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INNOVATION BRIEF

From Smart Cities to Cognitive Cities

How AI will enable cities to proactively respond to citizens' needs

WRITTEN BY

Jessica Constantinidis
EMEA Innovation Officer

Ian Krieger
APAC Innovation Officer

The Innovation Office

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Summary

- Rather than simply making incremental improvements, contemporary cities must undergo a fundamental transformation and paradigm shift to meet the challenges posed by today's physical infrastructure needs and digital transformation imperatives.
- If today's Smart Cities use intelligent technology to improve operations and services, tomorrow's Cognitive Cities represent a strategic inflection point where AI agents empower cities to function as unified intelligent command centers, actively and dynamically predicting the needs of citizens and stakeholders.
- The economic stakes are real: Cities that embrace cognitive transformation will become innovation hubs that attract talent and investment, while those that don't will fall increasingly behind.

Introduction

Picture a city where AI eliminates traffic through intelligent rerouting, prevents infrastructure failures through predictive maintenance, and elevates electric grid optimization into comprehensive urban wellbeing enhancement. Rather than spending a disproportionate amount of resources responding to every notification and complaint, these cities monitor infrastructure, anticipate resident needs, and preemptively address them, constantly adapting and evolving along with citizen needs and expectations. This isn't science fiction; it's the everyday working environment and competitive edge that Cognitive Cities are about to demonstrate.

A Cognitive City is a citizen-centric urban intelligent operating system that autonomously learns and acts to advance shared strategic goals and continuously orchestrates physical infrastructure and digital workflows.

Using trusted data and dynamic governance, Cognitive Cities employ artificial intelligence and agentic AI within a centralized, self-learning nervous system. This intelligent operations center has visibility across the digital and physical city and the ability to control, monitor, manage, and operate all the technological systems behind city operations. It can predict issues, make recommendations, and take autonomous actions, thus functioning proactively and predictably.

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While traditional Smart Cities collect data and optimize urban processes through isolated technological improvements, Cognitive Cities represent a quantum leap in urban intelligence. They continuously think (process and analyze), act (respond dynamically), and learn and evolve (adapt from outcomes and transform their capabilities) to meet the changing needs of the population. The difference isn't just technological; it's strategic, financial, and increasingly, existential, as cities compete for residents, businesses, and resources in an interconnected global economy.

When a major event occurs—such as a sports championship—a Smart City may deploy intelligent traffic lights that adjust signal timing based on traffic flow sensors or activate digital signage to redirect vehicles. These are isolated "smart" technologies operating in silos. In contrast, a Cognitive City will coordinate all infrastructure, including traffic lights, public transit, digital signage, and bridges, to support large crowds. The physical infrastructure will work in concert with emergency personnel, who will be directed to areas of need, while the command center monitors issues like the weather and takes preemptive actions to ensure the event runs smoothly. Citizens attending the event will be

supported by real-time directions to available parking and guidance to the best route to the event. And the Cognitive City will learn from the event, using the experience to support even more optimized operations in the future.

A Cognitive City approach evolves urban centers from a place containing pockets of intelligent infrastructure to a future where the whole city is self-aware, goal-directed, and accountable, turning disconnected data and systems into a coordinated, citizen-centered urban organism. Tomorrow's Cognitive City will deliver better service for citizens, better outcomes for cities and nations, and the contribution of trillions of dollars to global GDP over the next decade.[1]

Today, we are in the midst of an intelligence revolution. Artificial intelligence is set to far surpass human intelligence, leading to new technological capabilities and innovations that will transform how we work and live. To thrive in this AI-driven future, the existing cities that apply technology to today's processes to improve delivery will only scratch the surface of what AI can do. Cities must evolve to meet this moment.

