

Global Future Council on Cities and Urbanization

Agile Cities

Preparing for the Fourth Industrial Revolution

September 2018





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Foreword



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By merging the biological, physical and digital worlds, the Fourth Industrial Revolution is transforming the way people live. The rate of change unleashed by the Fourth Industrial Revolution is truly unprecedented, impacting all sectors and industries across the globe.

Cities, as global drivers of growth, must harness the opportunities and address the challenges brought about by this transformation. In this sense, “agility” has to be one of the defining characteristics of cities as they plan their future. To be agile is to move quickly and easily. But what exactly does this mean, and how can it be measured?

This report by the World Economic Forum’s Global Future Council on Cities and Urbanization begins to create a framework and provide metrics and guidelines for agility in the following key areas – city buildings, land, security, energy, mobility, education, governance and IT – that together will form the city agility index.

Starting from city-specific case studies sourced through the Global Future Council, the report illustrates how cities are being agile and serve as potential examples that can be improved upon and adapted by other cities to help them transform.



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Foreword



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The Fourth Industrial Revolution will unleash creativity with limitless potential. City administrators need to prepare by adapting the physical, digital and environmental elements of their cities to better respond to their citizens' dynamic and constantly evolving needs. How successfully they do so will decide whether we continue today's unsustainable patterns of urban development, or meet the urgent ambitions set forth in global accords such as the UN Sustainable Development Goals, Paris Agreement on Climate Change and New Urban Agenda.

This white paper is the third in a series curated by the Global Future Council on Cities and Urbanization. It builds on [Data Driven Cities: 20 Stories of Innovation](#), which reviewed how cities can apply new ways of using data, and the best practices for improving urban liveability presented in [Top Ten Urban Innovations](#). Together, these reports aim to encourage a robust multi-stakeholder conversation on urban innovation – asking what it means for the world's urban centres to be fully prepared for the technological, social and economic changes of the Fourth Industrial Revolution – and to catalyse action by sharing best practices among cities.

This work is a key part of the World Economic Forum's new Centre for Innovation and Entrepreneurship, created to support the scaling of entrepreneurial efforts that benefit the global good and dedicated to fostering innovation ecosystems in the world's global cities. As entrepreneurship and innovation become the drivers of global, economic and social progress, and urban centres their stage, the World Economic Forum is in a unique position to support start-ups in their quest for success, scale and measurable global impact. As an independent and impartial organization, the Forum is able to harness its resources, networks and experience to accelerate new ideas and support cities as they prepare for the Fourth Industrial Revolution.



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Introduction

We live in an increasingly urban world: 54% of the global population already reside in cities, and this will rise to an estimated 68% by 2050. The Fourth Industrial Revolution is changing the way in which these cities provide services to their residents. After years of building up both infrastructure and processes, cities must now break down siloes and invite innovation in order to fully benefit from the opportunities and meet the changes facing their populations.

The need to be agile – to quickly adapt to changing needs – cuts across all areas of urban infrastructure and processes. The guidelines and metrics provided in this report draw attention to three levels on which cities have experimented with innovation and found new solutions:

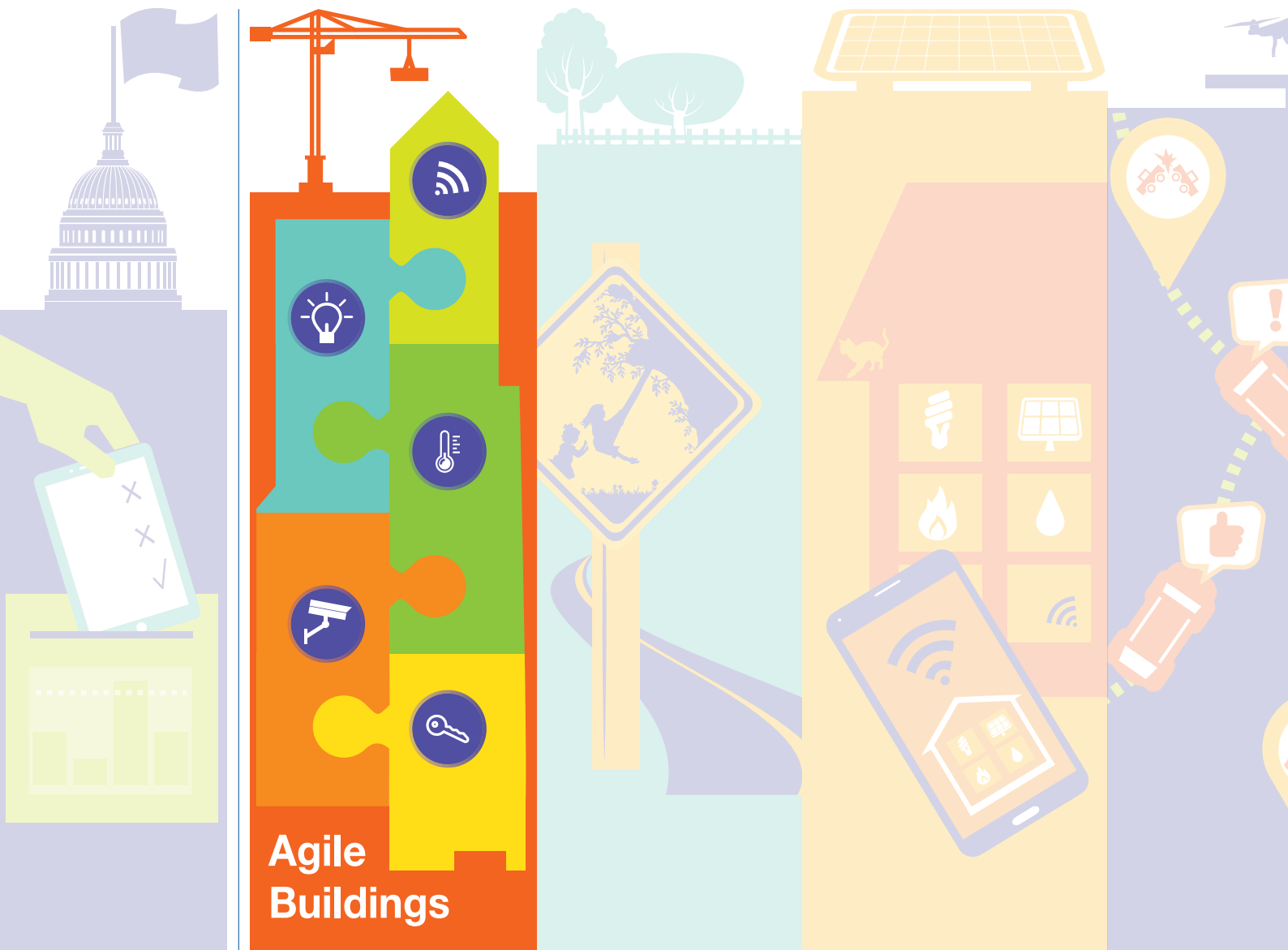
“Physical” components – how current infrastructure can be adapted to new needs and uses without outsized investment, long planning processes, or inconvenience to citizens.

“Digital” elements – how new technologies can be harnessed to better understand trends and citizens’ needs, as well as provide insight on current urban infrastructure and services and optimize their benefits.

“Environmental” factors – how the environmental effects of urban activity can be mitigated through innovative applications in both the physical and digital spheres.

Imagine a city where the government embraces ongoing transformation; planners efficiently rezone land for temporary uses; buildings serve a diverse mix of functions as needed; policing and prevention strategies are smart and data-driven; agencies share and seamlessly redeploy their IT assets; interoperable transport systems are optimized by real-time information; the energy network maximizes use of renewables while ensuring secure supply; and the education system quickly adapts to reflect the economy’s changing needs.

You have just imagined an agile city, as conceptualized by this report. Illustrated by emerging examples from around the world, these pages explore in detail why being agile is the key for cities to capitalize on emerging opportunities and enable their citizens to thrive assuming a leadership role, in our rapidly changing world.



Agile Buildings

1 Agile buildings are carbon-neutral, energy positive, technically sophisticated, and support a diverse mix of uses and activities through flexible space usage and shared working arrangements. They embrace the concept of “total building performance”, which evaluates building performance based on six core categories of design – spatial, acoustic, visual, thermal, indoor air quality (IAQ) and building integrity – and create market incentives for the transformation of old and underperforming building stock according to six key performance indicators: carbon reduction, energy independence, occupant health, integration with urban infrastructure, real-time performance monitoring and system interoperability.

Agile buildings leverage big data and real-time monitoring, making extensive use of the latest in sensor technology and leaning heavily on principles such as interoperability and passive design. Through transit-oriented design, they encourage walkability and provide easy access to mass transportation.

