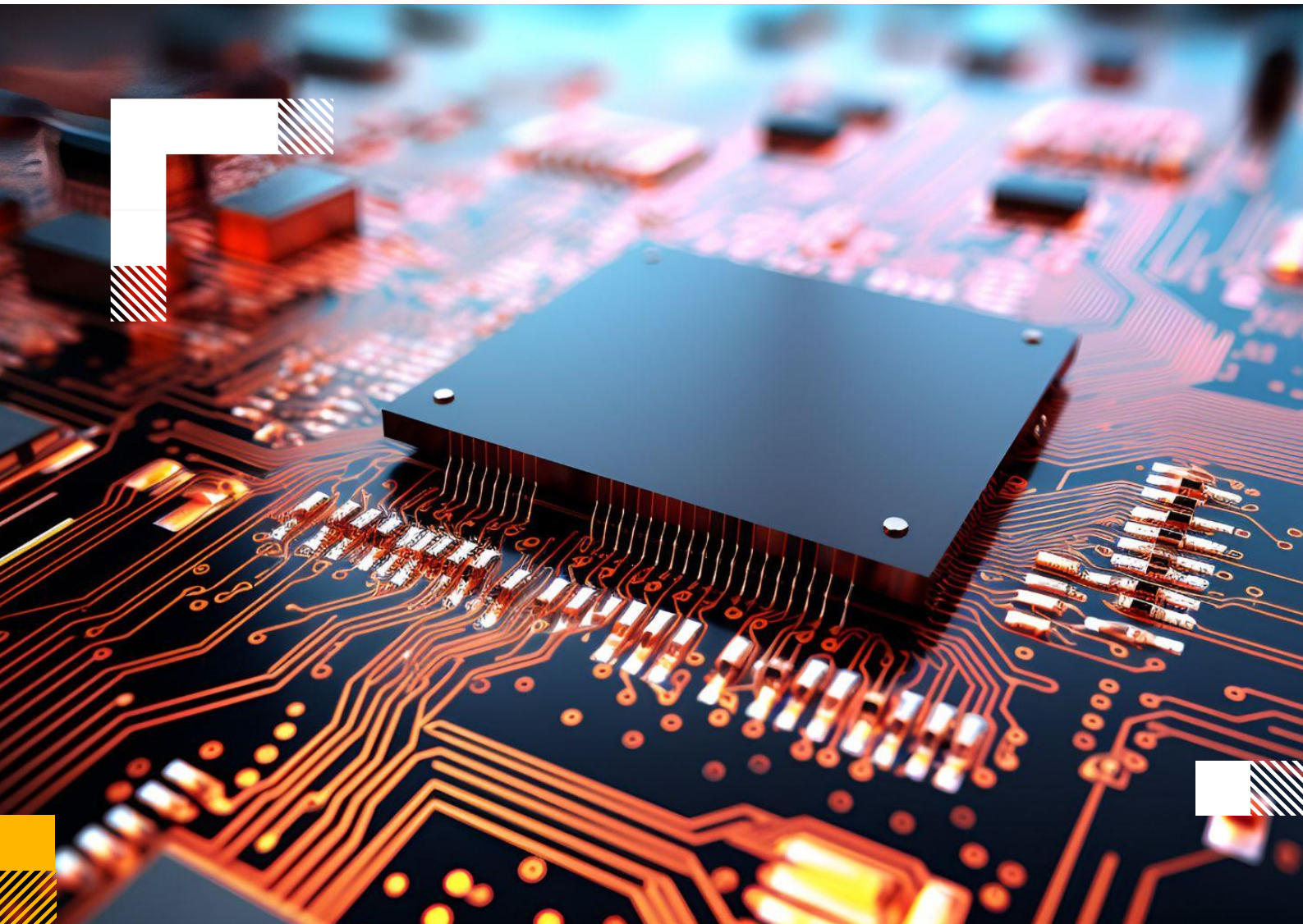
Hong Kong has embraced innovation and technology to deliver a high quality of urban living by implementing various use cases across areas such as mobility, traffic management, streamline airport operations, pharmaceutical traceability and many others. Key initiatives include:

- Enabling open access to the city’s data and facilitating the development of smart-city solutions through the Hong Kong city dashboards, that integrate data from more than 80 government departments and public and private entities.
- Enabling transparency of pharmaceutical products using blockchain technology to enhance the traceability of pharmaceutical products, identify patterns across sectors and seasons for the supply of medicines and facilitate efficient recall of medicines.
- Leveraging robotics to facilitate the maintenance of underground drainage systems, inspection of water lines and ensuring safe and effective maintenance of sewage treatment plant wells

Cognitive City principles and advanced technologies have the potential to improve urban living, which contributes to global efforts for eco-friendly and inclusive urban spaces. As these cities innovate, they provide insights for others on the path to cognitive transformation.