Leaders operating in urban enterprises have reached an unprecedented inflection point. Whether they are managing a municipality, overseeing corporate real estate across

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multiple cities, or making location decisions for their organization, the urban evolution represents both a challenge and an opportunity. Cognitive Cities that embrace transformation, seamlessly integrate AI, and embrace the most innovative technology solutions will become hubs of talent, innovation, and investment, while those that don't will spend the 2030s falling farther behind competitors that are already thinking, learning, and evolving at an exponential rate.

The question isn't whether AI will transform urban environments, but rather which cities will lead that transformation and capture the resulting economic advantages.

Understanding the limits of Smart Cities

The concept of the Smart City emerged in the 1990s to describe cities' efforts to harness technology to improve service delivery and other urban goals.[2] The digital era ushered in widespread Smart City initiatives, like the thousands of projects in the early 2000s that used IoT devices to improve public services.

But the current physical infrastructure and digital transformation efforts are no match for the challenges facing contemporary cities. Urban populations are expected to jump from 4.8 billion today to 5.6 billion by 2035.[3] There are 37 megacities today, each housing over 10 million people, and more of these megacities are expected by 2035.[4] While growing populations are a source of vibrancy and innovation, they will also place strains on cities, such as increased traffic congestion and pollution.[5]

Population growth is only part of the equation. Cities are experiencing continuous changes

and disruptions from shifting investment priorities, climate change, natural disasters, pandemics, evolving citizen expectations, and infrastructure failures. For example, since 1990, the number of category 4 and 5 hurricanes has almost doubled, averaging 18 per year globally, according to the National Science Foundation.[6]

Meanwhile, the American Society of Civil Engineers estimates in its 2025 report that the U.S. faces a $3.7 trillion gap in infrastructure funding by 2033 as the country copes with aging structures. That includes nearly 92,000 dams whose average age is 60 years old, 17,000 of which are considered "high hazard potential."[7] The same report estimates 240,000 water main breaks per year, causing $2.6 billion in repair and maintenance costs, as only 30% of the country's utilities have a complete asset management plan in place.[8]

Major global events, including the COVID-19 pandemic, have shown the critical need for public services that can swiftly respond to citizens' changing needs. It's no wonder that Fortune Magazine's recent global poll of 50,000 citizens in 23 countries shows that two-thirds of people in developed countries say their governments are not providing adequate services and crisis response.[9]

As these numbers show, traditional infrastructure, even with Smart City digital transformation approaches, is insufficient for these rapidly evolving urban environments. Physical infrastructure alone or ad-hoc digital initiatives cannot adequately address these unrelenting and multifaceted challenges. Smart Cities optimize individual processes but cannot orchestrate city-wide intelligence. Traffic systems optimize traffic flow. Energy grids

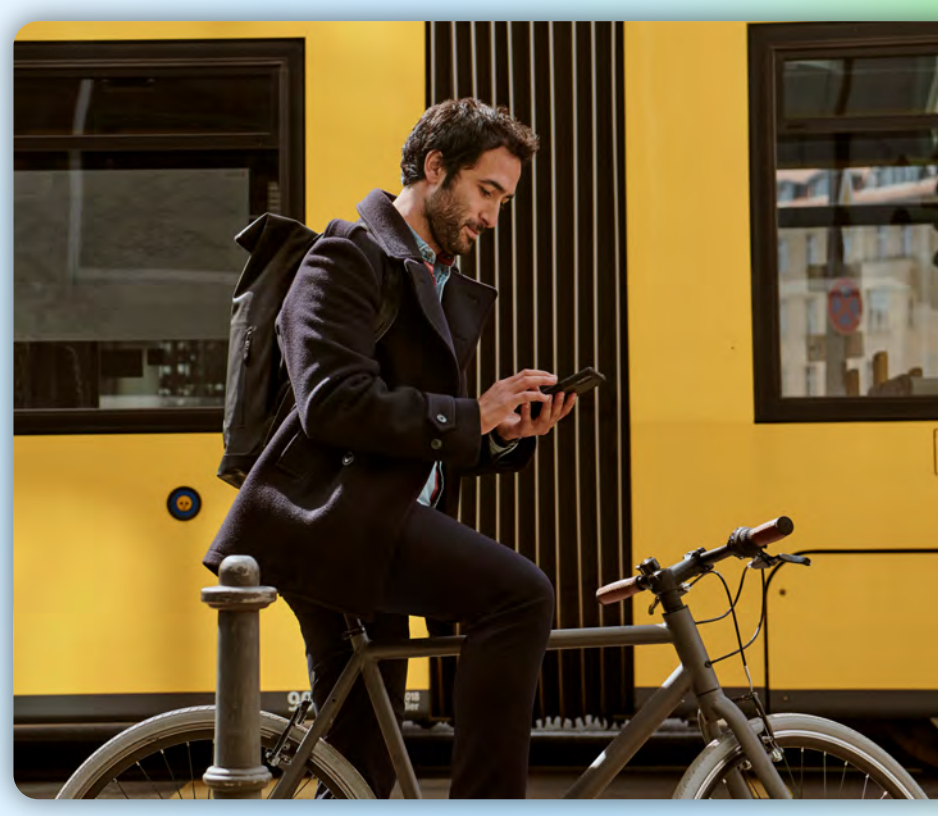
optimize energy. Public safety manages emergencies. But no system optimizes the citizen experience—or business operating environment—across all touchpoints simultaneously.

