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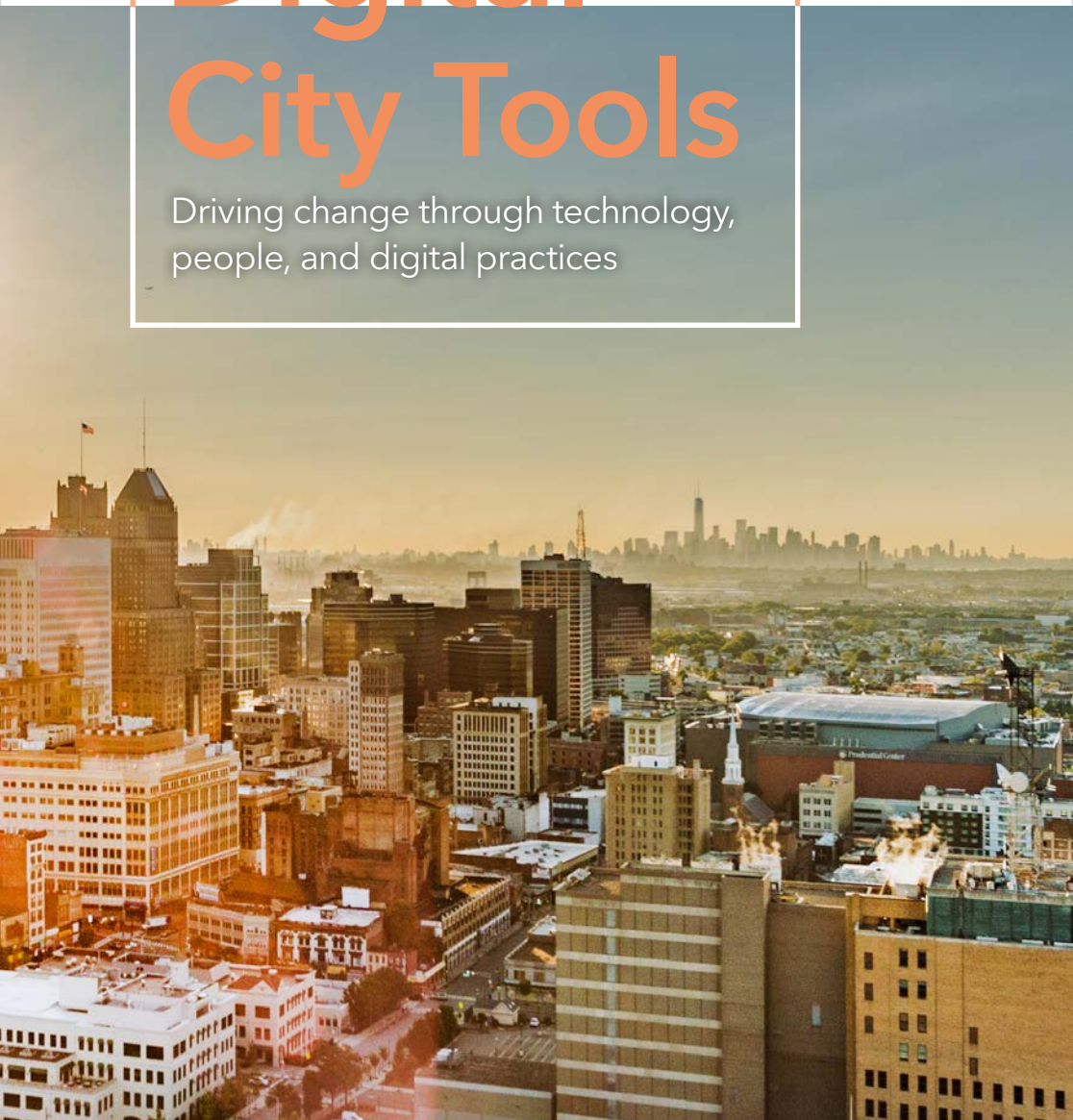
Bloomberg Associates

Digital City Tools

Driving change through technology, people, and digital practices



About Bloomberg Associates

Bloomberg Associates is an international consulting service founded by Michael R. Bloomberg as a philanthropic venture and is dedicated to supporting city governments to improve the quality of life of their citizens. Digital City Tools was created by the Media and Digital Strategies practice at Bloomberg Associates, which equips city governments with the skills and knowledge they need to be successful in applying digital approaches and tools.

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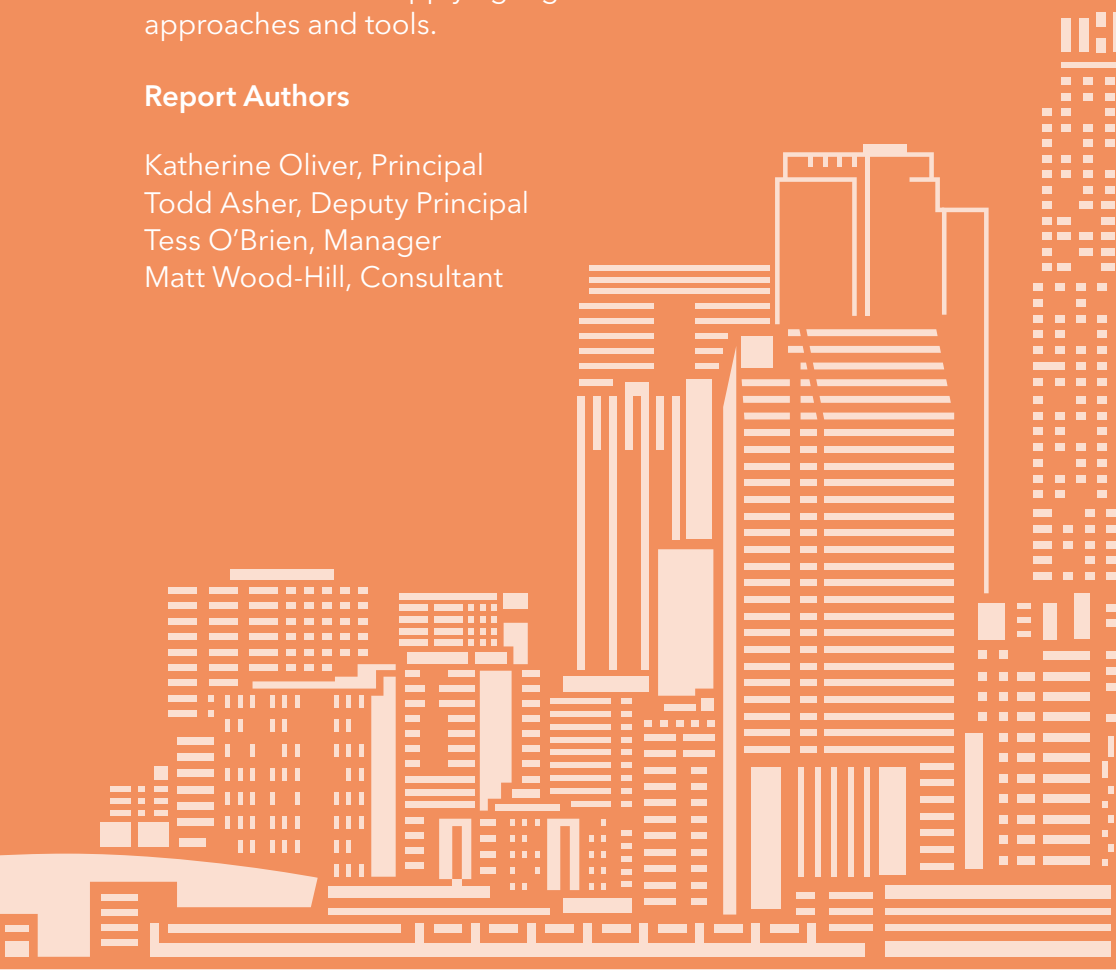

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Foreword

Katherine Oliver
Principal, Bloomberg Associates

We believe global cities can learn from each other. Bloomberg Associates created the first Digital City Tools guide to facilitate peer-to-peer learning and to showcase the innovative ways city governments around the world are using technology to engage with residents and visitors.

In this second edition of Digital City Tools, we have shifted our focus to the technologies that are enabling city services to be delivered more effectively. The goal of cities broadly remains the same – to provide better services and a higher quality of life for residents – but advancements in technology are enabling municipalities to be nimbler and more responsive to needs.

Cities are tapping into the collective knowledge of their residents to create solutions to some of the toughest urban challenges. They are putting data in the hands of their residents to drive better decision-making. They have adopted platform approaches that empower constituents to use technology to reimagine core city operations.

Our new report includes a survey of 30 leading digital cities, representing every continent, and is supported by in-depth interviews with digital leaders in each of those cities. Leveraging these interviews and additional research,

we compiled a series of case studies that highlight particularly innovative approaches city governments have implemented. We hope these innovative solutions will serve as models for others.

As we were conducting this research, the world changed. The COVID-19 pandemic altered every aspect of urban life. In response, digital leaders in cities around the world quickly used technology and data to track and mitigate the impact of the crisis. As we shifted to remote work our reliance on technology escalated and facilitated the delivery of essential services. The need for data collection, data sharing, and distribution became a very important part of those essential city services.

While resources and the level of digital preparedness varied widely from city to city, each city's response to COVID-19 crystallized the importance of leadership, digital approaches, and the use of technology. As a direct result of the pandemic, municipal governments have found faster, simpler, and less expensive ways to operate and, when the pandemic is over, they will not return to business as usual. Many have reinvented themselves, reimagining how they work in order to better serve their residents, businesses, and visitors.

This approach resonates with the work of Bloomberg Associates, a pro bono consultancy that works in cities around the world and reflects the aspirations of Michael R. Bloomberg, founder of Bloomberg LP, and Bloomberg Philanthropies, and three-term mayor of New York City. In our work, we see cities embracing technology to transform their public services and tackle complex challenges every day. Now more than ever, we realize the use of technology is a critical component in city government's day-to-day operations and necessary in order to provide efficiencies, transparencies, and platforms for expression.

Thank you to all those who contributed to the Digital City Tools report. We hope this report unifies digital leaders across city governments and supports your transformational work by sharing lessons learned as well as best practices for times of crisis and everyday life. We look forward to expanding our reach and learning more from city government digital leaders and innovators around the world.

Katherine Oliver
Principal, Bloomberg Associates

Executive Summary

Building a city government that is fit for the future requires experimentation with new and emerging technologies, constant iteration and improvement of services, and engagement with residents. But a technology-driven approach is not enough. In order to meaningfully understand the needs of residents and spearhead comprehensive change, city governments must also embrace new ways of working, shift processes and governance, and adopt a collaborative culture.

The 2020 edition of Bloomberg Associates' Digital City Tools showcases the innovative ways in which 30 leading city governments around the world are embracing technology and transforming the culture of their organizations.