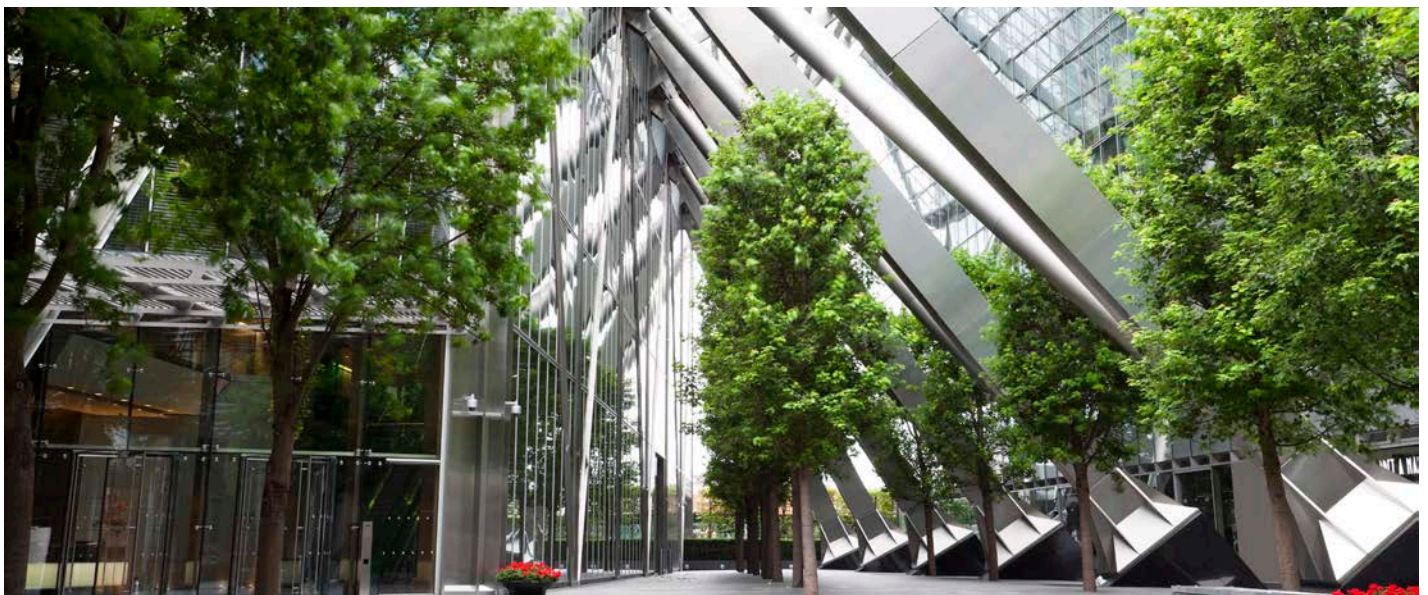
Best practices (city scale)

To promote agile buildings, cities can:

- Leverage the power of local building codes to promote net-zero energy benchmarks and support grid-diversification through incentivizing micro-grids and eco-districts, especially in central business districts where energy intensity is the highest.
- Adopt masterplans that support smart densification principles such as transit-oriented development and vertical urbanism.
- Promote land-use reforms that account for emerging technologies such as autonomous vehicles.

Agile Guidelines

Physical	Intelligent building operations Smart Building Energy Management System, or BEM; Mechanical systems located on elevated roofs or penthouse levels to prevent severe weather damage; strategies of redundancy to support resilience	High-performance design Indoor layout supports individual and focus work in diverse spaces, and is equipped with the latest technology. Site selection places projects outside of dangerous flood plains, supports urban resilience, walkability and community connectivity	Total building performance Performs well according to six key metrics: spatial, acoustic, visual, thermal, IAQ and building integrity
Digital	Interoperable IoT platform or central building app Allows cross-functional devices tied to the building's operation and maintenance, and also supports a range of user needs inside of the building	Big data A platform that collects and aggregates real-time building usage data in meaningful ways that enable facilities management to improve building functionality and occupant comfort	Machine learning/artificial intelligence to guide building systems AI actively uses the data that is collected and synthesized across the various sensor systems to improve building performance independent of active user control
Environmental	Net-zero or net-positive energy Using renewable energy sources, geothermal heating solutions and intelligent building systems to prevent the building from contributing GHG emissions	Energy independence Micro-grids, virtual power plants, eco-districts, and/or aquifer thermal energy storage enable buildings to be independent of the traditional single utility grid	Passive design strategies Uses natural ventilation, daylighting and other design techniques to reduce the building's energy consumption. Design features include biophilia, green roofs and walls, and low-carbon building materials





Case studies

The Tower at PNC Plaza, Pittsburgh, USA

An 800,000 square-foot office building, The Tower at PNC Plaza operates at near net-zero energy for 42% of working hours. Its innovative double-skin facade acts as a natural ventilation system, opening and closing based on outside temperature and humidity to keep healthy air circulating throughout the building. The building energy management (BEM) system ensures occupant safety in the event of fire or a natural disaster. A solar chimney keeps the building insulated during Pittsburgh's cold winter months, utilizing rooftop panels to capture warmth and transfer heat through a central shaft that runs through the entire building. An integrated stairway system allows for easy mobility, opening pathways to the large "collaboration neighbourhoods" located on every second floor of the building. Located in Pittsburgh's central business district, The Tower at PNC Plaza contributes to smart densification by providing easy access to mass transportation; multiple bike racks and a self-service maintenance centre encourages bike use.

Agnelli Foundation, Turin, Italy

The Agnelli Foundation in Turin has pioneered a system where heating and cooling – as well as its lighting – can all be personalized to individual preferences, creating a little environmental bubble for each worker that then "follows" them from room to room. The system is based on hundreds of WiFi-enabled sensors that collect data relating to occupancy, temperature, carbon dioxide concentration and the status of meeting rooms. By tailoring the heating and lighting to the needs of individuals and groups, design firm Carlo Ratti Associati believes the office could cut energy use significantly, as well as avoiding "thermostat wars". The central idea behind the Agnelli Foundation project is that by seamlessly integrating digital technologies within the physical space, one can forge better relationships between people and with the building they inhabit, ultimately fostering interaction and creativity.

Glumac, Los Angeles, USA

Sustainable engineering firm Glumac's 17,500-square-foot LA office, located in a 62-storey modernist skyscraper built in 1973 in the centre of the city's financial district, shows how existing technologies can be leveraged to make underperforming buildings more environmentally agile. A bespoke heat-recovery chiller harvests waste energy created by a lower-level data centre, using it to heat offices in the middle section of the building. LED lighting and extensive use of daylight further reduces the office's energy needs. The office produces three times more energy than it consumes, providing water and air heating for 20 additional floors within the building.

The Edge, Amsterdam, the Netherlands

Designed to house Deloitte's employees all in a single building, The Edge is a 40,000m²-office building in the Zuidas business district in Amsterdam. It was awarded the world's highest BREEAM rating of 98.4% through its integration of numerous smart technologies such as 28,000 sensors – including motion, light, temperature, humidity and infrared – and a central digital dashboard tracking energy consumption and user needs. Each light is integrated into the IT network, providing facility managers with real-time information about the building's usage, letting them target when and where to deliver lighting and other services. Office workers can adjust individual micro-environments, such as temperature settings, through a smartphone app. The office implements the hot-desking concept, with 2,500 employees sharing 1,000 desks during different time periods.



Agile Land

2

Agile land – or more correctly, agile planning and management of land – is becoming an urban as well as an agricultural concept, challenging the common assumption that land use change has to be expensive, time consuming and involve a long-term tie-up of the plot.

Agility promotes the idea that land use can be temporary (e.g. moveable prefabricated buildings); should be well distributed between vehicles, people and open space (about 80% of the public realm of a city is made up of roads); can change quickly (pop-up use); can be repurposed (e.g. car parks to flats); and can support multiple uses on the same plot, where buildings are energy producers as well as consumers.

Best practices (city scale)

To promote agile land, cities can:

- Reassess zoning policies to designate land for flexible usage and consider the scope for synergies by allowing, for example, services and manufacturing companies or business and academia to share flexible spaces.
- Examine potential to repurpose roads as public open space.
- Identify urban plots that could be used for community agriculture projects.

Agile Metrics

Physical	Area of land that has been planned for flexible space usage	Diversity of use
	The area of land that can be quickly repurposed to support multiple usage. [sqm]	Share of buildings that support a diverse mix of uses and activities through flexible space usage arrangements [% sqm]
Digital	Data capture	Data Storage
	Ability to capture and measure land use data that could subsequently be used for future land use planning, such as through simulations	Presence of digital means to store, manage and monitor land use data
Environmental	Measure biodiversity	Reduce heat
	Increase in tree species (biodiversity) indicates the success of environmental solutions in a city	% increase in tree canopies to reduce “heat island” effects



Errol Street, Melbourne renovation from 529m² of open space to 4900m² with cost savings of 14million AUD.
Source: City of Melbourne.

Case studies

Project Agrupar, Quito, Ecuador

Recently awarded the Climate Change Award for “Impulse for Change”, Agrupar is an urban agriculture project which benefits around 65,000 people in Quito, 84% of them women who often lack the skills for formal employment. It is a source of nutritious food – 53% of production is consumed by the beneficiaries and their families – and income, with the surplus production commercialized through bio-fairs organized through WhatsApp groups. Together, the income and savings on food purchases amount to three times as much as the government’s cash transfer to poor families in Ecuador. An assessment also found the project has increased women participants’ self-esteem. Agrupar is managed by ConQuito, the agency for economic promotion in Quito, and uses data from the municipal open government platform gobiernoabierto.quito.gob.ec to locate areas in Quito with malnutrition problems where the project could be expanded.