Evolving from Smart Cities to Cognitive Cities

To keep pace with these changing demands, cities must move from a reactive to a proactive "sense-and-respond" paradigm, as illustrated in the table below. Smart Cities sought to leverage technology to improve services, usually in specific use cases. For example, smart sensors could identify empty parking spaces and activate alerts to guide drivers to open spots, and streetlights could adjust brightness based on conditions to save energy. With the emergence of AI, Smart Cities became increasingly adaptable. Traffic signals could adjust based on current traffic levels, and energy grids could use data to optimize energy distribution.

The adaptive city model started to integrate physical infrastructure with digital workflows and bridge physical AI with digital AI to create a more nimble operations environment. But this thinking was largely developed before AI and agentic AI opened even bigger possibilities for city operations.

Now, agentic AI is enabling the next evolution of the Smart City concept, the Cognitive City: urban environments that learn, adapt, and proactively respond to citizen needs by coordinating all systems through an intelligent operations center. Technology is making Cognitive Cities possible, but technology alone will not create Cognitive Cities.



A more holistic and adaptive approach is needed that treats the city as a complex organism, acting autonomously to serve citizens and stakeholders while advancing and optimizing strategic goals. This ecosystem-oriented vision imagines the city of the future as interconnected, dynamic, and evolving.

Comparing Smart City, Adaptive City, and Cognitive City approaches

	Smart City 1990s-onward	Adaptive City 2022-onward	Cognitive City 2024-onward
Definition	A city heavily focused on the application of information and communication technologies (ICT) and data analytics to optimize urban services, improve efficiency, and enhance livability	A city that implements digital and physical workflows to adapt to events, rapidly respond to change and disruption, seize new opportunities, and continuously optimize the key performance indicators (KPIs) associated with its strategic goals	A city that places citizens at the center, using agentic AI to power intelligent operations that create responsive, adaptable, and proactive urban environments
Key characteristics	Pockets of intelligent infrastructure that primarily react to data to optimize urban processes	Intrinsic agility is built in to the city's operating model; continuously optimizes city strategic goals; works across both physical and digital enablers	The entire urban organism is self-aware, goal-directed and accountable, turning disconnected data and systems into coordinated, citizen-centered actions
Enabling technologies	ICT such as IoT, smart sensors, and data analytics	Smart City infrastructure with digital infrastructure such as AI/ML, blockchain, and digital twins; physical infrastructure such as moveable systems and modular design and construction	Adaptive city infrastructure with GenAI, agentic AI, and human-centric workflow systems
Example	Smart sensors identify empty parking spaces and activate signage to alert drivers to open spots	When congestion increases, a digital workflow triggers the opening of more parking garages	The intelligent operations center simultaneously opens more parking garages, adjusts signage and traffic flow to direct cars to the new garages, and provides drivers personalized wayfinding to open spaces