Through a detailed survey and in-depth interviews with municipal digital leaders, we:

- Mapped each participating city's deployment of 41 technologies across five thematic areas: **connectivity**, **data**, **city operations**, **transport and mobility**, and **safety and security**
- Conducted an analysis of key technology trends and looked at how these technologies are applied to specific city challenges and priorities
- Created a City Snapshot of each participating city that captures its leading digital initiatives and digital leadership roles
- Showcased leading-edge work through six detailed case studies featuring the cities of: **Helsinki**, **San Francisco**, **Seoul**, **Tallinn**, **Tel Aviv** and **The Hague**

The COVID-19 pandemic escalated during the course of our research. We decided to broaden our research framework to understand how city governments are adapting to new demands brought about by COVID-19. These insights are shared throughout the report.

Participating city governments represent a broad geographical sample of cities with a reputation for being leaders in digital governance or stated ambitions to be. The cities selected include a mix of different-sized cities, varying population densities, high-income and low-income locations, as well as a diverse range of city government structures.

Through this research, our intention is not to identify the world's leading digital city but to show the full sweep of activity under way around the globe. In doing so, we hope to spark knowledge sharing and collaboration around common goals or approaches across cities, and to inspire digital leaders in city government.

The research has highlighted six points that recurred in our conversations with city digital leaders:

- ***The pandemic has shone a light on the need to develop comprehensive "digital resilience."***
  During the COVID-19 pandemic, technology has enabled workforces to operate remotely, crucial city services to continue to function, and data analytics to inform the critical decisions of city leaders around the world. The strength of city governments' existing digital foundations – such as digital and data infrastructure – has had a significant bearing on their ability to successfully transition to remote operations during the crisis. These foundations are an essential pillar for overall city resilience and the continued well-being of citizens during times of crisis.

- ***City Leadership supports digital, but often does not understand it.***
  Two-thirds of participants feel their city leaders view technology as important to citywide transformation. While there is a general consensus regarding the importance of technology, digital leaders often reported feeling under-resourced. Moreover, there is less widespread understanding regarding how to apply digital approaches and what it takes to do this successfully. City leadership will need to invest time and resources to identify how technology and digital approaches can best support the needs of their city and further develop staff capability to turn plans into action.

- ***Digital is much more than technology, but municipal structures often don't reflect this.***
  Digital roles in municipal governments are growing as city governments realize the need for strategic direction regarding how technology and new ways of working can transform their organization along with its' operations and services. However, in some cities the agenda is not clearly differentiated from traditional IT teams and projects. Without determined and unambiguous leadership, efforts to mainstream new approaches may be viewed with apathy or suspicion across the wider organization.

- ***Incremental steps reap big rewards.***
  While all cities strive to digitize their services and operations, cities vary widely in their approach and progress toward making this goal a reality. Certain cities pursue aggressive top-down transformation mandates, but the most successful cities – referred to in several of our case studies – have fostered a digital culture and embedded digital tools into their operations over a number of years.

Leading examples of digital initiatives have collaboration at their core, and partnerships between digital teams and other city departments and external stakeholders are the norm. Often, rigid organizational structures and change-resistant cultures pose major barriers to fostering a digital culture effectively.

- *Cities have more experience with connectivity technologies than other types of technology, but are cautious about the benefits of 5G.*
  City governments have focused heavily on connecting their residents and public assets to the internet, placing more emphasis on this than digital tools to support data services, city operations, transport and mobility, and safety and security. Next-generation communication technologies like 5G will play an important role in cities over the next decade, but for now most cities are keeping their feet on the ground and taking a "wait and see" approach.

- *Data-driven decision-making is still a goal and not a common reality.*
  Despite the importance given to data tools, which include advanced data analytics and artificial intelligence (AI), few cities have the right data infrastructure, standards, and approaches to data sharing in place to take full advantage of these tools.

Lessons for City Leaders

Invest in your city's digital resilience.
Digital technology must be understood as a foundation of city resilience. Vital services should be accessible and manageable remotely, simple processes should be automated to reduce dependence on human intervention, and city data should be integrated so the right information can be found in haste during an emergency.

Collaboration is key to addressing citywide challenges.
Don't embark on an ambitious technology deployment or transformation before you have spent time engaging with your residents and the network of partners and collaborators who will help launch the new approach.

People make technology work, not the other way around.
The pandemic is just the beginning of the journey toward truly embracing the power of digital technology in public services. But working culture still needs to catch up; investment will be needed in organizational processes, staff, and digital skills programs for residents.

Make incremental steps toward digital transformation.
Small steps, shared narratives on the role of technology, and investment in digital foundations such as data standards and infrastructure lay the groundwork for future successes.

Overview

The 2020 edition of Bloomberg Associates' Digital City Tools takes a broad view of technology in cities by placing an emphasis on city operations and services.

Over the course of six months, Bloomberg Associates' Media and Digital Strategies team has engaged with digital leaders from 30 cities around the world. Participants in the research come from the main local government organization responsible for citywide governance. The structure and role of these organizations vary from country to country, and so there is variability between the sizes and the responsibilities of different city governments.

In Bogotá, for example, the municipality is responsible for the delivery of many services including education, transport, policing, and health care. In most other cities it is uncommon for the city government to directly manage all of these services, which are often the responsibility of regional administrations or separate public or private entities.

In cities such as Bratislava and London the main city government adopts a strategic role, with the delivery of everyday services managed at the individual district or borough level.

Approach

City representatives completed an online survey concerning their key city challenges, digital leadership and technology deployments. Participants were presented with 41 tools commonly used in smart cities and digital government and asked to report how much experience they have in deploying them in their city. The tools were grouped into five broad technology themes: connectivity, data, city operations, transport and mobility, and safety and security.[1]

Detailed interviews with all participants followed to clarify findings and gather further insights into leadership structures and the links between digital initiatives and city challenges in 29 of the cities. The City Snapshots, found on page 92, summarize these conversations.

Further interviews were carried out with six cities currently using innovative approaches to tackle major challenges. Detailed case studies have been written about these cities.

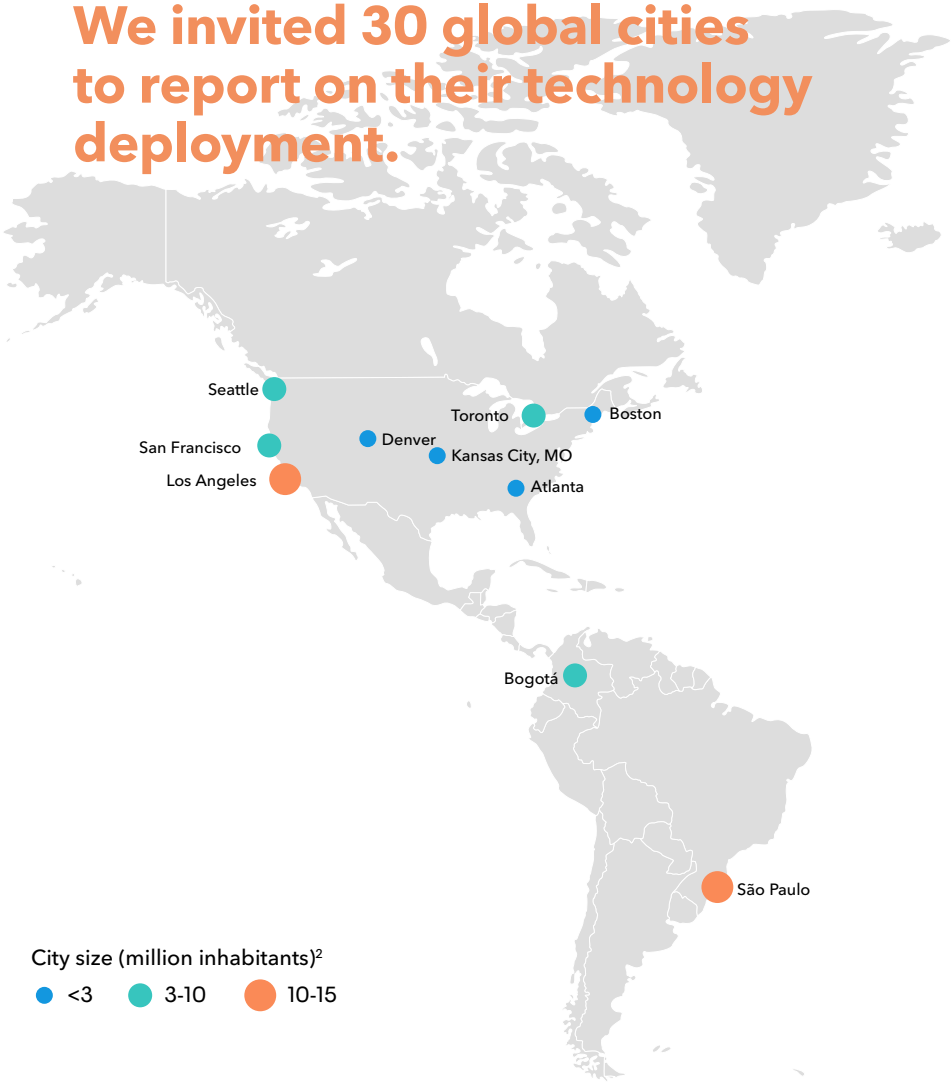
As a metric, the deployment of a tool or technology is not intended to be a judgment on digital maturity nor the success of technology projects. Rather it indicates the level of attention given to tools in different technology areas over the last five years or more. "Attention" may be linked to key city needs, political imperatives or major investments. But in the spirit of mutual learning, it is best viewed as a signifier of which cities have been most active in different technology areas and therefore could have the most to share about their successes, challenges, and failures.

[1]The list of digital tools was compiled following an extensive literature review of international reports and digital strategies from several cities. The results are self-reported. Specific technologies are described in the glossary of technologies beginning on page 154.

"**New and emerging technologies will be fundamental in meeting the increased need to deliver services safer, faster, and more equitably as cities grapple with declining revenues and workforces.** At the same time, we know that many of our residents are already overwhelmed with the rapidity of change in our daily lives, meaning we will need to focus as much or more on building trust in our communities as on the technical side of change – every new digital interaction is an opportunity to demonstrate technology's value to the budget bottom line and a place to work together with our residents to improve quality of life."

Miguel Sangalang,
Deputy Mayor for Budget & Innovation,
City of Los Angeles

We invited 30 global cities to report on their technology deployment.



	Population	City government workforce size
Amsterdam, Netherlands	1,139,606	15,000
Atlanta, USA	506,811	8,612
Barcelona, Spain	1,628,412	15,000
Bogotá, Colombia	8,363,671	140,000
Boston, USA	692,600	22,000
Bratislava, Slovakia	432,500	700
Cape Town, South Africa	3,859,500	26,225
Copenhagen, Denmark	632,340	40,000
Denver, USA	727,211	14,000
Dublin, Ireland	1,214,700	5,900
Ghent, Belgium	260,341	5,000
Glasgow, UK	692,600	19,000
The Hague, The Netherlands	546,335	10,000
Helsinki, Finland	655,395	37,000

[2] Municipal populations recorded per latest local or national census data and City government workforce sizes reported by research participants directly, or taken from municipal websites.