Flexible land-use policies and planning, Singapore

Government agencies in Singapore are working together to review land-use policies and planning guidelines to facilitate flexibility. Punggol North has been designated as Singapore’s first “Enterprise District” to test a new planning concept in which an appointed master developer, in this case JTC, has the flexibility to change the use of individual sites within a district-level zoning plan, rather than each individual site being separately zoned. The master developer is responsible for delivering a people-centric car-light vision, a comprehensive network of pedestrian walkways and cycling paths with green and community spaces, and district-level systems to manage waste and storm water. In Punggol North, JTC’s business park now shares facilities and collaborative spaces with the campus of the Singapore Institute of Technology, creating synergies between academia and businesses. Another pilot project, at Woodlands North Coast, is allowing greater flexibility of land use among businesses of different sectors and functions, reflecting the blurring line between services and manufacturing and the growing potential for cross-sector synergies and innovation.

Converting roads to parks, Melbourne, Australia

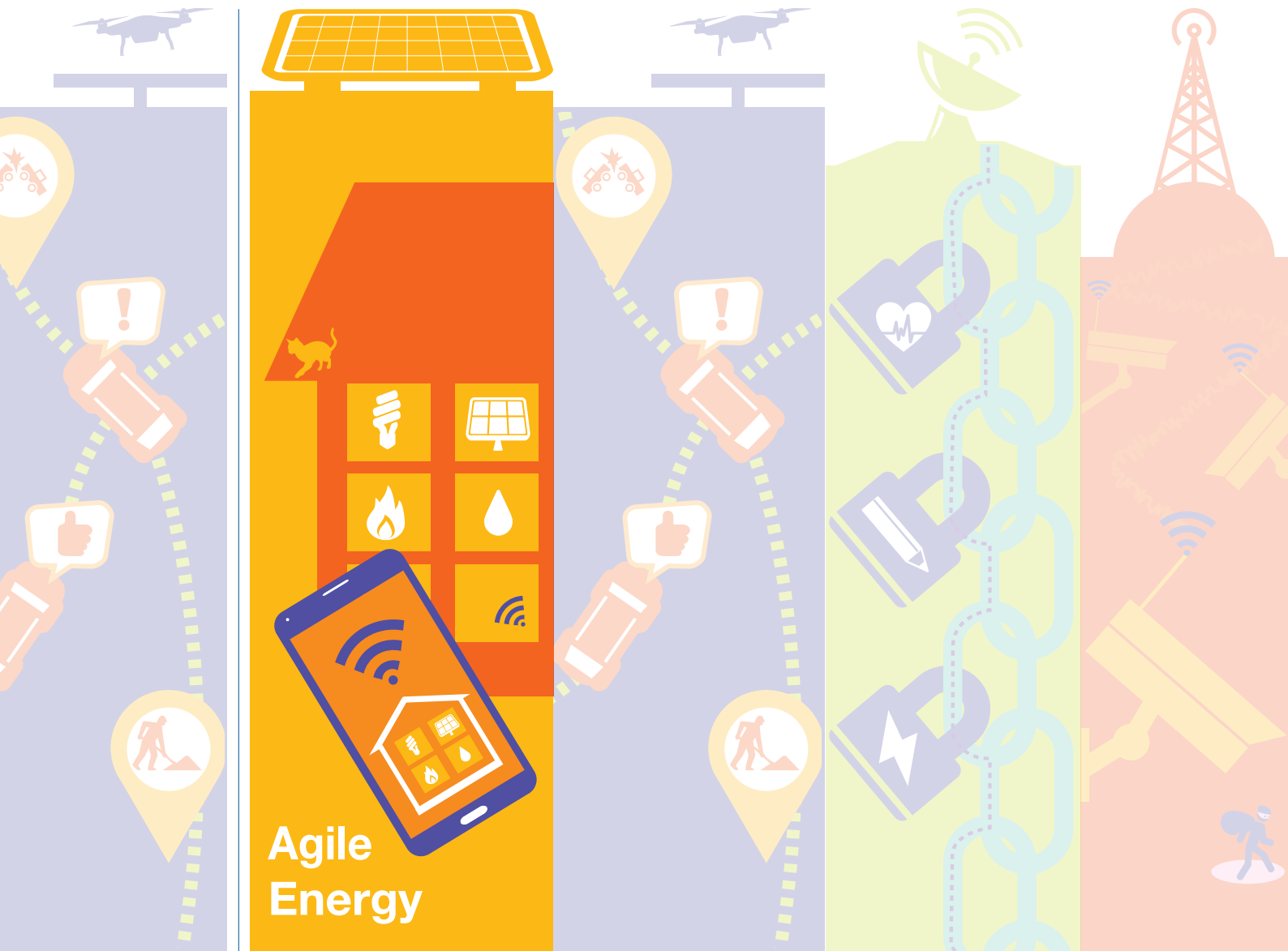
Melbourne is identifying roads it can close, without worsening traffic congestion, to transform areas into public green spaces. Parts of Neill Street and Drummond Street, for example, were removed to form an active recreation park. A roundabout on Errol Street was turned into almost 5,000 square metres of local open space – including additional space for a primary school – by reducing road widths and utilizing a one-way access system.



Over the last 30 years the City of Melbourne has converted over 90 hectares of asphalt to pedestrian and park uses.

Source: City of Melbourne

The advantage of this approach is that the cost of land purchase is avoided – the only costs are those of creating the open space amenity. The cost savings in the case of the Errol Street roundabout were estimated to be in the region of AUS\$14 million. The transformation also increased property values, which flowed back to the city council through higher annual rates.



3

Agile energy is the type of networked energy system that on average decreases energy loss, facilitates transition to renewable energy sources and coordinates diversified energy sources to provide supply security.

Best practices (city scale)

To promote agile energy, cities can:

- Consider potential synergies from integrating systems, such as electricity, gas, district heating and cooling, and biomass.
- Explore the use of smart metres and related technologies to optimize grid usage, offer consumers opportunities to save money and minimize the risk of outages at peak periods.

Agile Metrics

Physical	Share of energy that can be sourced from low-energy sources (e.g. heat < 80 Deg. C.)	Share of flexible consumers that have the ability to adapt to fluctuating energy supply (minimum ratio of flexibility)	Degree of diversification in terms of the number of different primary energy sources that can be integrated
Digital	Share of connectivity-enabled control components installed in the system (enabling advanced/ smart control)	Share of users that can follow their energy consumption (and/ or CO2 footprint) in real time	Ratio of energy consumption measured at the final point of usage (e.g. on individual household level)
Environmental	Share of energy supply currently coming from renewable energy sources	CO2 emission per unit of final energy consumption, considering also improved end-use efficiency	Energy efficiency, in terms of energy units supplied relative to primary energy units consumed

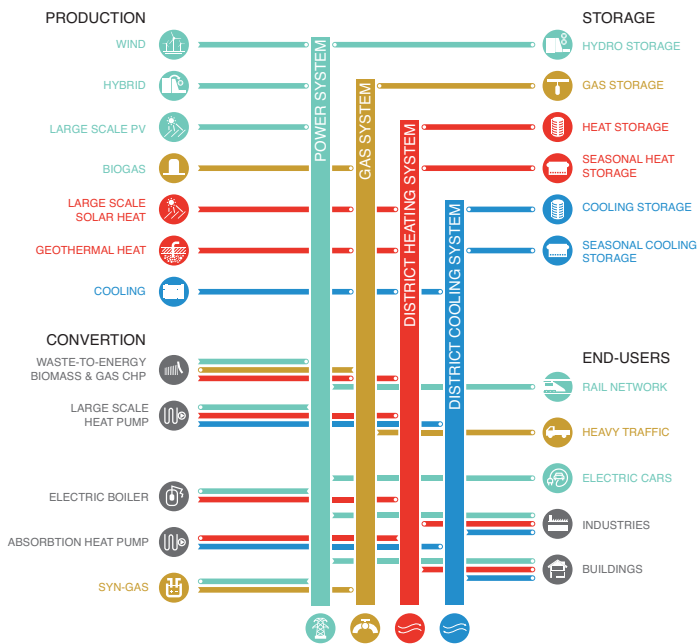


Case studies

Smart energy system, Denmark

CITIES, an R&D project at DTU (Technical University of Denmark), is researching how to organize future cities with intelligent IT solutions for the analysis, operation and development of integrated energy systems, including electricity, gas, district heating and cooling, and biomass fuel. A smart energy system links production, transmission and distribution, conversion, storage and intelligent consumption to improve its overall performance.

For example, fluctuating energy sources (e.g. wind and solar) are converted into other forms of energy, such as battery storage, at times of peak production; smart meters allow companies to plan better; and tariffs are structured to incentivize consumers to use energy when the price is lowest.