Changing the game with agentic AI

For cities, agentic AI offers an unprecedented opportunity to transform. The self-thinking, self-learning, and self-evolving nature of AI agents enables responsive, adaptable, and proactive urban environments. AI agents are a step beyond generative AI because, rather than simply responding to questions like a chatbot, they can execute tasks autonomously and be given specific tasks or goals (i.e., outcomes) to accomplish. Exactly how they achieve those tasks is handled entirely by the AI orchestrator and the AI agents themselves.

The transformative capabilities of AI agents to support the Cognitive City fall into three main categories:

1. Self-thinking: AI that reasons

Self-thinking is an AI agent's ability to analyze information and make decisions. Instead of just following a simple script, these agents can process complex data, weigh different factors, and determine the best course of action. This is much like someone who uses their knowledge and experience to think through a problem and decide what to do next. In the Cognitive City, AI can handle more sophisticated tasks, like a public service bot that doesn't just respond with pre-written answers but can diagnose a citizen's problem and suggest a specific solution. Helsinki's AI assistant "Helmi" demonstrates this capability by acting as a proactive help desk that can analyze citizen

inquiries and provide personalized solutions rather than generic responses, making public services more transparent and human-centered.[10]

2. Self-learning: AI that improves

Self-learning is the core of an AI agent's growth. They learn from every interaction, data point, and feedback, constantly improving over time. This is much like a new employee who learns the ropes by doing the job, receiving feedback, and adapting their approach. An AI agent might be trained on a large data set to start, but its real power comes from its ability to continuously improve its performance based on new experiences.

For example, a traffic management AI (i.e., Adaptive Traffic Control Systems[11]) gets more accurate at spotting new opportunities to reduce wait times the more it sees them. Singapore exemplifies this through its intelligent transport system, which continuously learns from data collected by sensors, cameras, and GPS-enabled taxis to adjust traffic signals dynamically, predict congestion before it happens, and improve coordination across public transit—resulting in faster commutes and reduced congestion as the system becomes smarter over time.[12]

3. Self-evolving: AI that adapts

Self-evolving is the most advanced AI capability. It's an AI agent that adapts and improves itself without needing constant human updates. This means the AI can adjust its own internal "instructions" or "reasoning," and even create new tools to accomplish its goals. It's a proactive level of intelligence where the system isn't just learning from data but actively refining its structure to be more efficient and effective.

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This is a game-changer for the Cognitive City because it means AI can solve increasingly complex problems, such as optimizing for operational efficiency and sustainability, and staying ahead of challenges with minimal human oversight. Barcelona's smart grid transformation showcases this capability. AI-driven grid management systems use digital twins and predictive maintenance to automatically adapt the energy network in real

time, making it more resilient and efficient while scaling to meet the city's evolving energy needs without constant manual intervention.[13]

Optimizing strategic city goals

The Cognitive City represents a paradigm shift in urban governance, from managing individual systems to orchestrating holistic outcomes. Where traditional cities balance competing priorities through manual oversight and reactive adjustments, Cognitive Cities leverage AI to simultaneously optimize multiple strategic goals in real time, such as mobility, health and wellness, efficiency and resilience, sustainability, and more.

Cognitive Cities will become global destinations because they will be better able to deliver on these key goals. To truly understand what sets a Cognitive City apart, consider how it would handle a major urban event: a marathon that brings 50,000 runners and 1 million spectators streaming into the city center, creating a complex orchestration challenge that showcases the city's intelligent, adaptive capabilities.