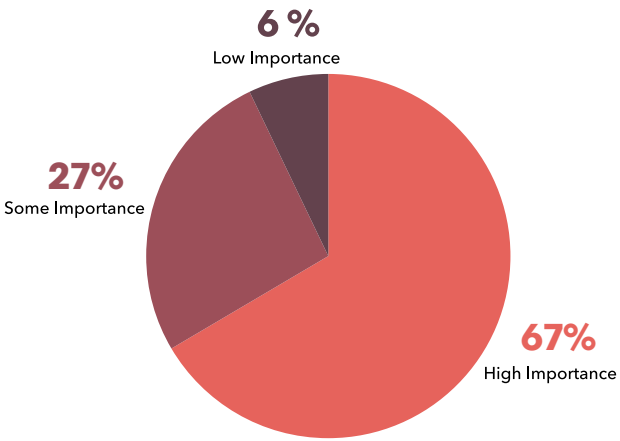
Kansas City, MO, USA	495,327	4,400
Kobe, Japan	1,537,272	21,185
Los Angeles, USA	3,979,576	50,000
Melbourne, Australia	178,955	1,700
Milan, Italy	1,686,013	14,374
Paris, France	2,148,271	52,000
Pune, India	6,501,957	15,000

San Francisco, USA	881,549	50,000
São Paolo, Brazil	12,252,023	120,000
Seattle, USA	753,765	13,615
Seoul, South Korea	10,013,781	10,356
Sydney, Australia	246,343	2,000
Tallinn, Estonia	444,970	14,000
Tel Aviv, Israel	451,520	12,000
Toronto, Canada	2,956,024	30,000

Digital Leadership in City Government

> **"There has to be a clear mandate from the very top to align all the government agencies."**
>
> **Tom Gao,**
> City of Sydney

Figure 1. City leaders' perceived attitudes toward technology's role in citywide transformation

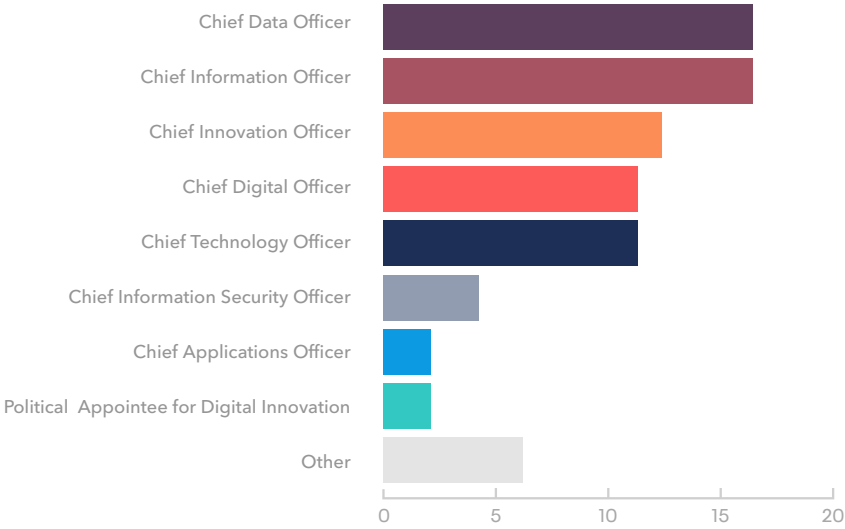


An awareness of the empowering role that technology can play in citywide transformation is an asset for city leaders. In two-thirds of the cities surveyed, respondents believe that their leadership teams appreciate the transformative potential of digital technology. Just two respondents feel their leadership gives low importance, and no one has suggested that no importance is given.

This appreciation is reflected in the different types of digital leadership roles in city government, which are expanding. In total, the 30 cities surveyed highlighted 82 separate roles – an average of 2.7 per organization. U.S. cities notably have more dedicated digital leadership roles than others, with an average of four per organization.

The Chief Information Officer (CIO) remains the most common digital leadership role across city governments. CIOs tend to lead the directorship of technology departments or have an operational

Figure 2. Digital leadership roles in city government among participating cities



responsibility for technology infrastructure and systems, although this latter role is often fulfilled by a Chief Technology Officer (CTO). Chief Officers for Applications and Information Security manage parts of the CIO portfolio.

Many cities have appointed a Chief Data Officer or are planning to in the near future. As the joint most common role, the scope continues to expand from data control and management to the strategic use of data and analytics.

Chief Innovation Officers are another large group. Typically, this role leads internal transformation programs and initiatives to address city challenges. The Chief Digital Officer (CDO) role has grown in recent years, although responsibilities vary. Helsinki's CDO directs citywide IT strategy and operations; in Boston the CDO is responsible for the municipal website and communications, while London's CDO develops citywide policies and drives cross-agency digital collaboration. The Chief Digital Services Officer for San Francisco has an exclusive service focus.

The research has identified at least two cities in which the digital leader is a political appointee, hinting at the importance attached to digital technology and innovation mandates in some city governments. Other roles, not specified in the chart, include Chief Marketing Officer, Head of Transformation, and policy roles such as Technology Advisors to the Mayor.

Common City Challenges

"It's about 'What does this mean for us?' rather than putting in new tech for the sake of it," says Bart Rosseau, Chief Data Officer for the City of Ghent in Belgium. His view is mirrored by digital leaders in city government around the world, for whom technology deployment and the design of services depend on first understanding the needs of residents and other users.

The priorities of cities surveyed in this research, represented in Figure 3, frequently revolve around extraordinary challenges that cannot be solved by a single intervention or agency. All require time, vision, leadership, and collective endeavor. The COVID-19 pandemic is prompting city leaders to reassess their core priorities and revisit decade-long strategic plans as they plant the seeds of recovery.

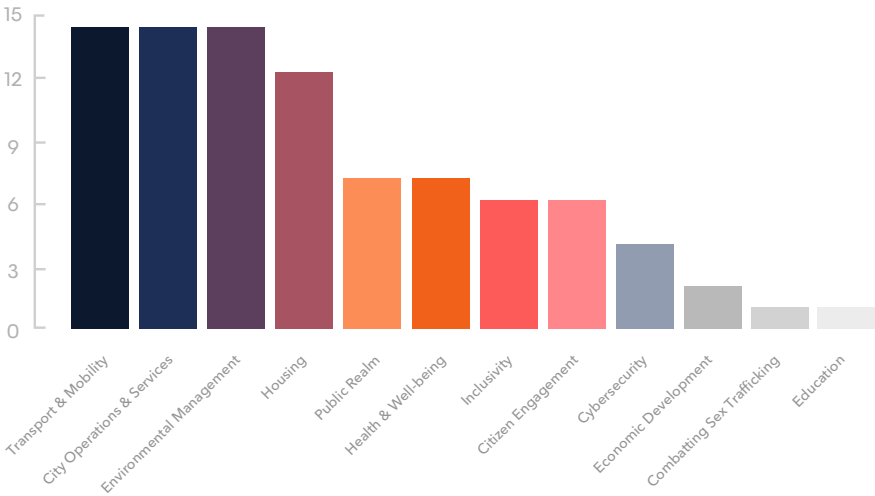
The contribution of digital technologies and data-driven approaches to city operations, service delivery, and policy making has yet to become truly mainstream in city government. These approaches offer a viable, and perhaps necessary, means of continuing to address many long-standing urban issues during this time of global uncertainty. Cities are not starting from scratch. Municipal digital teams are already focusing their efforts on the most pressing challenges in their cities.

Long-Term Priorities

Transport and mobility

City governments are seeking to reduce traffic congestion, particularly in inner city areas and main arterial roads, and to improve public transport and alternative transportation options. The most common motivations are to reduce pollution and carbon emissions, to improve road safety and to provide more equitable mobility services.

Figure 3: Priority city challenges for digital teams in city government



The COVID-19 pandemic has radically altered how most people go about their daily lives. In cities, the impact on people's movement has been profound, with fewer able to journey to their usual place of work. Even as restrictions ease, public transport is not a conducive environment to the social distancing required to prevent the spread of the virus. Changes in travel habits may yet become permanent, which could offer an opportunity to think differently about urban mobility. Cities such as Bogotá, London, and Paris are giving streets over to cyclists and pedestrians to support safer travel and improve air quality as they navigate their way out of the crisis.

City operations and services

Almost half of the participants interviewed are working on challenges related to city operations and services. These include developing quality digital services for residents, improving back-office operations, and applying data-driven approaches to policy making. The steady growth of urban populations in recent decades has caused city administrations to pursue more efficient, accurate, transparent, and cost-effective ways of serving their residents. Meanwhile reliable, accurate, and timely data form the evidence base needed to inform key decisions.

The pandemic has brought existing challenges into sharp relief. Residents cannot attend in-person appointments and cannot always depend on telephone calls; they need to be able to access services online. Fulfilling resident requests still relies heavily on manual processing, but when municipal staff cannot work due to illness the resilience of services is undermined. Data, meanwhile, is being meaningfully used to inform crisis response and recovery, but the lack of available, accessible, and standardized data prevents data-driven approaches from reaching their potential.

Environmental Management

Climate change, sustainability, flood management, and air quality are major challenges in the built environment. Cities have clear goals to reduce their carbon footprint and increase their resilience to climate change in the decades ahead. More immediately, there is a consistent emphasis on improving the health and well-being of people across society.

The dramatic decrease in movement of people and goods due to the pandemic may have seen short-term improvements in air quality, for example, but environmental challenges will persist. Many cities will use the crisis to build their resilience to better prepare for these future threats. Milan saw the pandemic as a historic moment for the city to change course. Instead of "returning to normal," the City launched Milan 2020, a strategic plan to reopen and fast-track the ambitious sustainability goals already outlined in the City's 2030 Masterplan.[3] As of May 2020,

"**One impact of the pandemic is that you can't view critical city services from administration to transport, schools, or supporting vulnerable citizens without a digital lens.** Where before IT might have been seen by some as 'back-office' online access, using data and designing new services are shown as integral to what cities do."

Theo Blackwell,
Chief Digital Officer,
Greater London Authority

greater priority has been given to cyclists and pedestrians through temporary road configurations. This is all part of the bold Open Streets Plan, which aims to reduce car use and reallocate street space from cars to facilitate social distancing and more environmentally-friendly transport options.

Housing

Many cities face acute housing shortages brought about by urban growth and housing supply deficits. Efforts are being made by municipal housing teams to increase the number of affordable units in the city and, in collaboration with digital teams, to make them accessible to the residents who need them.

Identifying vulnerable people and offering direct support or connecting them to civil society organizations is another top priority in the battle against homelessness.

Seattle's Navigation Team uses technology to help unsheltered people to access existing services and find available beds in homeless shelters, for example.[4] These safety nets can be lifelines for vulnerable residents. The demands on services will increase if an economic downturn follows the pandemic, as predicted.[5]

[3] Comune di Milano (N.D.), Milano 2020, www.comune.milano.it/aree-tematiche/partecipazione/milano-2020 [accessed August 3, 2020].

[4] City of Seattle (N.D.), Innovation Advisory Council: NavApp 2.0 www.seattle.gov/innovation-advisory-council/projects/nav-team-20 [accessed August 3, 2020].