# 5

# Way forward: Building the roadmap for transformation



# Stakeholder collaboration

A Cognitive City transformation requires collaboration from a diverse set of stakeholders, each playing their part and contributing to a step within the overall value chain. The key stakeholders that play an important role are

| Regulators / policy makers | Local governments | Private sector service / technology providers | Research and academic institutions | Citizen groups / NGOs |
|---|---|---|---|---|
| Federal and national governments, authorities | Regional and city governments, municipalities | Technology companies, sectoral operational service providers | Universities, research institutions focused on emerging technologies | Civil society, NGOs focused on addressing city challenges |

For each stakeholder group, several key actions are required:

## Regulators / policy-makers

Regulators and policy-makers at the national, regional and city level have a role to play in advancing cognitive cities by setting national directives and national digital transformation/ cognitive cities program that define standards, share best practices and provide funding. The regulators also have the responsibility to define / update relevant regulations and standards, such as emerging technology, data management and partnerships that can have an impact on cognitive city solution implementation. Additionally, these regulators and authorities need to provide the necessary enabling digital and communication infrastructure that enablers cognitive city solutions, while also facilitating funding and financing to support regions and cities, where required.

## Cities and local governments

Regional and city governments have a critical role in cognitive city transformation as they are responsible for defining the city's vision, strategy and aspirations, which can be shaped by engaging with relevant stakeholders such as residents, visitors and businesses to gather feedback. Accordingly, cities have a role in defining and implementing user journeys for their citizens, visitors, investors and businesses as well as service level targets to meet those defined aspirations. This will help city governments in identifying, funding and implementing (in partnership with national and regional governments, academia and the private sector) the cognitive solutions that are required to deliver the desired services. Cities also play an important role in designing and operating enabling cross-sectoral digital platforms (e.g. integrated operations center), for data-driven decision making. Essentially, cities need to act as an ecosystem orchestrator to ensure stakeholder cooperation.

## Private sector service / technology providers

The private sector needs to play a proactive role and to get involved (at the local government invitation) early in the planning, design and funding of cognitive city solutions. The implementation and operations of cognitive city solutions is the primary responsibility of private sector service / technology providers. Their role is to also help city governments in the conceptualisation and detailing of various solutions as well as supporting in the development of the cross-sectoral digital platform.

## Research and academic institutions

As cognitive cities is an emerging trend, there is an important role that research and academic institutions can play. Their role is to identify these latest trends and advancements in emerging technologies such as Generative AI and assess their impact and viability for city solutions. Research and academic institutions can also support in pilot and research projects to test out new and innovative solutions. Finally, a cognitive city generates a large amount of data which can be shared with research and academic institutions to help analyse and synthesise it in order to facilitate decision making.

## Citizen groups / NGOs

A cognitive city needs to be citizen-centric and ensure technology and data are a means to improve service delivery. Thus, citizen groups and NGOs have an important role in voicing their aspirations and identifying the challenges faced. Additionally, citizens can play an important role in engaging and providing feedback on new services being rolled out. This will ultimately help decision-makers such as city governments ensure they are addressing their citizens' needs.

# Ways to bring a Cognitive City vision to fruition

## Accelerators

### 1 User-centricity

- **User journey designs:** Capturing citizen/resident expectations, including personalised features, throughout all the touchpoints in accessing various city services.
- **User-centric service catalogue:** Building service catalogues based on the requirements of the citizens and users.
- **Education and training:** Practical training to upskill citizens/residents and ensuring capability on new platforms, applications and services.

### 2 Innovation

- **Emerging tech as a service:** Leveraging and provisioning of cutting-edge technologies and innovations through subscription-based or on-demand models to enable access and boost innovation.
- **Innovation think tanks:** Collaborative spaces that foster creativity, idea generation, and development of solutions.
- **Sandboxing and experimentation:** Creating controlled environments for testing and exploring specialised technologies and allowing assessment of their potential value and viability.

### 3 Process Agility

- **Market scan and leading practices study:** Ensure learnings and innovations from other leading cities/ regions are taken into consideration while designing the new era of Cognitive Cities
- **KPI/SLA monitoring framework:** Continuous monitoring of metrics related to sustainability, efficiency, innovation and citizen well-being; empower cities to make data-driven decisions, optimise resources and proactively adapt to evolving city challenges.