At 4 a.m., the city's cognitive system begins its orchestrated response. Having analyzed weather forecasts showing unexpected rain at 10 a.m., the AI-powered command center's self-thinking capabilities kick into high gear, automatically adjusting the marathon route's drainage systems, pre-positioning medical tents in areas prone to slippery conditions, and coordinating with building management systems along the route to prepare indoor warming stations.

As runners and spectators begin arriving, the city's self-learning capabilities activate. The system recognizes from previous marathons that subway stations near the starting line experience 300% capacity surges from 6-7 a.m. It proactively reroutes trains, deploys additional cars, and sends personalized notifications to spectators suggesting alternative stations with

real-time walking directions. When the AI detects an unusual cluster of social media posts about confusion at a newly renovated intersection, it instantly updates digital wayfinding displays and dispatches human ambassadors to that specific location.

Throughout the race, the cognitive infrastructure demonstrates its self-evolving nature. When a runner collapses at mile 18, multiple systems respond in concert. Surveillance cameras identify the incident. The nearest automated external defibrillator unlocks and provides audio instructions to bystanders. A trauma doctor within walking distance receives a notification and directions to the incident. Traffic lights create an emergency corridor for the ambulance through the least congested route, already dispatched based on the runner's biometric data from their smartwatch. The crowd management system subtly adjusts barriers to handle the crowd. The hospital is alerted of the incoming patient with the relevant doctors ready and waiting, and the command center automatically notifies the runner's emergency contacts and provides them with real-time hospital directions.

As the unexpected rain arrives, the city adapts dynamically. Storm drains increase flow capacity. Electronic billboards transform into shelter guides. Ride-sharing prices are regulated to prevent surge pricing. The finish line celebration is seamlessly relocated to a covered venue, and all vendors, media, and services are notified through integrated communication channels.

Post-event, the cognitive system analyzes millions of data points—from runner completion times affected by weather to spectator movement patterns—automatically updating its algorithms for future events. It identifies that

certain pedestrian bridges experienced unexpected congestion during peak rainfall and evolves new crowd distribution strategies, ensuring the next marathon will run even more smoothly regardless of weather conditions.

This level of intelligent coordination isn't a distant future. Trailblazing cities are already leading the charge:

- Singapore's Smart Nation initiative demonstrates this integrated approach. It uses real-time data and predictive analytics to manage traffic, energy, and public safety, integrating sensors and AI to optimize urban planning and citizen services.[14]
- Pittsburgh's SURTRAC system uses AI to control traffic lights based on real-time conditions, cutting travel time by 25% and emissions by 20%,[15] exemplifying dynamic optimization.
- More broadly, Dubai's 2030 vision showcases how intelligent coordination translates into a competitive advantage, blending infrastructure, services, and citizen experience into one cohesive system. Innovations such as autonomous mobility, real-time traffic optimization, and predictive infrastructure maintenance are transforming urban planning from static master plans into living, adaptive systems.

For executives evaluating urban investments, this represents a fundamental shift in how cities create value. Cognitive Cities don't just deliver services more efficiently; they craft environments where businesses can operate more effectively, talent wants to locate, and innovation flourishes through seamless integration of physical and digital infrastructure.

Powering cities with an AI platform

The fundamental element distinguishing Cognitive Cities from their predecessors is the integration of AI as the central nervous system rather than an add-on technology. Instead of playing catch-up with never-ending, siloed, digital transformation initiatives, the Cognitive City will have an intrinsic agility built in both digitally and physically to respond, predict,

proactively act, and innovate to continuously maximize benefits for all stakeholders.[16] This platform-centric approach serves as an intelligent command center capable of coordinating the entire city to deliver optimized operations and exceptional services. Rather than a collection of independent systems, the Cognitive City delivers intelligent, coordinated action.

Cognitive Cities will employ AI and machine learning at the core of a new platform architecture—a city-wide operating system—to predict issues and make recommendations or even take direct actions (such as raising an automated flood barrier), thus functioning in a proactive and predictive manner.