[5] Kose, A. & Sugawara, N. (2020), Understanding the depth of the 2020 global recession in 5 charts, World Bank Data Blog. blogs.worldbank.org/opendata/understanding-depth-2020-global-recession-5-charts [accessed August 3, 2020].

Public safety and the public realm

Solving major challenges in the public realm through effective urban planning and the management of public space can lead to better public safety outcomes, such as reducing criminal activity and improving road safety. City governments are using a wide range of technologies to advance their public safety goals. These include advanced cameras, video analytics, and tracking tools, which are changing policing practices and helping address issues emerging as a result of COVID-19.

For example, the growing adoption of body cams by the police force is allowing for more transparent interactions in law enforcement, and some cities are using video and GPS tracking to monitor people's movement and compliance with social distancing guidance, such as in São Paulo. Personal data can be important to the success of these tools and may leave residents with choices to make in the future. Do they want direct control over how their data is used, or are they content to trade privacy in exchange for fewer restrictions of movement?

Cyber risk

Cybersecurity is a long-established challenge for municipal digital teams, where protecting sensitive public information and residents' personal data is vital to maintaining trust in government. The pandemic raises more cybersecurity questions than ever before. Changing work patterns, for instance, require that many people use their own personal devices when working from home out of preference or necessity. Municipal information systems are more vulnerable to cyber attack through household internet connections, even when staff join the network via a secure VPN.[6] The sudden increase in digital activity has left some organizations playing catch-up. The combination of new users experimenting with new technologies has already had dire consequences, such as the hijacking of video calls when effective security protocols have been absent.

Health and well-being

Health services are not directly managed by many cities, which may be why health and well-being challenges are superseded by others, as seen in Figure 3. However, city governments are vital contributors to the public health of their cities since they encourage residents to live healthier lifestyles, improve their quality of life, and reduce longer-term health risks through city services, urban design, and support programs. This has come into sharp focus during the pandemic and will receive significant emphasis moving forward.

[6] Jordan, A. & Olson, R. (2020), How to protect yourself from cyberattacks when working from home during COVID-19, World Economic Forum, www.weforum.org/agenda/2020/03/covid-19-cyberattacks-working-from-home/ [accessed August 3, 2020].

For municipalities involved in primary health care services, the shift to virtual health care was already under way before the pandemic. It has now become mainstream and is probably here to stay.[7] Some cities have pivoted resources to support mental health and loneliness as residents adjust to a new reality and major life changes. Research suggests that residents with a lower quality of life due to socioeconomic factors, often people from Black and minority ethnic groups (BAME) and the elderly, are being disproportionately impacted by the virus. Health and well-being objectives are likely to be even more closely tied to social inclusion in the future.[8] Our case study from the City of Helsinki explores how proactive approaches to health care and city services can improve the long-term well-being of residents.

Inclusivity

Addressing social inequality and poverty is an established priority in many cities already; six respondents cited inclusivity as a main focus of their digital work. In the wake of global protests and the disproportionate impact of the pandemic on minority groups, mayors and city leaders may use this moment in time as a stimulus for greater social equality. Digital leaders will need to think about how digital processes and technology will contribute to these goals. For instance, strengthening digital foundations – connectivity, equity, skills – that have in many cases overlooked some under-resourced communities, will be imperative to success. City governments, whose influence embraces more than half of the global population, are among the best-placed institutions to catalyze this at a scale.

[7] Jordan, K.T. (2020), An unexpected benefit of the pandemic: The doctor will virtually see you now, www.washingtonpost.com/outlook/2020/04/14/telemedicine-virtual-health-coronavirus/ [accessed August 3, 2020].

[8] World Health Organization Regional Office for Europe (2015), Health 2020: Social protection and health https://www.euro.who.int/__data/assets/pdf_file/0019/324631/Health-2020-Social-protection-and-health-en.pdf?ua=1 [accessed August 3, 2020].

City Challenges During COVID-19

Strategies to tackle these long-standing challenges have, in many cases, been put on hold due to the pandemic. City governments are on the front line of the COVID-19 response, and pathways out of the crisis will dominate their work in the months, and possibly years, ahead. As providers of essential services for residents and as connectors of people and organizations at a time of acute need, rarely has their role felt so pronounced. The role of digital leaders and their teams is changing, too, as they play a significant part in meeting the immediate needs of the city during these times.

Community support and engagement

City governments are the first port of call for residents requiring non-medical support. Virtual hubs, usually accessed via municipal websites, provide residents with health advice, updates on social restrictions, and access to support channels. Some cities have coordinated food and medicine drops for vulnerable residents, others a connecting role between people in need and civil society organizations and volunteers able to provide support. Data and digital tools have been deployed to facilitate these requests at speed and scale.

City services

Cities that implemented lockdowns continued to deliver critical services, such as trash collection and public transport. Where essential work has carried on, city governments are working closely with their staff and partner agencies to establish guidelines so that this work can be undertaken safely. Across all cities, digital services are ensuring that whatever can be done online is being done online.

Remote working

Major shifts in working culture are seeing municipal staff use new and existing tools to effectively work with their colleagues online, often for the first time. Teething problems such as equipment availability, resolving VPN licenses, and bandwidth issues mean the transition has not always been seamless. In many cities, political processes also moved online, which has been a procedural challenge as much as a technological one.

Local democracy

City councils have rapidly enacted legislative changes and made key decisions to facilitate the crisis response. Often unable to meet in person, some have been taking committee and council meetings online for the first time. Municipal IT teams have played an essential role in helping to implement the right tools and processes for sharing sensitive information, voting, and authenticating decisions.

Education

Schools may be closed in many cities, but teaching resources are being made available digitally. This works where internet penetration and laptop ownership are both high, but it works less well elsewhere. Some municipalities decided to distribute laptops to pupils from low-income households so they can continue their learning from home.

Current shifts, long-term implications: four ways city operations are changing due to the pandemic

City budgets have been devastated by the pandemic.

Many cities face difficult trade-offs in determining how to allocate scarce resources. Any work deemed non-essential is likely to stop if it hasn't already, and major investment programs will be reviewed in light of their contribution to the post-pandemic vision of each city. Budget shortfalls are particularly acute in cities across the U.S., which largely rely on property and sales taxes. In June, the U.S. Bureau of Labor Statistics reported that local and state governments had already laid off 1.5 million government workers as a result of COVID-19-related budget challenges.

Restarting local economies is a major focus of cities.

Local and state governments will continue to face significant challenges as they balance public health measures and economic considerations for their residents. Most cities are implementing a phased approach to reopening their economies. Restrictions are lifted step-by-step for different industries, depending on how essential they are, the level of risk they present for spreading the virus, and their economic condition. However, cities must be ready to quickly scale back reopening measures in the event of resurgence and future waves of the pandemic.

Increased focus and investment in digital infrastructure and services.

In spite of budget concerns, the pandemic crystallized the importance of digital municipal services to enable uninterrupted operations in times of crisis and revealed which cities' digital infrastructure were not prepared to deal with a challenge of this scale. Outside of City Hall, the pandemic placed huge demand on broadband infrastructure around the globe as daily life moved online. Moving forward, cities will allocate greater resources to their technology stack, and cities without universal broadband coverage will reexamine how to scale internet access to all residents.

Public health concerns drive management of public spaces and transit.

The pandemic has fostered a renewed appreciation of public spaces and transit as essential city infrastructure, and how cities manage this infrastructure has taken on a new meaning. Some cities are making changes to their built environments, including Paris, Milan, and London, all of which have fast-tracked the transformation of their streets to enable more people to walk and bike safely. Data analytics and digital tools such as video analytics and location data are helping city governments to better understand people's behavior in the public realm and to monitor the effectiveness of policies and guidance such as social distancing.

> **"Anything that is not absolutely important we will not do."**
>
> **Mayor Matúš Vallo** of the city of Bratislava in Slovakia comments on a 10 percent shortfall in the municipal budget as a consequence of COVID-19.[9]

[9] As reported by the SITA Slovak New Agency, cited in the Slovak Spectator (May 2020), Greenery and repair of roads remain priorities in corona-affected Bratislava, https://spectator.sme.sk/c/22411331/greenery-and-repair-of-roads-remain-priorities-in-corona-affected-bratislava.html [accessed August 3, 2020].

Case Studies

Tallinn

Years of investment in public technology keep city operations resilient in the face of a public health emergency

Overview

How would a mature digital society cope with a crisis like the COVID-19 pandemic? The City of Tallinn in Estonia offers some clues. Leveraging the nation's advanced digital and data infrastructure, the city has responded to new challenges at pace, which has allowed city services and daily routines to continue relatively smoothly.

COVID-19 in Estonia

Despite its distance from European hotspots like the UK, Spain, and Northern Italy, Estonia has not escaped the spread of COVID-19, seeing significantly more deaths per capita than its Baltic neighbors Latvia and Lithuania. The mayor of Tallinn, Mihhail Kõlvart, has issued clear and strict guidance in response to the crisis, including the closure of recreation facilities and shopping malls to encourage social distancing. Early on, he announced that all city services must remain available for residents.

e-Estonia's digital backbone

In some contexts, such mayoral declarations might be met with uncertainty as crisis response takes over, but not in Tallinn. Estonia has achieved an international reputation as one of the world's foremost digital nations, primarily for its work in two key areas. First, every citizen has a national ID card linked to an e-identity that they use to access services and ratify transactions with their own legally binding digital signature. Second, information

systems from different organizations interoperate via X-Road, the national government's data exchange layer. Because data is federated, it can be securely shared between public agencies in seconds – but remains in the systems of the department that controls it.

The national infrastructure underpins city services, too, contributing to their resilience during a crisis. "The hard work that we have done over the last 25 years has really paid off," says City of Tallinn's CIO Martin Männil. Tallinn uses microservices: modular technology components that can be managed independently of the wider system. Männil reflects on the advantages of this approach, "It has allowed us to make changes in the information systems very quickly because they are not big monoliths."

Local democracy

This flexibility was evident as digital tools were used to support urgent democratic processes. In April 2020, Tallinn's city council voted to postpone rent collections by several months and to suspend the city advertisement tax. The first online city council meeting was held on April 16 using Microsoft Teams and was supported by existing legal systems. With no provision for voting in place, decisions had to be made by consensus.

By the time the city council next met, on April 30, a new system for e-voting had been developed by the municipal IT department and a partner organization. Councilors logged into the system using their national ID card and cast a time-stamped vote. Männil reflects on the quick turnaround, "We managed to do it because of our existing cornerstones of our estate and existing workflow management systems. Without it, it would not have been possible. You can't just create it from scratch."

e-Services in Tallinn

Tallinn's digital services – locally referred to as e-services – have continued to function close to normal, but not without disruption. Many services, even when digital and automated, still require some degree of human intervention. Committees need to meet to make certain decisions, though Männil is confident that the new e-voting system could soon change this, too, "The solution we created is not only for council meetings, but for all the meetings that require identification and voting capabilities."

Some e-services are now seeing significant use for the first time. Applications for funeral expenses, childbirth benefit, pension supplements, and child disability benefit were traditionally paper-based, with only 18 percent of applications made online in April 2019. One year later, however, 70 percent of applications were made online, which is causing service teams to update how they work to correspond with the changing behavior of residents.