### 4 Governance

- **Establishing a dedicated entity:** A specialised organisation such as an SPV that helps in streamlining planning, convergence of funding, and collaborating with the public and private sectors, therefore driving efficient development and innovation.
- **Multi-stakeholder collaboration:** Bringing together government, industry, academia and citizens to combine different perspectives, resources and expertise to harness innovative solutions and drive collective action.
- **Data transparency and accountability:** Ensuring transparency in data collection and sharing, alongwith robust accountability mechanisms in safeguarding data, which helps build trust among citizens and fostering responsible innovation and governance.
- **Enabling public-private partnerships:** Jointly investing and deploying advanced technologies and infrastructure by combining public resources and innovation from the private sector, which will play a role in accelerating the growth of intelligent urban environments.

# Accelerators

## 5 Collaborate

- **Co-create with industry players:** Implementation of various technologies involves a robust enabling ecosystem consisting of OEMs, system integrators, and services providers.
- **Leverage global expertise:** Tapp into insights, experiences, and best practices from experts worldwide to help address complex challenges and ensure evidence-based growth for urban innovation.
- **Leverage proven design and technologies:** By drawing from established principles and tested technological implementations, solid foundations can be built to ensure future-ready, stable and scalable urban environments.
- **Convergence of funding:** National, Regional / State as well as City-level administrations should come together to converge funding so as to support the growth and sustainability of various city-level initiatives. Convergence with external national or international-level entities such as World Bank etc. can help in setup of foundational infrastructure for city goals of global relevance so as to offload the financial burden of kick starting an initiative.

## 6 Conducive ecosystem

- **Adoption of 'open' culture:** Open standards, open architecture and open communication within government entities can accelerate in unlocking the potential of the 'cognitive' paradigm.
- **Alignment with national level/local regulators:** Staying up-to-date on regulatory policies may serve as a guide to city technology implementations and help deal with complex issues related to the urban environment.
- **Regulatory sandboxes:** Testing, developing and refinement of innovative technologies and concepts in controlled environments guided by applicable regulations will help support growth of such technologies, foster innovation and ensure regulatory compliance thereby mitigating risks.
- **Availability of digital infrastructure:** Accessible digital infrastructure – high-speed internet connectivity, data centres, and a reliable network to connect smart services, systems and citizens seamlessly – supports real-time data analytics and facilitates the deployment of intelligent city services.

# Considerations and implications of cognitive technologies

The transformational journey for a city towards the “cognitive” will involve a wide range of considerations and implications, spanning across technological, social, ethical and governance aspects, that should be addressed to reduce risk and ensure smooth delivery of services.

## Service Equity

A Cognitive City should consider the provision of services to beneficiaries in an equitable manner.

## Data privacy and security

The collection and use of vast amounts of data can raise significant privacy concerns.

## Data sharing

Data sharing within and between government agencies and private entities is crucial for efficient urban planning.

## Transparency and accountability

As AI and automation make more decisions, transparency in algorithms and accountability for outcomes become critical.

## Digital literacy

Not all residents may have the necessary digital skills for full participation in Cognitive City initiatives.

## Cybersecurity and resilience

Cities become more vulnerable to cyber threats as they digitise more services.

## Regulatory challenges

Regulations may need to adapt to accommodate emerging technologies.

## Ethical AI and bias mitigation

AI systems may perpetuate bias or make unfair decisions and it is important to prioritise ethics in AI to address algorithmic bias and ensure transparency and accountability.

## Interconnected city platforms and integration

Effective integration of interconnected systems is crucial to realising the full potential of a Cognitive City.’

# 6

# Conclusion

The transformation of cities from smart to cognitive is not just a technological transformation. It is a transformation from being reactive to being proactive, from predictive analysis to perceptive analysis and most importantly for strengthening the socioeconomic development of a city in an equitable manner. As cities become cognitive, they must balance the risks associated with emerging technologies while remaining focused on data protection and privacy, maintaining their goal to enhance the quality of urban life.

Urban cognitive transformation is guided by a clear framework and guiding principles for the planning and management of urban environments in the digital era. Cognitive technologies offer an opportunity to revolutionise almost every sphere of our lives, with several use cases across the sectors, leading to an enhanced urban living experience and sustainable, resilient economic growth.

Data, AI and next-gen infrastructure are some of the key themes that strengthen cognitive foundation of a city. As urban areas strive to leverage advanced technologies to enhance the quality of life for their citizens and residents, it is equally important to adopt proper controls related to privacy, data sharing and the ethical use of emerging technologies to gain trust of residents.

Collaboration between the public and private sectors and active participation from the community is imperative to establish a holistic approach to the transformation process. Cities can only achieve the vision of cognitive urban development through a balanced integration of technological advancements and a people-centric focus.

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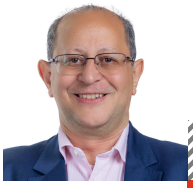

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