Connecting digital and physical infrastructure with integrated workflows

The power of Cognitive Cities emerges not from advanced technology alone, but from the seamless integration of digital intelligence with physical infrastructure. This convergence enables cities to respond to challenges with coordinated actions that span multiple systems and jurisdictions. The intelligent operations center platform extends into the physical world through workflows that connect digital and physical enablers of this city-wide operating system (e.g., moveable barriers, IoT devices, etc.). These workflows empower municipalities to swiftly meet citizens' needs, while AI capabilities enable proactive city management through predictive analytics and real-time data integration. This approach paves the way for infrastructure resilience by integrating data streams, automating workflows, and acting

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upon end-point devices and systems, facilitating rapid responses during crises. What's more, "resilience" is no longer brittle and static—it's flexible and dynamic.

In the Cognitive City, not only is the workflow flexible and adaptive, but the physical and digital endpoints of the workflow are also flexible and adaptive. On the physical side, think of movable systems such as the Thames Barrier in the UK, or modular design and construction techniques such as Stadium 974 in Dubai, a soccer stadium made for the 2022 FIFA World Cup entirely from reused shipping containers. On the digital side, think of digital twins such as the "Virtual Singapore" nationwide 3-D digital twin that's linked to live IoT feeds and lets agencies simulate policy trades-offs before acting (e.g., heat-island mitigation versus traffic flow).[17]

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This integration creates new possibilities for business operations. Companies benefit from infrastructure that can adapt to changing needs, supply chains that adjust automatically to optimize efficiency, and regulatory environments that respond intelligently to new business models. In turn, Cognitive Cities benefit from edging out competition to attract companies that provide employment and tax revenues. The workflow integration can coordinate business decisions with city responses, further fostering symbiotic relationships between private enterprise and public infrastructure.

Constructing the Cognitive City

The transition to Cognitive Cities requires more than technological upgrades. Urban centers must lay the technology foundation while championing a holistic, multidisciplinary, and ecosystem-oriented vision. Success requires a systematic approach that simultaneously addresses technology, organization, and culture.

The transformation begins with designing and building flexible digital platforms and physical infrastructures (e.g., the city-wide operating system) so they can effortlessly integrate the requisite emerging technologies. Equally critical is the mindset shift from Smart City thinking—focused on specific use cases and technologies—to holistic Cognitive City thinking that considers the city as an interconnected organism. Many previous initiatives failed because they created islands of innovation without connecting them to broader urban systems and built on top of outdated physical and digital technology that limits what's possible.

This six-step implementation framework provides a roadmap for businesses preparing for this transformation:

1. Embrace a cognitive platform and agentic AI strategy.

At the Cognitive City's core, an intelligent command center unifies all urban operations through a seamlessly connected digital platform. Establish a clear vision linking AI capabilities to strategic outcomes, ensuring the platform can "meet more of its goals, for more of its stakeholders, for more of the time."[18]

As the platform vision is prepared, it will be essential to codify mission KPIs (such as net-zero goals, 15-minute access), map endpoint systems (such as digital twins, adaptive streets), and stand up an agentic AI layer and components that reason against those mission KPIs and can orchestrate workflows (such as across transport, energy, planning, and emergency services).

2. Cultivate a transformative leadership mindset.

Move beyond focusing on specific technologies to holistic thinking about people, environments, and infrastructure as interconnected systems. The digital and physical enablers throughout the city, acting as the execution arm of the agentic AI city-wide operating system, are vital to turning insights into a dynamic, city-wide operation. The Cognitive City will require not only the latest technologies, but also the latest innovations in smart and resilient infrastructure, waste and energy management, concrete materials, and much more.