Key factors in Tallinn's response

Five factors have been central to Tallinn's digital response to COVID-19:

1. Strong digital foundations facilitate interoperable data and systems, enabling residents to access all city services online.
2. Deliberate efforts to cultivate a digital society have encouraged a digitally literate population and a culture of innovation in both the public and private sectors.
3. Modular microservices allow the City of Tallinn to work with partners to nimbly update and build systems — free from dependencies on vendors.
4. Strong political leadership sets the tone for city operations from the start by supporting the city's digital services.
5. High levels of trust exist between residents and different levels of government.

Outcomes

Work continues, and while it may be too early to measure the benefits of Tallinn's digital first response, Männil anticipates that the influence of digital teams could grow. Before the pandemic, Tallinn's key challenges were social services, security, and spatial planning. Despite probable cuts to the city's operating budget, these priorities are not expected to change dramatically in the immediate future.

However, Männil sees a greater role for digital teams in city government going forward: "After the crisis [response], IT is in a stronger position than it was before to implement changes and drive a cultural shift."

Seoul

Encouraging new businesses by putting data analytics in the hands of residents

Overview

South Korea is an entrepreneurial country. Forty-three percent of businesses are micro-enterprises employing fewer than nine people, ranking fifth among OECD countries in this metric.[10] In the capital city of Seoul, however, life is tough for new businesses. The national Ministry of Startups and SMEs (MSS) reports that only 29 percent of new businesses survive beyond five years. But a new digital tool is putting powerful data analytics into the hands of would-be business owners so they can make smarter decisions.

Entrepreneurial but cautious

Research published by the Global Entrepreneurship Monitor (GEM) suggests that only 7 percent of South Koreans see good business opportunities in their country, and many are reluctant to start a business for fear it might fail. This is dramatically lower than for other countries featured in GEM's report, the next lowest being Switzerland, where around a quarter of people see good opportunities.[11]

The challenge at the city scale is stark, where 71 percent of businesses in Seoul do not survive past their first five years. The Seoul Metropolitan Government (SMG) fears the impact on urban life, driven at least in part by gentrification in some areas. Rents are increasing and competition from larger businesses is growing as they begin to diversify their products and services. These threaten self-employed people running existing small-scale local businesses and make it even more difficult for new businesses to establish themselves.

Big data demystifies risk

To support potential new businesses in their decision-making, the Seoul Metropolitan Government has developed *My Neighborhood Analysis*, a tool that makes an unprecedented amount of commercial information – using over 200 billion data points – available to residents. Developing the tool has been a collaborative effort between SMG's Fair Economics Division, Regeneration Policy Division, SME Support Division, and the Big Data Division that now manages it.

The tool combines key government data, such as business licensing records, property information, rental prices, and transportation card data, with datasets from Seoul's entire business ecosystem. All data is anonymized, and detailed business information is displayed as averages by month, industry, or area.

The SMG has worked closely with banks and credit card companies to gain insights into customer behavior to inform their own economic development strategies. Partnerships typically begin with a Memorandum of Understanding (MoU) for data sharing that often establishes an intention to undertake joint projects. A recent collaboration with Shinhan Bank has directly informed the historical data behind *My Neighborhood Analysis*: the bank analyzed credit card use between 2002 and 2018 to generate insights into the behavior and success of businesses launched by youth, the elderly, and women.

Tailored to the user's needs

My Neighborhood Analysis exists as a web and mobile app with a map-based visualization at its center. When a user enters information about their proposed business type, they are presented with an overview of business performance in the district they are exploring and given a traffic light rating to indicate the expected level of risk for a new business. Trends in sales activity and business performance can be seen over time by viewing data within a particular time frame. Users can even select comparable businesses to understand their historic performance.

The spatial information is analyzed and processed in ArcGIS from ESRI and uses a front-end solution provided by Carto. A chatbot supports users needing help or looking for specific information.

[10] Organisation for Economic Co-operation and Development (2018), OECD Economic Surveys: South Korea 2018, Chapter 2 Figure 2.3 [most recent data available], read.oecd-ilibrary.org/economics/oecd-economic-surveys-korea-2018/the-share-of-employment-in-smes-in-korea-is-the-highest-in-the-oecd_eco_surveys-kor-2018-graph62-en [accessed August 3, 2020].

[11] Global Entrepreneurship Monitor (2020), 2019/20 Global Report, p.31. www.gemconsortium.org/report/gem-2019-2020-global-report [accessed on August 3, 2020].

Outcomes

My Neighborhood Analysis is giving prospective businesses access to powerful big data analytics that were previously the preserve of large commercial operations. At the time of writing, the app's dashboard shows that 38 percent of new businesses in Seoul have been going for five years or more. On its own, the tool may not be enough to guarantee that every new business survives, but it allows SMG to observe small business dynamics in the city and to tailor their business support policies and initiatives appropriately.

The approach can be and is being used elsewhere: in 2017, a delegation from Seoul supported the Municipality of Buenos Aires in developing their own version. The SMG is harnessing data from other relevant sources and plans to introduce a 3D map visualization to the tool in the near future.

Helsinki

Toward citywide preventive health care services enabled by data

Overview

Pressure on health care services in Helsinki is intensifying. Three demographic trends—an ageing population, immigration, and a growing city—are expected to significantly impact the city in the coming decades. To alleviate the strain on Helsinki's health care services, the city is moving from a reactive to proactive model of health care, preventing ill health before it occurs.

The challenge of an ageing population

Estimates suggest that 10 percent of Finns – mostly elderly residents and patients with multiple health problems – generate 80 percent of the country's health and social care costs. In Helsinki, 16 percent of residents are over 70, but this number is projected to climb significantly over the next 50 years, when one-third of the Finnish population will be 70 or older.[12] Finland already experiences a shortage of qualified medical professionals, with many nursing vacancies unfilled as demand for medical services outweighs the capacity of the system.

Faced with significant challenges, the entire Finnish health care sector is fundamentally realigning its practices.

Much of this is happening at the city level, where primary health care services are shifting to a proactive approach based on data and digital tools. By strengthening analytical capabilities in primary health care, medical professionals will be able to identify and treat at-risk patients early on before costly specialist care is required.

[12] Statistics Finland (2019), Population Projection 2019, www.tilastokeskus.fi/til/vaenn/2019/index_en.html [accessed August 3, 2020].

Using data to identify care gaps

The City of Helsinki's Social Services and Healthcare Division is working with The Finnish Medical Society Duodecim to develop a Health Benefit Analysis (HBA).[13] The tool analyzes a patient's data and applies a set of rules – based on medical guidance – in order to recommend the appropriate actions and treatment. All data is pseudonymized and pulled from existing health records, giving medical professionals an overview of a patient's test results, previous diagnoses, medication history, and more, all without disclosing their identity.

The data is analyzed to highlight any "care gaps" that may exist where a patient is not receiving the treatment expected based on their health record. High-risk patients are prioritized based on need of intervention and invited to discuss their health issues with a doctor; the pseudonymized patient ID is used to identify them in the health record.

Moving to a citywide system for health data

Realizing the full potential of a diagnostic tool like the HBA requires all patient data to be accessible. Currently, relevant data in Finland is held both at the city and regional levels and separately for health and social services. Part of the data is also maintained by the private health care sector. The national Kanta health register aggregates both public and private health care data.

European General Data Protection Regulation (GDPR) sets strict rules for personal data use that are based on consent given by the patient. Sharing data between registry holders is not allowed without permission.

Enter Apotti: a common system for health and social care services in Greater Helsinki, developed in collaboration with six neighboring municipalities and the Helsinki University Hospital (HUS).[14] Apotti integrates both health and social care data into a single system so that it can be used by multiple health and social care agencies if permission is given by patients. Apotti makes available all the patient data from the same data source when both primary and specialist health care, and social care services, use the same patient information system starting 2021 in Helsinki.

"We should understand the person holistically – a 360° view of the person."

Mikko Rusama,
Chief Digital Officer,
City of Helsinki

[13] Duodecim (N.D.), EBMEDS® Health Benefit Analysis, www.ebmeds.org/en/products/products-for-professionals/ebmeds-health-benefit-analysis/ [accessed August 3, 2020].
[14] Apotti (N.D.), Apotti as a project, www.apotti.fi/en/what-is-apotti [accessed August 3, 2020].

An active pilot is exploring two use cases set by the City of Helsinki:

1. The identification of patients prescribed central nervous system drugs, e.g., antipsychotics, to ensure they have a dedicated doctor.
2. The optimization of medication for patients with high blood clotting risk to keep the TTR-value within the acceptable limits (over 80).

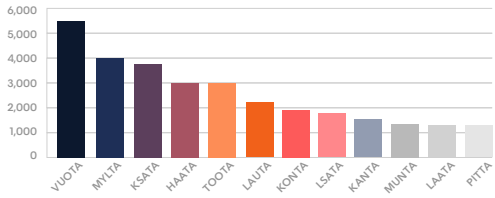


Figure 4: Number of patients using central nervous system drugs without a dedicated doctor at City health care centers

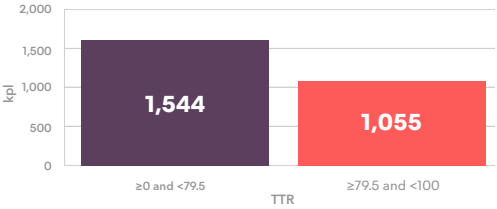


Figure 5: TTR-level of patients using blood-thinning medication

Outcomes

The Apotti system will provide a platform for many tools like Health Benefits Analysis to access timely and accurate patient information, thereby unlocking the potential of preventive health care. This should trigger an increase in early diagnoses and less demand for specialized health services. By taking a system-wide view, Helsinki's medical community and city government are better placed to evaluate the impact of their interventions and improve their medical practice.

Integrated health care information is only the beginning, says Mikko Rusama, Chief Digital Officer for the City of Helsinki: "Well-being of people is not only about health care. Cities have a wide range of services. If we are better able to understand their individual needs and problems, we can provide more personalized suggestions of what should be done." In taking a wider view of residents, the City of Helsinki aims to proactively meet their service needs,[15] and ultimately resolve underlying issues and thus improve well-being.

[15] Statistics Finland (2019), Population Projection 2019, www.tilastokeskus.fi/til/vaenn/2019/index_en.html [accessed August 3, 2020].

Tel Aviv

Mapping real-time data to manage the Nonstop City

Overview

"If you know in real time what problems you have, then you will be able to fix these as soon as possible," says Liora Shechter, former CIO of Tel Aviv-Yafo Municipality. Launched in 2019, a real-time information map of the city monitors everything from trash collections to vandalism, allowing municipal departments to visualize and respond to issues as they arise.

A pioneering approach to city management

Tel Aviv-Yafo Municipality has taken an incremental approach to strengthening its technology and data architecture, enabled by a centralized IT Department where 95 percent of applications are developed in-house. The result is a series of information systems that generate data that, when integrated, provides the foundation for a pioneering approach to city management.