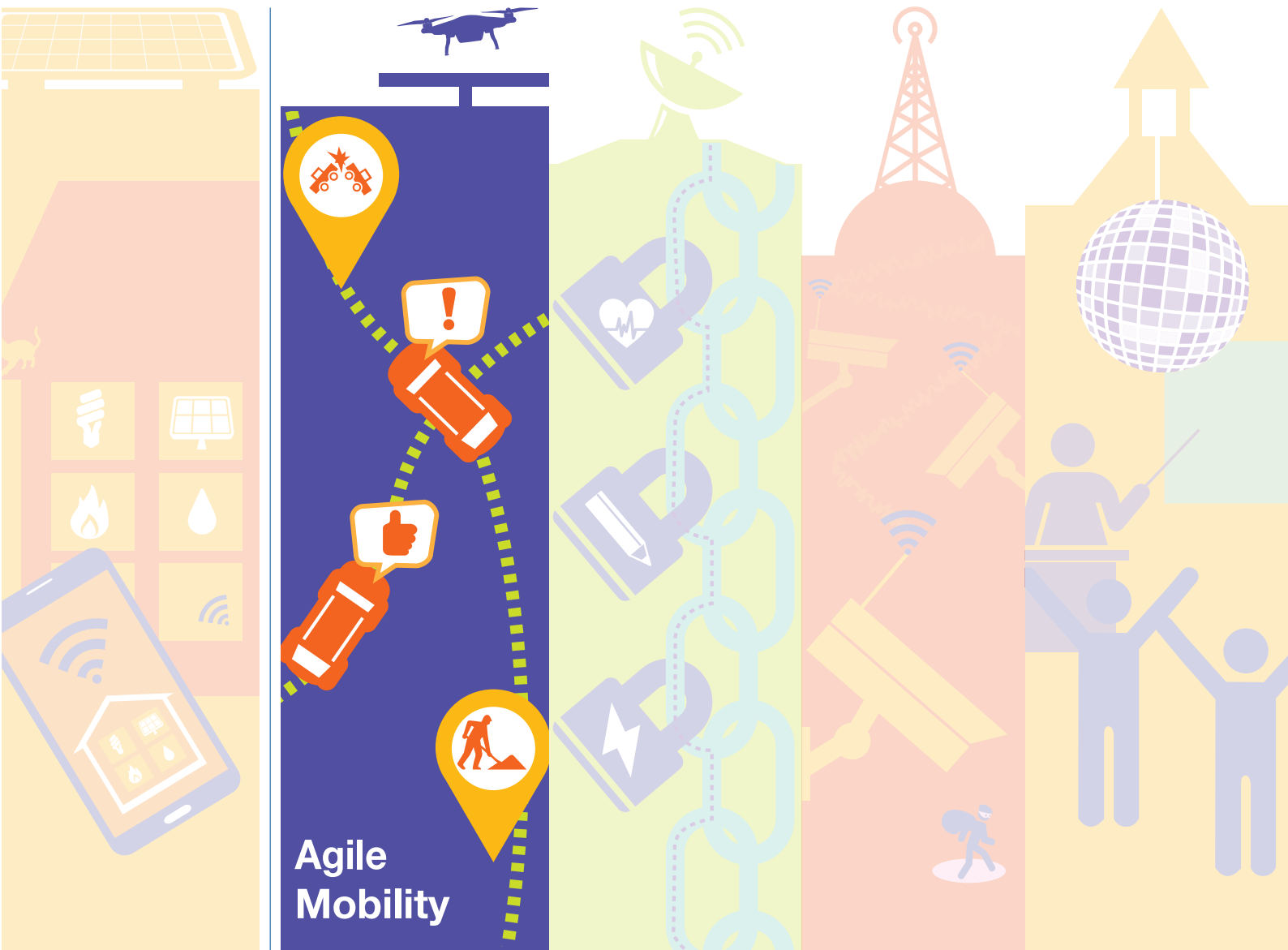
Source: Technical University of Denmark

EcoGrid 2.0, Denmark

A development and demonstration project that will run until 2019, EcoGrid 2.0 is investigating homeowners' comfort levels with allowing their power consumption to be regulated for them. The project remotely controls devices, such as heat pumps and electric radiators, in 1,000 households on the Danish island of Bornholm. Consumers can specify requirements such as their home being heated to between 20-22°C, or their electric car being charged by 07.00 each day. The project then attempts to optimize these aggregated requirements, adjusting to the differing amounts of renewable energy available at any given time.

SmartView metering infrastructure project, New Orleans, USA

The US city of New Orleans developed SmartView in collaboration with US energy company Entergy. This pilot programme gave 4,700 low-income local residents smart meters and the tools and training to make smarter energy decisions. In exchange for monthly rebates on their bills, for example, residents could agree to have their air conditioning shut off for 20 minutes per hour during peak periods; over 80% of the programme participants believed it saved them money on their energy bills, and more than 90% suggested interest in participating on a permanent basis.



4

Agile mobility involves flexible infrastructure supported by a collaborative digital platform that makes available real-time information about supply and demand of services, and ensures transportation optimization, unhindered access, and systems interoperability.

Agile mobility is multimodal, including human and machine powered mobility, and can absorb new forms of transportation. It is low-cost and scalable, and includes types of networked mobility that on average increase commuting speeds, decrease greenhouse gases, decrease harmful pollution and improve lifestyle, security and health issues in cities.

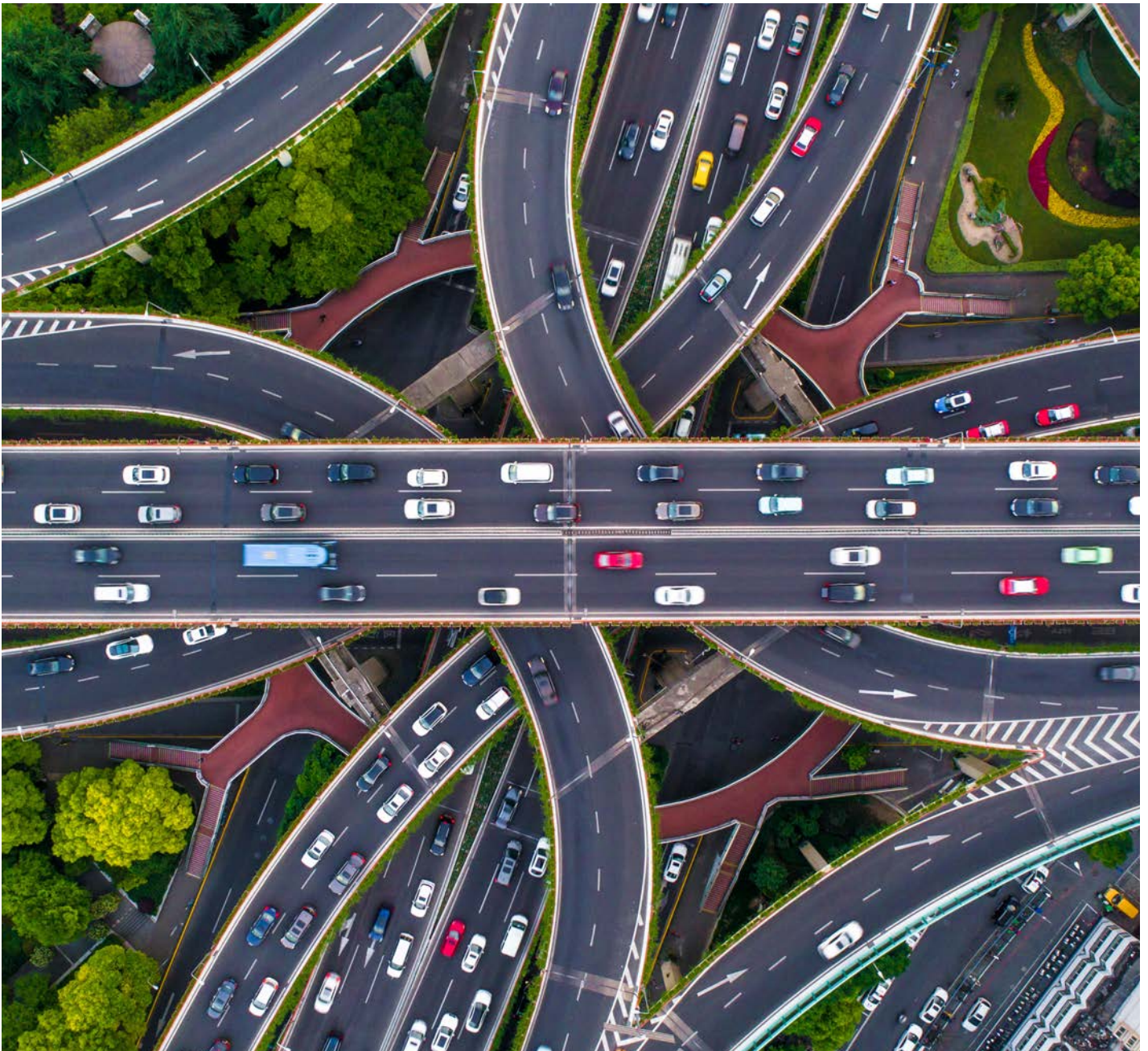
Best practices (city scale)

To promote agile mobility, cities can:

- Use data to inform decisions on integrating different modes of public transport, to minimize journey times and give travellers more information about their options.
- Consider new technologies to offer incentives for drivers to use public transport during periods of congestion.