3. Establish trusted data and ethical AI governance frameworks.

Create collaborative frameworks involving experts, communities, and policymakers to ensure transparency and accountability as AI integrates deeper into government operations. A clear understanding of ownership of digital and physical infrastructure and robust data management will be vital because the Cognitive City unites systems and data. Since AI is at the core of the Cognitive City, robust AI governance will be essential for risk management. This foundation helps to make every algorithm auditable and every data set defensible. With the AI landscape evolving rapidly, these AI governance frameworks must keep up with traditional AI/ML, GenAI, and agentic AI advancements. Each one presents an increasing risk profile as AI is integrated

more deeply into government applications, systems, and processes.[19]

In addition, it is crucial to implement robust cybersecurity protocols that adhere to zero-trust principles to protect citizen data. The use of data, sensors, and IoT devices that enable the Cognitive City also makes data privacy and security even more pressing.

4. Adopt human-centric, integrated workflow systems.

Deploy integrated platforms that connect humans to humans, humans to machines, and machines to machines, with human-in-the-loop checkpoints for critical decisions. Cities should adopt integrated workflow management platforms to streamline interactions between

different government levels and private entities, facilitating more agile and responsive city management.

This will enable the agentic AI-powered cognitive platform to connect directly to the city's digital and physical infrastructure, closing the loop from AI insight to cross-government action while keeping humans in charge. Key elements include a workflow orchestration layer spanning local, state, and national systems together with human-in-the-loop checkpoints, so that critical workflows can be paused for policy, ethics, or budget approval.

5. Invest in skills, training, and public engagement.

Consolidate skills into centers of excellence while enhancing public understanding through continuous education about AI's role in city management. The Cognitive City will require an investment in people, including training and upskilling government workers, as well as hiring curious and adaptable new employees. Strategic initiatives might include upskilling programs such as AI-for-civic-workers micro-credentials, paired with reverse-mentoring from data scientists; engineering–tech labs with planners, civil engineers, and software architects who co-design digital-physical pilots; and ecosystem accelerators with open APIs and challenge grants awarded to local SMEs and universities.

Cities should also enhance public understanding and trust through continuous engagement and education about AI's role and impact in city management. These sustainable

AI practices not only prioritize community engagement, protect citizen data, and foster inclusivity in technology adoption, but they also enhance innovation. Collaborating with citizens, schools, organizations, and other government entities can help create a Cognitive City that serves everyone.

6. Foster multi-disciplinary relationships and collaboration.

Bridge traditional divides between engineering and technology disciplines while managing complex intergovernmental relationships essential for success. Cognitive Cities, or any city for that matter, do not exist in isolation. Ensure multidisciplinary relationships and collaboration, and build an extended ecosystem of partners. This applies to both functional disciplines (e.g., engineering and technology) and all the international, national, regional, and local relationships that need to be managed and maintained for accountability, funding, communication, and effective policy implementation.

A true Cognitive City collaborates with its broader ecosystem, benefitting from shared governance and integration (e.g., common data standards and protocols), transparency and accountability (e.g., across multiple jurisdictions), and resiliency and scalability. Maintaining this intricate system of intergovernmental relations is crucial for success and ensuring that public services are delivered efficiently and equitably to citizens.

Embracing a cognitive future

The shift toward Cognitive Cities marks more than technological evolution. It represents a fundamental redefinition of urban competitiveness in the era of AI. Cities that successfully navigate this transformation will become magnets for talent, investment, and innovation, while those that don't risk becoming technological and economic backwaters.

Successfully managing this change necessitates a cognitive platform and agentic AI strategy, a holistic mindset, strong AI governance frameworks, human-centric workflow systems, multi-disciplinary collaboration, and meaningful citizen involvement.

The evidence is already emerging in cities such as Dubai and Singapore, where integrated AI platforms are delivering measurable improvements in citizen satisfaction, business efficiency, and environmental sustainability. Adopting these strategies and factors will allow urban areas around the globe to tackle future challenges.

The stakes couldn't be higher. With 68% of the world's population projected to live in urban areas by 2050,[20] the Cognitive City represents humanity's best opportunity to create an adaptive, intelligent, sustainable, and equitable urban future. The question is not whether this transformation will occur, but which cities will lead it and which will be left behind.

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