These disparate data sources include reports to the city's non-emergency "106" hotline; DigiTel, an online "residents club"; live reports from municipality field teams; field systems such as Internet of Things (IoT) sensors and cameras; and third-party applications. The map gives each municipal department a spatial view of their operations in real time, enabling them to quickly locate and respond to incidents.

Where the tool comes to life

Combining data is only part of the story, however. To unlock the true potential of the tool, each municipal department programs logic into the system to automate and inform decisions so that remedial action can be taken with minimal human intervention. "This is the thing that makes it go from passive to something that is responsive and operational," says Shechter.

At present, 80 categories of operations are displayed on the platform, with this number set to increase. Incidents range from reports of trash piles and graffiti to parking offenses and monitoring the locations of subcontractors' vehicles such as garbage trucks. A specific category responds to COVID-19-related requests to ensure the municipality is providing timely support for vulnerable residents asking for food packages, medicine, or support from the Social Welfare Department.

The cornerstone of the system is iView, the municipal Geographic Information System (GIS) platform that provides a spatial visualization of key operational data. iView, based on an ESRI ArcGIS server and Microsoft Silverlight client, is also the basis for a public-facing map of open geospatial data.

A system of systems

The real-time information map leverages data already held by the municipality. Shechter explains, "The system cannot stand on its own. The force of the system comes from the systems that are underneath this. It's really an integration tool, but you have to combine it with your own tools in your own municipality."

A small in-house team spent around 12 months developing the architecture and integration for the tool. Their rapid progress was made more straightforward by the interoperability of the systems used by different departments for data management and analysis. Building it in-house has saved costs and reduced dependencies on external vendors.

The result is a powerful and cost-effective tool that leverages the municipality's existing data. Developing it themselves was the only option, says Shechter , "If you procure the system of systems from a big company it could end up costing millions of dollars." When support is needed, the municipality reaches out to companies in the city's flourishing tech sector.

Outcomes

The real-time information map receives 90 percent of its data in real time. It has been created in the confidence that digital engagement between residents and the municipality is sufficient to provide a consistent source of resident-level data. When a new issue is raised, an automated alert is sent to the corresponding service team and any affected residents.

The system is already improving the accuracy and speed of response; so far, they estimate that issues are being resolved 30 percent quicker than before, despite the map only becoming operational in 2019. Further insights should enable the spotting of patterns in demand and common types of reports that will guide future operations and investment decisions.

City management in Tel Aviv will continue to evolve. In the future, the municipality aims to proactively identify and respond to an issue before a resident has become aware of it. Tests are already underway: Internet of Things-enabled cameras using AI are likely to be the next step.

San Francisco

Designing a resident-focused affordable housing service: from innovation to implementation

Overview

The City of San Francisco went through a rapid design-led innovation process to improve a housing service that was previously time-intensive and often confusing for citizens. The elegant *DAHLIA* housing portal makes searching and applying for affordable housing units simpler and more transparent.

Analogue applications put pressure on residents

San Francisco is experiencing a housing crisis. The average price for a home is $1.47 million, 5.8 times the national average.[13] As home prices have risen, so, too, has demand for affordable housing, but supply has remained static. In the 2018-19 fiscal year, 146,000 people applied for 486 affordable housing units in San Francisco.[16] The City and County of San Francisco aimed to build 10,000 more units of affordable housing between 2014 and 2020. But housing supply is only part of the story. The application process for affordable housing has been a barrier in itself in recent years.

A lottery system decides who gets to buy or rent a property. For years, this was a convoluted and time-intensive process for residents and property developers alike. A potential applicant would need to approach each developer directly, complete a set of specific forms, and provide supporting documentation just to enter the lottery.

An in-person process and strict deadlines allowed for little flexibility; lines of people would often run around the block in the hours before applications were due. Not everyone could afford to take time away from their work or families to submit the paperwork, and no system was in place for applicants to update and resubmit their paperwork if any information was incorrect or missing. The process was not just inefficient, resulting in long delays, it was also opaque and could not be tracked by applicants.

Design-Discover-Develop

In 2015, the affordable housing applications service was nominated by the Mayor's Office for Housing and Community Development (MOHCD) as a challenge for the Civic Bridge program run by the Mayor's Office for Innovation.

[16]Zillow (N.D.), San Francisco Home Prices & Values, Zillow Home Value Index www.zillow.com/san-francisco-ca/home-values [accessed August 3, 2020].

Civic Bridge partners city government teams with corporates who volunteer their time over 16 weeks to explore new approaches to major city challenges. Google supported the MOHCD through a design-discover-develop process to build a prototype of what a new digital service could look like.

The MOHCD commissioned Exygy, a locally based digital design agency, to scope and develop a full online affordable housing application service. Exygy undertook detailed research with stakeholders across the San Francisco landscape, including residents and more than 15 property developers. After many months of discussions between the area developers, housing counselors, and affordable housing advocates, a minimum set of standard required information fields was agreed upon so that applicants could enter the lottery online without first having to fill out complex forms for each developer.

Introducing DAHLIA

The first iteration of the tool went live at the end of 2015. Since its launch, the Database of Affordable Housing Listings, Information, and Applications (DAHLIA) portal has allowed residents to browse units online, view property information, and learn how the application process works through straightforward messaging in a number of languages.

DAHLIA makes deadlines and eligibility requirements for each development clear to potential applicants from the start – information that was not always readily accessible previously. Applications can only be finalized once all required fields are complete, so invalid submissions are eliminated entirely. A resident is entered into a lottery once they have filled in the basic information. If selected, they then complete a detailed application for the developer and provide documents to verify their eligibility. A notification service keeps applicants informed of their progress throughout.

The tool is designed using open source software – Ruby on Rails and Angular – that plug into any CRM, currently a Salesforce backend. The City and County of San Francisco actively encourage reuse and have published the code and design patterns openly. Other cities in the Bay Area are looking to adopt the platform, which will provide a consistent way for citizens to consider options in the broader metropolitan area unconstrained by administrative boundaries.

Outcomes

Ninety-seven percent of applications are now made using the digital service, which has fast become a one-stop shop for affordable housing searches. The days of long waits, inconsistent application forms, and limited communication are a distant memory. Property developers benefit greatly, too; previously they would have had hundreds, if not thousands, of paper applications to sift through.

Last year, 168,888 applications were made using DAHLIA, and 79,554 people registered to use it in 2019 alone. Their data and the DAHLIA housing portal support a more comprehensive understanding of housing dynamics in the city. The MOHCD is in the process of bringing the design and development of the tool in-house in order to reduce dependencies on vendors, to limit financial outlays, and to make it a more integral part of their daily operations.

From a challenge-based innovation project to an impactful city service, DAHLIA has demonstrated the benefit of applying design-led approaches to develop and deploy a digital solution. Business Analyst Michael Solomon reflects on its impact: “There’s no way we could do the work that we do without DAHLIA. There’s just no way we’d be able to get through everything.”

The Hague

From Monitoring to Response: Securing IoT devices within the city limits

Overview

Home to international organizations such as Europol and the International Courts of Justice, The Hague is fast becoming a global hub for cybersecurity – with the updated moniker of the International City of Peace, Justice and Security. Through partnerships with security experts across The Netherlands, the municipality is piloting new approaches to improve the security of devices used by its residents and businesses.

Insecure devices are a growing threat

Public institutions play an essential role in keeping people safe in their towns and cities. But these roles and responsibilities aren't as clear in the digital world as they are in other areas. The threat of cyber crime is increasing: estimates suggest that almost 1 percent of global GDP was lost to cyber crime in 2017. This threat is expected to rise with the growth of connected devices globally: from 8 billion in 2017 to a projected 20 billion devices in 2020.[17]

Many IoT devices in common use – from video doorbells to air quality monitors – are not effectively secured. They are rarely, if ever, updated, and security-by-design principles are often left behind in favor of cheaper production costs. Lax security opens the door to malicious activity such as botnets, distributed denial of service attacks, and malware.

In The Hague, home to international organizations where security is paramount, insecurely connected IoT devices are a threat to the city's digital infrastructure, critical national infrastructure, and the security of residents and visitors.

The municipality believes it can play a key role in supporting cybersecurity for everyone within its city limits. Marijn Fraanje, CIO of Municipality of The Hague, highlights the challenge: "At the moment everyone fends for themselves. And, in the digital world, you are likely attacked through the weakest point. And yet things are linked, so everyone is affected through the links in the chain."

[17] Gartner (2017), Press Release: Gartner Says 8.4 Billion Connected "Things" Will Be in Use in 2017, Up 31 Percent From 2016, www.gartner.com/en/newsroom/press-releases/2017-02-07-gartner-says-8-billion-connected-things-will-be-in-use-in-2017-up-31-percent-from-2016 [accessed August 3, 2020].

A central awareness system for the city

To better support citywide cybersecurity practices, the municipality has collaborated with Cybersprint to pilot an IoT security monitoring tool. Cybersprint, a cybersecurity organization based in The Hague, has close connections to the municipality and the Hague Security Delta (HSD), the national innovation center of the Dutch Security Cluster. The other key partners are the Public Prosecution Service, which is keen to gather new insights into criminal behavior, and the Technical University of Delft, which processes and analyzes data.

The tool monitors open and commercially available data sources like Shodan and IP geolocation and then combines the data with Open Source Intelligence. It then creates a real-time view of all the connected IoT devices within city boundaries with detailed information, such as their whereabouts and level of risk. So far, the monitor has identified 3,100 insecure devices in The Hague. Typically, insecure devices are those using no passwords or default passwords or outdated software — all problems that can be easily resolved.

"Before any organization can effectively increase their cyber resilience, they first need to know how big their digital attack surface is," says Pieter Jansen, CEO of Cybersprint. "Together with the municipality, we expanded the vulnerability scanning capabilities of our Digital Risk Protection platform to create the IoT security monitor. The automated detection and assessment of devices provide insights that can directly be translated into action."

The municipality's intervention is not based on fixing these insecurities directly, however, because they lack the authorization to do so for devices outside of their own online footprint. Instead, the objective is to raise awareness where there currently is none: "If you want to solve something, you first have to make everybody aware that there's a problem," says Fraanje. Organizations, especially small businesses, might lack knowledge around cybersecurity; once the tool has picked up a weakness, the municipality can contact owners or users via telecom operators to encourage them to take action themselves.

Outcomes

The goal is an automated central awareness system that identifies any new insecure devices in real time and notifies their users and owners about the risk. Cybersprint and The Hague expect to launch the full product by the end of 2020. The city is serving as a testing ground not only for the technical aspects of the tool, but for understanding how to design the most effective response procedures.

Promoting cyber awareness continues in several of the municipality's activities. In September 2019, they invited 80 ethical hackers to "Hack The Hague," an annual event designed to test the resilience of the systems used by the municipality and to identify any weaknesses. When the IoT security monitor goes live, they plan to set up a screen in City Hall displaying live data to increase visibility of the risks among residents.

The need for continuous innovation in the field is clear, says Max van Meerten, Policy Advisor for IT at the Municipality of The Hague: "It is important to keep reinventing in the field of cybersecurity. Criminals are willing to misuse technology for malicious activities; you always have to be one step ahead to keep up."