Agile Metrics

Physical	Person-based accessibility (time it takes to earn the cost of mean travel time to work) [min]	People density [people per m ² of transportation device]	Multimodal transport: links between different modes of transport [number of links]
Digital	Presence of dynamic tolling and road use pricing to influence behavior	Presence of integrated mobility payment systems	Use of mobile applications to facilitate transport activity
Environmental	Transport-related CO ₂ emissions [kg per capita]	Transport-related NO _x emissions [kg per capita]	Transport-related noise pollution [reduction in %]



Case studies

Multimodal public transportation system, Quito, Ecuador

The Municipality of Quito is building the city's first metro line as part of a sustainable urban development strategy that integrates existing mobility systems. At its heart will be an integrated payment system, scheduled to start working in October 2019 when the system is inaugurated. It will initially include the metro and public bus systems, and expand to include public bike and two new cable car lines that are also being built. The municipality is working on systems that will produce data to analyse and optimize the routes, informing users about their journey planning and measuring how long journeys take. In 2017, the municipality launched MovilzateUIO, a mobile app that keeps citizens informed about the routes and stations of the BRT system, public bikes and privately operated buses. The city government has been introducing more accessible buses, and is working on incentives to promote the use of electric buses and taxis.

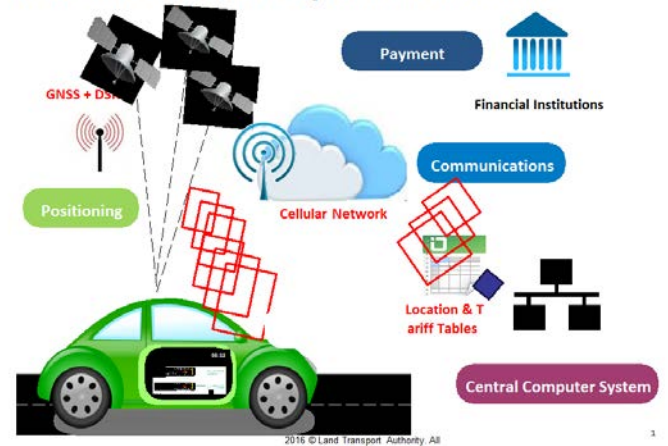
On-road integrated optimization navigation software, UPS

The on-road integrated optimization navigation (ORION) algorithm uses historical route tracking to identify the most efficient path for each UPS driver to follow to deliver packages on a given day. It learns over time how to optimize routes to increase efficiency and reduce fuel consumption, and adapt to changes in the environment and surrounding infrastructure. Similar tools can be used by public transportation departments.

Electronic road pricing system, Singapore

Singapore has launched a next-generation electronic road pricing (ERP) system to manage traffic congestion issues. Global navigation satellite system technology will enable motorists to be charged according to distance travelled on congested roads. On-board units will provide real-time traffic information and alert drivers of potential charges before their journey, allowing them to decide whether to drive or choose public transport instead.

Next-Generation ERP System Architecture



Source: Singapore Land Transport Authority

ORION

With our initial deployment of ORION in 2013, we optimized 10,000 delivery routes in the U.S.

We expect to avoid 14,000 metric tonnes of GHGs and save 1.5 million gallons of fuel on those routes in 2014

We plan to complete the full deployment of ORION in 2017

We estimate savings of US\$50 million a year if every UPS delivery driver avoids 1 mile driven per day

ORION-optimized routes require fewer miles of driving

Non-ORION routes include miles that can be avoided

ORION stands for on-road integrated optimization and navigation.

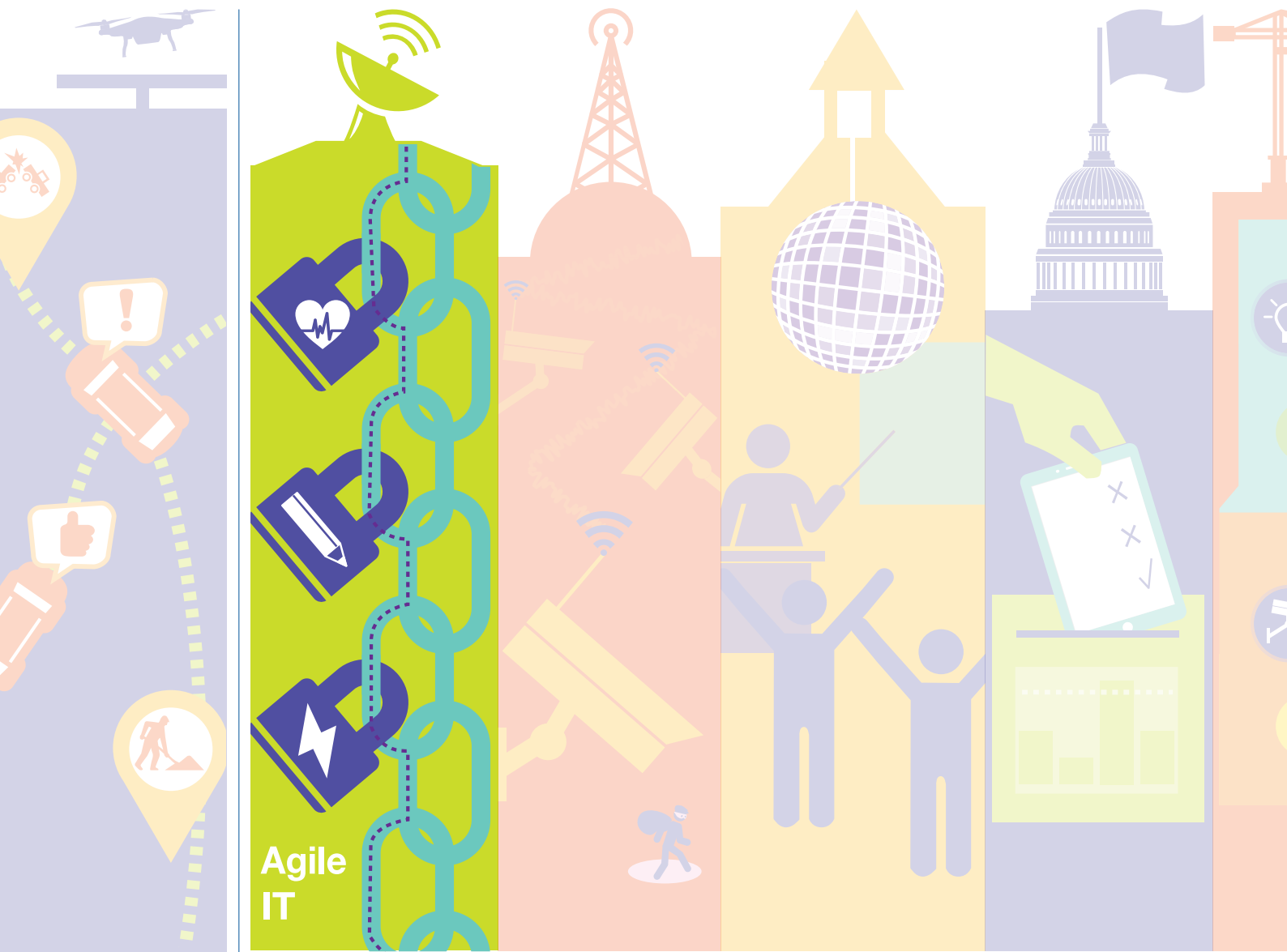
ORION knows a delivery route's customer addresses for the day, locations with required delivery and pickup times, and business rules for drivers. It also knows 250 million delivery addresses and the routes our drivers have used in the past. ORION analyzes it all and prepares optimized routing instructions right up to the minute a driver is dispatched.

ORION matters because e-commerce is increasing the number of residential and small-business customers we serve. To meet our sustainability goals we need to avoid driving additional miles to reach these customers, and ORION helps us do just that. ORION also helps our drivers concentrate even more on safety, and on providing great customer service when they pull up to your door.

Every delivery route begins and ends at a UPS facility

To learn more, please visit [ups.com/sustainability](https://sustainability.ups.com/sustainability)

Source: https://sustainability.ups.com/media/UPS_ORION_2016.pdf



5

Agile IT assets are efficient and responsive to users' service delivery needs at a reduced cost or risk. Key elements include convergence of services, increased capabilities on processing, storage and connectivity, automatic troubleshooting of failures, high availability, low-resource consumption and unlimited scalability. Agile IT assets must prove easy to manage, resilient and able to host new structures of data, services and applications.

Agile IT assets allow user requirements and policy changes to be implemented easily, and entities to be flexible in their knowledge sharing. They incorporate flexible security mechanisms, create positive economic impact through operational efficiencies and enhanced productivity, and limit environmental impact through energy efficiency and reduced waste.

Best practices (city scale)

To promote agile IT assets, cities can:

- Leverage the synergies existing in multiple city organizations for their IT needs.
- Provide customer-focused, highly flexible and resilient IT services.
- Achieve operational efficiencies and enhanced productivity while reducing the environmental impact of IT assets and services (through consolidation of IT infrastructures and services, and utilizing green computing).