Analysis of Trends by Tech Area

Overview of Technology Trends

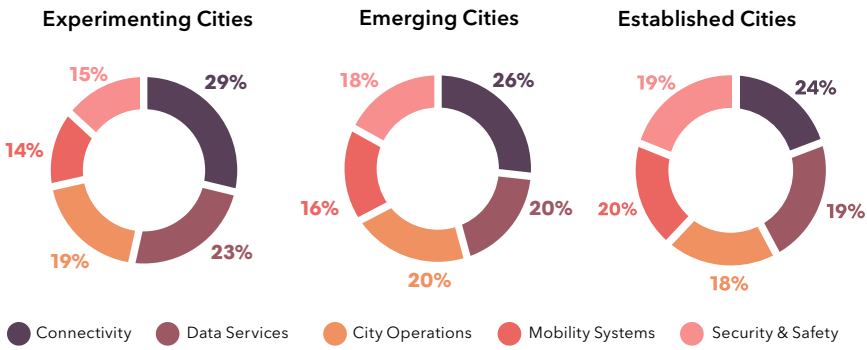
Participants from 30 cities reported on their adoption of 41 different digital tools and technologies across five broad technology themes: connectivity, data, city operations, transport & mobility, and safety & security. The options were compiled following an extensive literature review of international reports on digital innovation in city government and digital strategies from several cities. Specific technologies are described in the glossary of technologies beginning on page 154.

Stages of Deployment

Each city has a different set of challenges and priorities and a different set of influences on which technologies are deployed and when. Nevertheless, observations can be made on cities' journeys through three stages of technology deployment. At the Experimenting stage, eight cities have deployed technologies for the least amount of overall time.
Ten cities are at the Emerging stage, having deployed technology for up to two years on average. The largest group is at the Established stage. In these 12 cities the average technology deployment is over two years in length, and many more in some cases.

These classifications are not a universal reflection of a city's activities. Deliberate decisions made by city governments not to explore or invest in certain digital tools are not registered as such. Chatbots, where a high degree of skepticism still exists, are a good example of this. The classifications are also not a commentary on the success of technology deployments. After all, adopting a specific tool for five years is no substitute for a well-designed service that meets residents' needs.

Figure 6: Average deployments in tech areas by cities at the different stages



Bogotá, Colombia
Boston, USA
Bratislava, Slovakia
Dublin, Ireland
Paris, France
San Francisco, USA
Sydney, Australia
Toronto, Canada

Cape Town, South Africa
Copenhagen, Denmark
Ghent, Belgium
Kansas City, USA
Kobe, Japan
Melbourne, Australia
Milan, Italy
Pune, India
São Paulo, Brazil
Seattle, USA

Amsterdam, The Netherlands
Atlanta, USA
Barcelona, Spain
Denver, USA
Glasgow, UK
The Hague, The Netherlands
Helsinki, Finland
Los Angeles, USA
Seoul, South Korea
Tallinn, Estonia
Tel Aviv, Israel

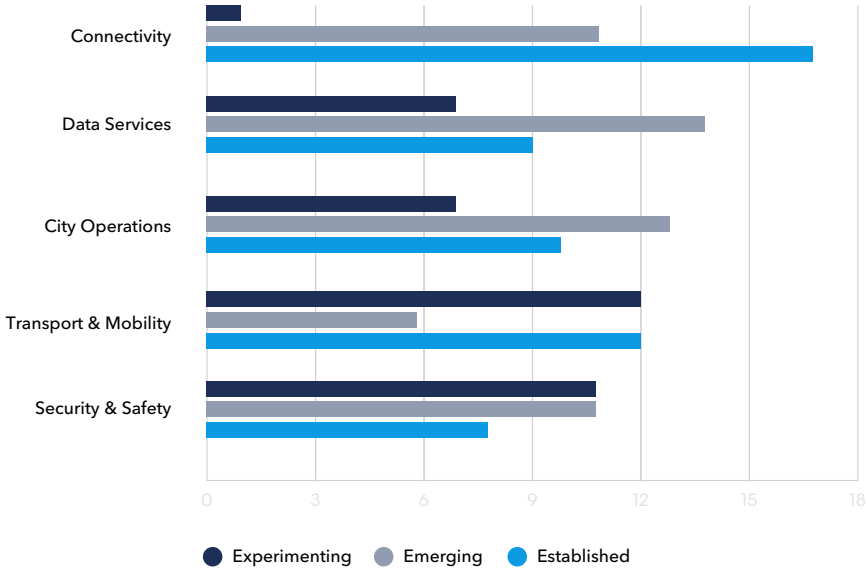
Rather, the insights in this report capture a moment in time: where cities are with regards to their deployment of different digital tools in early 2020. They point to general trends in cities' behavior and the sequencing of deployments in different technology areas. Figure 6 depicts the relative deployment of different technologies by cities in the three groups.

These charts show a clear pattern of movement in the attention of cities to certain technology areas throughout the stages of deployment. The distribution of deployments is most balanced in cities at the Established stage. This changes subtly for those Emerging and more profoundly for those Experimenting, where the spread is quite uneven.

The relative attention given to both connectivity and data tools decreases as a city's overall experience grows, possibly because many of the foundational elements within these technology areas form the basis upon which other tools are developed or required. Another reason for the relatively low uptake of data tools in more established cities is suggested in Figure 6, where the largest number of cities are currently at the emerging stage. This may be due to limited data science capability in city government to make the most of AI, for example, or because certain technologies such as edge computing are relatively new to market.

Concentrating attention on these two foundational technology areas is logical. However the lack of attention given to safety and security tools is notable. This is significantly down on other areas in cities at the Experimenting stage, but starts to level out with other technology

Figure 7: Number of cities at each stage of deployment, organized by tech theme

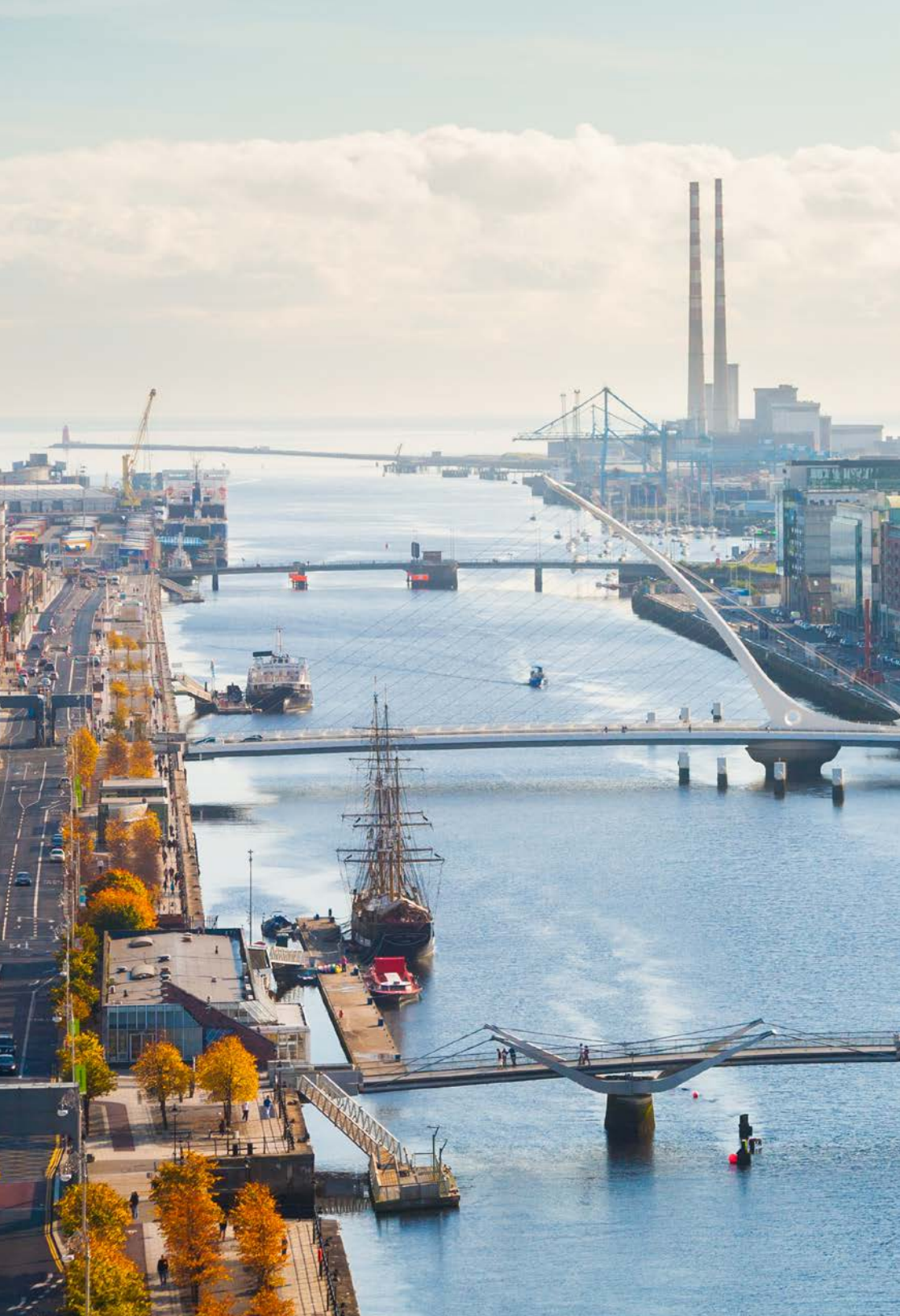


areas at the Established stage. This may imply that cities are not giving cybersecurity the same importance as other factors when experimenting with new technologies, or that they have fewer security needs until live deployments and real data are used.

Figure 7 shows the smallest range between the number of Established and Experimenting cities is found in this area, and no city reported deploying safety and security tools for over five years, indicating that this is the least mature area of technology.

What is less clear is why fewer deployments of public safety tools are being made, although we can speculate that it follows a logic similar to transport and mobility tools, which tend to be more application-based and dependent on robust digital and data infrastructures. After connectivity (18), mobility tools have the highest number of cities at the Established stage (12), although an equal number are still experimenting with different tools in this area. Curiously, lots of cities are experimenting, but far fewer have, on average, initiated live mobility-related technology deployments in the past two years.

Finally, digital tools for city operations are evenly spread across the three groups of cities (see Figure 6), showing that they are receiving the same amount of relative attention no matter what else the city might be focusing on at that time.



Cities' experience in deploying connectivity technologies

Amsterdam
Atlanta
Barcelona
Helsinki
Tallinn
Los Angeles
Tel Aviv

Cape Town
Denver
Glasgow
The Hague
Kobe
Seoul
London
Melbourne
Milan
Pune
São Paulo

Bogotá
Boston
Bratislava
Copenhagen
Ghent
Kansas City
Paris
San Francisco
Seattle
Sydney
Toronto

No cities

Dublin

Digital infrastructure investments are vital to expanding connectivity to all city residents. Giving everyone the opportunity to access the internet is the first building block to support digital equity and inclusion, to encourage residents to develop new skills and to stimulate growth of local digital economies.