Agile Guidelines

Physical	Consolidation of IT assets Captures the extent of physical IT assets' consolidation within or across city entities leading to operational efficiencies	IT assets utilization Aims to encourage efficient utilization of IT assets	Flexibility to incorporate user requirements Ability to capture and implement new user requirements, especially related to 4IR technologies, data processing, etc.
Digital	Number/extent of agile IT services Crossentity city digital services breaking silos across boundaries	Resilience/availability of agile IT services Captures the resilience of IT services to measure their availability, fault-tolerance and disaster recovery aspects including cybersecurity	Satisfaction with agile IT services Measures customer centricity of IT services, encourages customer feedback and engagement during services design
Environmental	Emissions Reduction in GHG emissions of IT assets/infrastructures	Energy Use Reduction in energy consumption of IT assets/infrastructures	Land Resources Reduction in land/space requirements of IT assets/infrastructures



Case studies

Smart Dubai

Smart Dubai has mobilized all entities in the city administration – including mobility, energy, environment, economy, society, education, health and public services – to coordinate their IT services and assets, capitalizing on synergies. It has implemented and delivered more than 60 shared IT services, managing more than 90% of all Dubai government employees and more than 95% of Dubai government budgets. Dubai aims to become the first city on blockchain by 2020.

The benefits of Smart Dubai's agile IT services include the ability to focus on core businesses, easy adoption of Fourth Industrial Revolution technologies, cost savings through operational efficiencies, digitized and streamlined processes, SLA-based service delivery, easier implementation of government-level policies, the ability to accommodate future expansion, improved disaster recovery and resilience, and easy generation of consolidated reports. Emissions from ICT equipment have been considerably reduced as there is no longer a need for government entities to replicate ICT infrastructures.

Urban mechanics, Boston, USA

Formed in 2010, the Mayor's Office of New Urban Mechanics was one of the world's first municipal innovation offices. Its civic research and development team pilots ways to improve the standard of living for Boston's residents. The office is an accessible way for civic innovators (both inside and outside of government) who want to propose solutions to local challenges, and a safe place for government officials and community collaborators to experiment. The office acts more like a digital consultancy than just another city agency, spending time talking to other city agencies and engaging citizens to find out what people need and develop accordingly. By involving users in the process, the agency can come up with truly user-centric digital applications.

Integrated urban services SaaS platform (URBO), Caracas, Venezuela

Started in May 2018, the Capital District Government in Caracas, Venezuela, began the deployment of an IoT/software as a service platform, called URBO®. With this effort, the local government has broken up data silos, integrated urban services management under a unified IT cloud-based infrastructure and deployed plug and play IoT devices to reduce the costs of collecting data and making it available to the public and city officials. City government has increased services convergence, increased usage of the existing mobile operators' communications infrastructure, dramatically reduced IT costs by deploying XaaS assets and simplified data acquisition, as well as remote asset management, to increase resource efficiency in city operations.

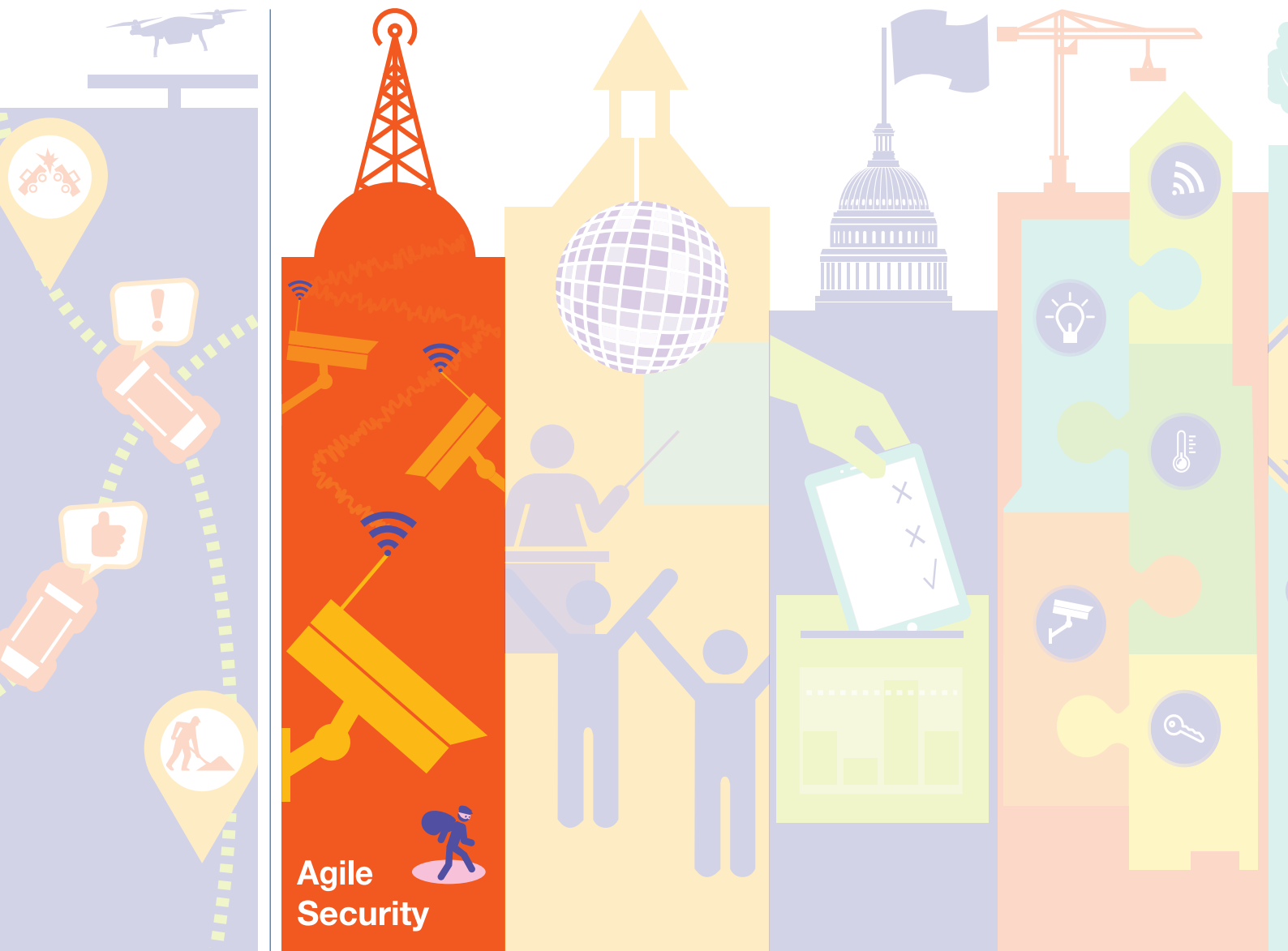
URBO® has harnessed the power of citizens and city contractors to contribute data via web and mobile app, which together with Sinapsis® IoT devices, allow real-time data access and remote operation capabilities for city officials on urban services such as waste collection, public works, street lighting, traffic lights and transportation routes.

Building trust in society, Singapore

DEX is a city-wide data exchange in Singapore using a decentralized data-sharing model to drive data innovation among businesses. It was developed by DEX, Singapore's Info-communications Media Development Authority (IMDA) and PwC to develop a trusted data framework for safe and secure data exchange.

DEX empowers the data community with open source software, tools and services so that secure marketplaces can be built on Ocean Protocol to drive the data economy. DEX provides the tools for global data sharing and enables AI development by offering data exchange services and an open source marketplace solution. The Ocean Protocol Logical Framework is a Decentralized Data Exchange Protocol empowering DEX to unlock data for AI. Benefits and sustainable outcomes include a worldwide benchmark for a trusted data framework, establishing a data-value business model for the data-sharing economy, acceleration of the adoption of data innovation, and AI applications.





6

Agile security encompasses a wide range of data-driven, problem-oriented approaches. It involves smarter policing and prevention strategies, using big data and machine learning to inform decisions about where to deploy scarce resources and about bail, sentencing and parole. It deploys a diverse range of new technologies including real-time crime mapping, biometric platforms, body cameras, personal alert systems, gunshot detection and social media sentiment analysis.

Agile security takes seriously the ethical questions generated by the application of new technologies, such as potential corrosion of civil liberties and crime prediction algorithms reproducing human biases. It works to combine technological approaches with policy moves such as hotspot policing, moving away from mandatory incarceration for non-violent and first-time offenders, and changes to the built environment such as barricades, street lights and CCTV cameras.

Best practices (city scale)

To promote agile security, cities can:

- Introduce measures transparently and in consultation with residents, with appropriate safeguards on data protection.
- Harness machine learning to predict crime and analyse hotspots using data from, for example, social media analytics, crowd-sourced crime alerts and networked surveillance cameras, and monitor measures such as changes in fatalities due to homicides and terrorism, the prevalence of violent crime, and the response rate of first responders.
- Address social and economic factors that influence crime and terrorism, such as concentrated disadvantage, high rates of youth unemployment and income inequality.

Note: All measures must be accompanied with clear protocols, ethical standards and data protection rules to reduce unintentional harm and infringement on civil liberties.

Agile Guidelines

Physical	Defence & design Combine defensive infrastructure such as anti-vehicular and loitering systems and blast walls with “designing-out” strategies such as low-rise buildings, open markets and parks to increase “eyes on the street” and promote social cohesion	Urban planning Targeted urban planning measures to reduce spatial segregation, increase opportunities for reporting suspect individuals or behaviour, and improve social efficacy	Communication Interoperable communications and ICT infrastructure and smart building communication strategies to minimize exposure to crime and terrorism
Digital	Dashboards AI-enabled dashboards to digitize, monitor and predict crime (real-time crime mapping, predictive policing, crowd-source alerts, gunshot detection)	Interpreted response systems Installation of digitized communications, storage and dispatch system with cloud-based management to integrate all emergency responders	Smart sensors Deployment of smart CCTV cameras, body-worn cameras, smart lighting and sensor networks, and other platforms to detect crime and terrorism risks, reduce violence, and increase response times
Environmental	Intervention Data-driven interventions focused on areas of concentrated disadvantage	Citizen input Digital systems to ensure citizen inputs to design, implementation and evaluation	Smart monitoring Deployment of smart technologies to monitor and prevent crime and reduce the prison population



Case studies

COMPSTAT and homicide decline, New York, USA

New York faced a crime epidemic in the 1980s and 1990s. After a series of targeted digital, environmental and physical interventions, the city's crime rate dropped by almost 90%. At the centre of the city's strategy was COMPSTAT, a statistical database and monitoring system installed in 1994 which enabled the NYPD to track crime in real time at the city, borough and precinct level. This was accompanied by changes in police practices that targeted hotspots and high-risk individuals, especially gangs and repeat offenders, along with extensive training for police officers and improved procedures and training. Improvements in income equality and employment during the same period have also been credited with improving the security environment.

Project Green Light and violent crime drop, Detroit, USA

Smarter surveillance contributed to Detroit reducing violent crime by over 50%. Project Green Light, started in 2016, allows for more efficient incident management and collaborative responses between the city police department and citizens. The initiative mixes real-time crime fighting and community policing with efforts to improve safety, revitalize and grow local business, and strengthen investigation

measures. Project Green Light includes high-definition (1080p) indoor and outdoor cameras at gas stations, which were upgraded with high-speed network connections, to allow for constant video streaming to the police department. The city is expanding the initiative to other businesses in hotspot areas.

InfoCrim and homicide decline, Sao Paulo, Brazil

Sao Paulo's murder rate has dropped from 52.5 per 100,000 in 1999 to just 6.1 per 100,000 today, almost five times lower than Brazil's national average. The most convincing analyses attribute this to changes in law enforcement practices together with strict controls on firearms. Innovations in this time have included the deployment of community police units in hotspot areas and reforms to the police, such as rewards for good performance, human rights and technical training. Technological innovations include the data-driven crime mapping tool Infocrim. One groundbreaking programme was launched in Diadema after data showed high rates of crime around areas where bars are clustered; municipal authorities introduced strict controls on alcohol sales after 23.00, installed smart monitoring systems to track alcohol vendors, and invested in public lighting and security cameras.



7 Agile education models can quickly respond and adapt to the constant changes in the world. Agile education moves away from traditional models based on building up expertise for extended periods of time before applying it in the real world, and towards intensive formats with quick proof-of-concept, shorter time cycles and a project-based approach that involves testing ideas, allowing changes in focus, theme and parameters.

Agile education stresses the curatorial role of educators and designing an adaptive framework rather than fixed curriculum. It blurs the lines between educators and students to create an environment for collective research investigation, not based on top-down passing of expertise but a fluid, think tank-like approach for collaboration between peers and specialists. Agile education allows for reflection, reassessment and re-calibration.

Best practices (city scale)

To promote agile education, cities can:

- Offer flexible physical environments that can adapt to different types of needs and activities.
- Scale learning through creative use of digital platforms and adaptation for different learning styles

Agile Guidelines

Physical	Flexible multi-use environments/formats/layouts Ability to quickly adjust and reconfigure educational spaces for different types of activities, including non-educational activities	Opportunities for direct engagement with the context Importance of field research and working “on the spot” as opposed to following a prescribed itinerary	Direct connection to the outside world Escaping the “institutional bubble” format, engaging with the city, making facilities available to external events and visitors and inviting external voices
Digital	Strategic mapping of educational value to most suitable formats Having a clear approach to distinguishing what needs to happen in person and how digital resources can be used to discover new perspectives and channels and grow the network	Use and integration of blended learning formats Enriching the learning experience through a variety of educational formats combining digital and traditional classroom methods	Diversification of digital resources Fitting existing digital platforms and resources to organizational needs, educational activities and a collaborative approach to learning, engaging students who are less active in traditional classroom formats
Environmental	Conscious approach to the learning environment Actively promoting conscious decision-making through design of the physical learning environment (use of sustainable eco-friendly materials, prioritization of natural light, etc.)	Integrating environmental context Actively integrating environmental questions into the subject matter in every field of study	

Case studies

Strelka Institute, Moscow, Russia

Moscow's Strelka Institute organizes its educational facilities around a public courtyard, with the aim of engaging different audiences and bringing in new perspectives and voices. The courtyard space is easily reconfigured, from lectures and film screenings, to conferences or a quiet working environment. Strelka's educational model also encourages off-site visits and field trips to conduct research in new contexts. Its "blended learning model" is embedded in the [Vector Online School](#) for urban entrepreneurs, launched in 2015, leveraging the institute's physical resources and expertise into online videos, assessments, seminars and various channels of feedback, and posting results to encourage input from the local and online community.

Global experimental education programmes

There have been many experimental education efforts around the world that reflect the move toward agile education. [42 Silicon Valley](#) is a non-profit organization and innovative engineering college in the San Francisco Bay area. As a leading college for software engineering, coding and programming, it is disrupting engineering education and tech talent pipelines in the Bay. The school does not have any professors, does not issue any diploma or degree, and is open 24/7. The training is inspired by new modern ways to teach, which include peer-to-peer pedagogy and project-based learning.

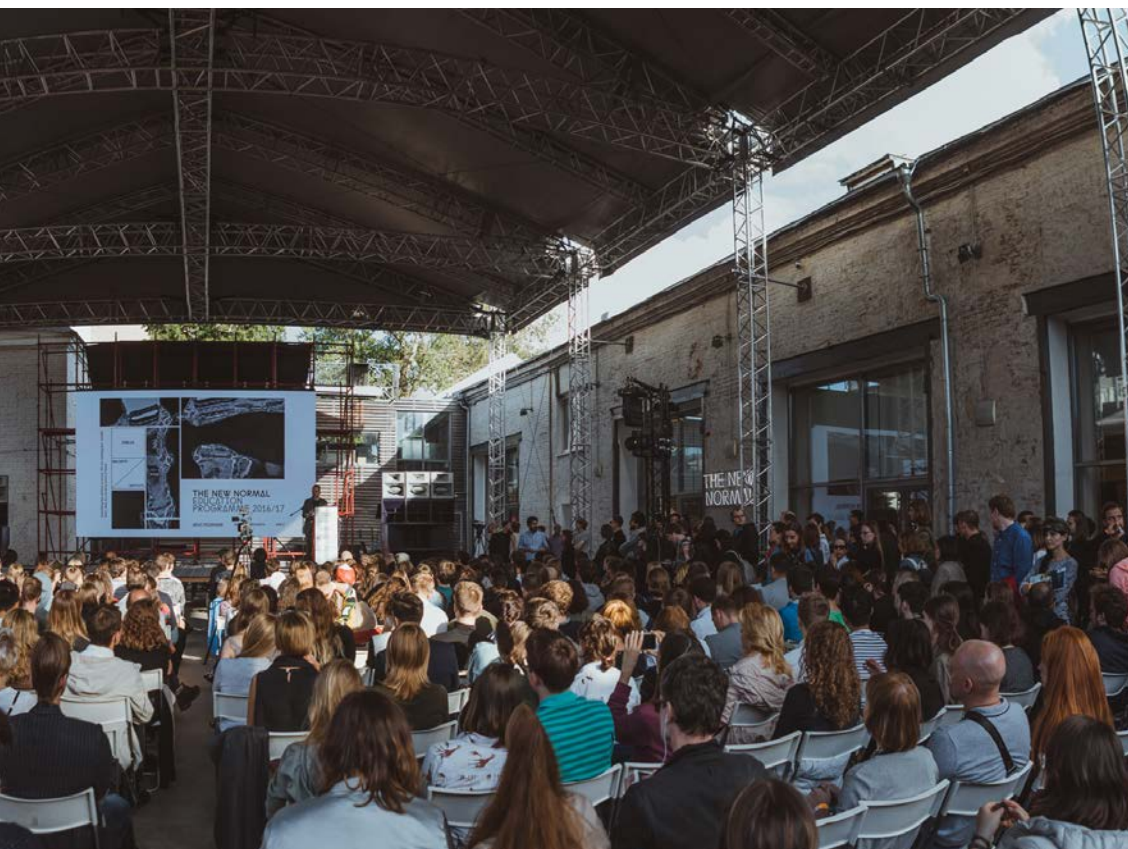
The [University of the Underground](#) in Amsterdam, the Netherlands, is a tuition-free, experimental education institute based below a nightclub. The institute believes in a transnational form of education, which goes across borders and beyond nation-states. It supports unconventional research and practices that challenge the formulation of culture, and the manufacture and commodities of knowledge.

Another innovative programme, [Kaospilot](#) is a hybrid business and design school based in Aarhus, Denmark, offering multifaceted education in leadership and entrepreneurship. Its programmes are not designed simply to shape students to fit the future, but to help them create it. As such, they centre their approach on the students and provide a place where creatives and potential change-makers can develop the knowledge, skills, attitudes and competencies they need to fulfil their values and visions.

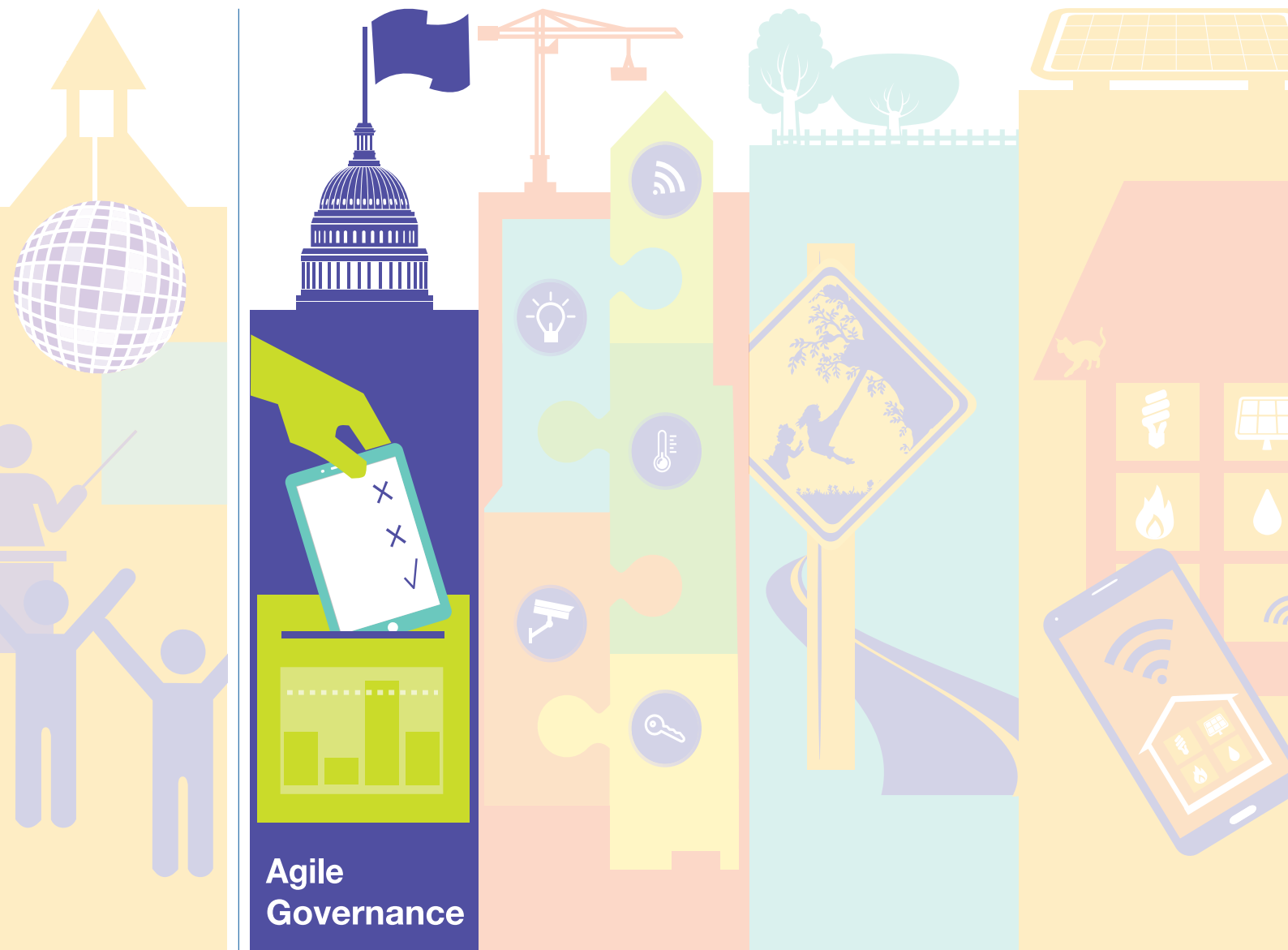




Source: Strelka Institute, Moscow



Source: Strelka Institute, Moscow



Agile Governance

8

Agile governmental structures operate under a systems approach: silos are broken, constant transformation is part of the culture, and innovation is continuous and pervasive. They exhibit distributed bottom-up leadership, transparent service delivery, permanent stakeholder engagement, open data sharing mechanisms, lean budgeting and speedy procurement processes. They build their foundations organically on an evolution plan (instead of a strategic plan) in which public policies are constantly designed, prototyped and tested to address citizen needs.

Agile governance involves cross-entity common platforms and initiatives to encourage multistakeholder cooperation and collaboration. It enhances citizen satisfaction by optimizing city experience and related services delivery, across administrative boundaries where needed, and using regulatory interventions and Fourth Industrial Revolution technologies.

Best practices (city scale)

To promote agile governance, cities can:

- Leverage multistakeholder platforms to design and implement enhanced city experiences.
- Promote cross-entity and bottom-up innovation for optimal use of city capital.
- Formulate policies and regulations on disruptive emerging technologies and flexible use of city resources (e.g. lean budgeting, staged procurement allowing prototyping).

Agile Guidelines

Physical	Multistakeholder engagement Encourages cross-entity multistakeholder, bottom-up participation and engagement in urban innovation	Lean and agile procurement and financing Supports flexible budgeting and procurement such as prototyping, multi-stage success-based procurement, public-private partnerships, etc.	Policy and regulatory environment Supports the formulation of regulations and policies for the use of disruptive and emerging 4IR technologies for urban innovation through a multi-stakeholder consultative approach
Digital	Number/percentage of crossentity digital services Promotes breaking silos across boundaries of different administrative departments	Use of 4IR in city services design Supports urban innovation through 4IR technologies, e.g. percentage of services incorporating 4IR technologies	Satisfaction of city digital services Supports customer-centric urban services design, encourages customer feedback and engagement during services design
Environmental	City resources efficiency Savings in energy and water use	Air quality Includes particulate matter, EMF, noise and reducing GHG emissions	



Case studies

E-voting, Moscow, Russia

On the Active Citizen app and website (<http://ag.mos.ru>), authorities in Moscow can interact with citizens before making decisions on urban development issues such as renovation programmes. More than 1.5 million citizens – nearly 20% of all Muscovites with voting rights – are registered on the portal, and about 5,000 more join every week. Four-fifths are aged 18-44. Since the platform launched, more than 2,500 issues have been put to the vote – about half have since been decided – and 65 million opinions have been received. City-wide issues tend to draw over 200,000 opinions, and district-level issues around 20,000 opinions. Participants can see how the vote is going, with updates every 10 minutes, and they can see how votes differ according to participants' profile information or when they cast their vote.

Climate adaptation, Denmark

In an effort to make Denmark climate-proof through improved regulation and plans on managing water and floods, the government chose an open approach with broad stakeholder involvement. By applying a snowball model for consulting stakeholders, where each group of interviewees was asked to recommend further contacts, the Ministry of Environment connected with more than 200 diverse stakeholders, including industry, insurance companies, nature conservation organizations, homeowners, designers, engineers and municipalities. Participants were invited to a series of workshops to collaborate on a climate adaptation strategy and share their opinion on what is most pressing. The approach allowed the government to test new ideas and benefit from the variety of different knowledge among the stakeholders. Apart from generating more robust and well-considered solutions, the approach enabled the government to move the different stakeholders in the same direction, establishing a positive consensus on difficult questions, such as financing activities through water fees levied on homeowners. After the involvement, several of the stakeholders took responsibility for moving things forward in their own area hence increasing overall involvement in making Denmark climate proof.

Meu Rio, Rio de Janeiro, Brazil

Meu Rio aims to create a new culture of political participation by mobilizing Rio de Janeiro's younger citizens, going beyond voting in elections to sustained civic engagement. The movement has drawn over 200,000 registered members, who can use its website to keep up with issues in the city and launch campaigns to put pressure on decision-makers, business people and public administrators. It has been able to successfully challenge some decisions that had been made without input from the city's residents.

Happiness, Dubai, UAE

Dubai's vision to become the "happiest city on earth" is being realized by enhancing city experiences for residents and visitors alike. One important factor in delivering on the vision is putting in place a mechanism for harnessing Fourth Industrial Revolution technologies, such as AI, blockchain and advanced analytics, to improve city services. Through the Smart Dubai Office, more than 30 government entities and select private sector organizations are designing digital services to optimize city experiences. These are meant to overcome current silos through citizen participation as well as by applying prototyping and lean design thinking toward innovations such as flexible budgeting.

Conclusion

Across the world, very different cities are facing the same question: how to harness the opportunities and best prepare themselves for the Fourth Industrial Revolution? As each city seeks its own answers, the examples gathered in these pages are intended to provide inspiration, while the metrics and guidelines offer a structure for discussion. The World Economic Forum's Centre for Innovation and Entrepreneurship will continue to support cities in meeting this pressing challenge and encourage the sharing of lessons and ideas as they emerge.

Acknowledgements

Global Future Council on Cities and Urbanization

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Toshiko Mori, Robert P. Hubbard Professor in the Practice of Architecture, Harvard University Graduate School of Design

Robert Muggah, Research Director, Igarapé Institute

Juan Jose Pocatererra, Co-Founder, ViKua

Mauricio Rodas, Mayor of Quito

Jens Martin Skibsted, Founding Partner, Skibsted Ideation A/S

Harry Verhaar, Head of Global Public & Government Affairs, Philips Lighting

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Endnotes

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