City governments enable and incentivize the deployment of connectivity networks and emerging technologies in several ways. Commissioning the expansion of fiber networks to public properties makes it is easier for network operators to extend wired connectivity to adjacent neighborhoods. By granting telecommunications service providers access to public assets – such as poles, rooftops, city conduit and public rights of way – wireless networks can be tested. By establishing experimentation zones, IoT nodes can be installed and emerging technologies trialed.

Full deployment is often market-driven, though alternate delivery models are seen where current or former state-owned telecommunications companies exist. The City of Bogotá is working closely with ETB (Empresa de Telecomunicaciónes de Bogotá) to create a citywide IoT network over the next four years. Seoul Municipal Government has partnered with Korea Telecommunications to use cellphone data to gather insights into passenger behavior on public transport.

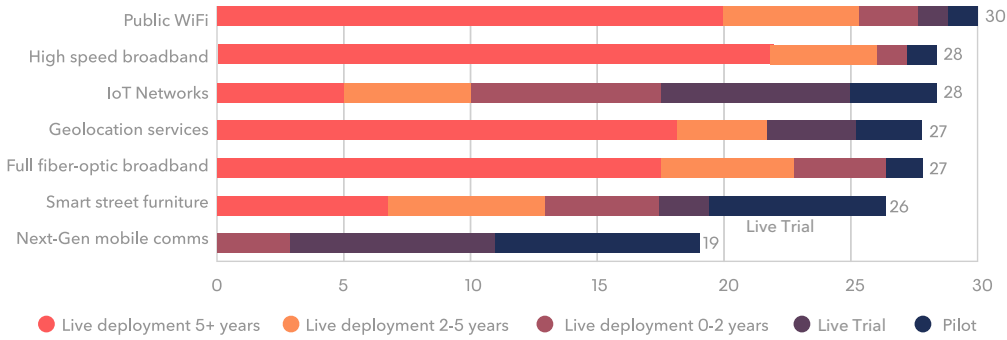
Bratislava, one of the cities with less experience in overall technology deployment, has focused attention heavily on connectivity. This provides a strong basis for digital innovation, which received mayoral backing in 2018, to flourish.

Several of the connectivity technologies reviewed are long established. High speed and fiber-optic broadband, public WiFi, and services that provide geolocation capabilities have been deployed in 90 percent of cities – for over five years for the majority. Two cities are reliant on standard broadband, however.

Deployment of IoT networks and smart street furniture is very mixed, though only a handful of cities are not experimenting with these tools at all. Among the most experienced, Barcelona uses an extensive network of IoT sensors to monitor air quality. When analyzed, the data informs major policies, such as whether banning high-polluting vehicles from the city center is making a difference.

Over one-third of cities have not started experimenting with next-generation communication technologies like 5G. The main role of many cities surveyed is most often to work with telecommunications service providers seeking access to public assets, rather than directly experimenting with use cases for 5G. Jim Loter, Director of Frontline Digital Services for the City of Seattle, expresses a common view: "Overall, we're maintaining a careful, cautious and even skeptical attitude about the transformative capabilities of 5G." Some cities have partnered with telecommunications providers as part of early 5G trials. The City of Atlanta worked with Verizon to install 5G infrastructure ahead of the 2019 Super Bowl and has since scaled it to other parts of the city.

Figure 8: Distribution of experience with connectivity technologies



Connectivity and COVID-19

The coronavirus pandemic has seen an unprecedented shift to working from home in many people's lives – a shift that is dependent on effective digital infrastructure and connected devices. The UN Human Rights Council declared internet access a basic human right in 2016, and seldom has this felt truer than at a time where millions of people's livelihoods depend on their connectivity. But still millions more do not have the financial means, the skills or the option to go online.[18]

Around the world, city governments have been helping their workforces transition to new ways of working and have overcome logistical challenges from rapidly purchasing VPN licenses to adopting the most user-friendly and secure video conferencing tool. Many are supporting students' learning through the provision of laptops to schools.

The core business of extending connectivity infrastructure to more households also continues. As dependency on the internet for essentials like food and sanitary products becomes more entrenched, there is a risk that some residents – often the most vulnerable – will be left behind.

In addition to providing access to goods and services, digital connectivity can provide a lifeline for vulnerable groups, such as the elderly, who are statistically more likely to experience loneliness. Digital equity and inclusion programs have already been trying to redress this imbalance by ensuring that all residents have the digital skills they need. But in the aftermath of the crisis, will digital literacy be taken as seriously as basic literacy? No matter what the world looks like once the pandemic has passed, connectivity will be more important than ever.

[18] International Telecommunications Union (N.D.), Digital Inclusion of All, https://www.itu.int/en/mediacentre/backgrounders/Pages/digital-inclusion-of-all.aspx [accessed August 3, 2020].

Cities' experience in deploying data technologies

Photo credit: Joséphine Bruederer/City of Paris

"We would like citizens to understand and share our ambition to create a public service for data. This would entail helping citizens to better understand how we use their data to improve urban services, providing citizens with solutions so that they can regain control over personal data, which are too often left to private digital platforms, and strengthening citizen participation in decision-making."

Emmanuel Gregoire,
First Deputy Mayor, City of Paris

An extensive array of data tools is being deployed by city governments; this technology theme reviews the largest number of tools. Some, like open data platforms, are considerably more established than others. Making better use of data is seen as vital to improving operational performance and making better decisions that are rooted in evidence. "We currently spend 90 percent of our time trying to track down the data and only 10 percent making use of it" says David Edinger, Chief Information Officer for the City and County of Denver. "We want to flip this around." This sentiment is echoed by the majority of interviewees, where common barriers include the absence of data standards, the lack of data skills and capability, and organizational cultures that do not encourage data sharing.

The structure of city government can make data integration a particular challenge. In many U.S. cities, where large city departments have their own technology leadership and practices, a recurring issue is streamlining permitting processes. If a resident wants to open a new business in San Francisco, they may require permits from as many as 12 different departments. These could include permits to register a new business, pay tax, or dispose of waste. Data sits in separate departmental systems and is federated via a series of Application Programming Interfaces (APIs). The city's digital services team supports the permitting departments in consolidating the information they need into a single form.

Effective data integration is vital for those seeking to turn raw city data into insights. A few models for achieving consistency in data practices have been observed.

1. Top-down digitization mandates
2. Organization-wide adoption of a single IT system or product
3. Centralized IT departments that set and manage standards
4. National IT infrastructure that requires compatibility
5. Bottom-up standardization to address specific needs

In London, 32 borough councils operate independently of one another, making it difficult to take advantage of citywide data. The London Office of Technology Innovation was established in 2019 to catalyze an important change by supporting cross-borough collaboration and data standardization.

The future of data governance looms large in the thinking of some cities like Amsterdam and Barcelona. Their data commons[19] approach redefines the relationship between the resident, their data, and the city so that people can "equitably control, share, and benefit from data." The premise behind this approach is that data captured by private companies is too often locked away and not accessible for the public good.

In Europe, General Data Protection Regulation (GDPR) defines clear responsibilities around personal data use. Public agencies are carefully navigating the regulation to ensure any personal data shared is done so with the consent of residents. Helsinki is testing how to proactively offer services to residents, even though consent is required to contact them directly. Other cities have introduced strict privacy policies; the City of Seattle Privacy Principles[20] may seem more akin to European rules than those found in most American cities.

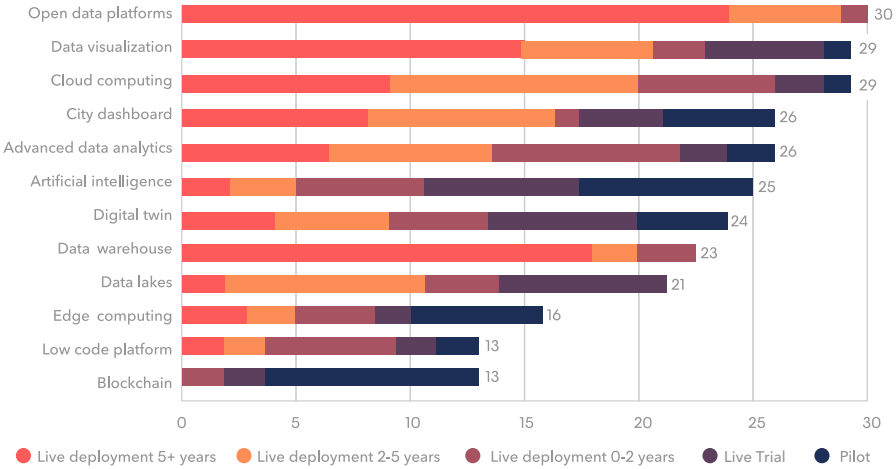
Open data platforms stand out as the most extensively deployed tools in the research. Every city surveyed uses one, and, in over 80 percent of cases, they have been in place for more than five years. Some cities are in the process of

> **"Data quality, data governance, data literacy. It's about continual uplift in these areas"**
>
> **Rebecca Marson**
> Smart City Strategy Team Leader for the City of Melbourne

[19]An explanation of the benefits of a data commons is provided by Nesta (N.D.), Unlocking the value in data as a commons, https://www.nesta.org.uk/feature/four-future-scenarios-personal-data-economy-2035/unlocking-the-value-in-data-as-a-commons/ [accessed August 3, 2020].

[20]City of Seattle (N.D.), Privacy Principles, https://www.seattle.gov/Documents/Departments/InformationTechnology/City-of-Seattle-Privacy-Principles-FINAL.pdf [accessed August 3, 2020].

Figure 9: Distribution of experience with data tools



refreshing their open data offerings, for example, the London Datastore, which first launched in 2010.[21]

Federated data from a growing array of sources and a vibrant marketplace for visualization tools underpin the continued evolution of open data platforms. Currently, geospatial representations of open data are making city data more accessible to residents in cities from Bogotá to Tel Aviv.

The evolution is likely to continue as digital twins are adopted more widely. At present, 14 of our surveyed cities have a digital twin and a further 10 are experimenting; many are already discussing their plans for 3D city models. Helsinki has published a city information model that illustrates energy consumption and carbon emissions from buildings; Dublin has built a 3D virtual environment of its Smart Docklands testbed through which residents can view proposed developments for the area.

There are two main uses for city dashboards, which are used in over half of our surveyed cities. Usually, dashboards are used either to display public-facing information on transport services or air pollution or to help city managers monitor operations.

Data warehouses and cloud computing are a mainstay of half of the cities' operations. Data lakes and edge computing are in the early stages of deployment or experimentation in the majority of cities. Live deployments are unusual and found in only around one-third of cities. This is similar to the results for next-generation communication technologies, but both are likely to change in the coming years. The expansion of 5G networks will require the ability to rapidly process and store vast amounts of unstructured data and should see the take-up of edge computing and data lakes grow.

Advanced tools for data analysis are already modeling mobility flows,

[21]Mayor of London (N.D.), London Datastore: Welcome to the Datastore, data.london.gov.uk [accessed August 3, 2020].

emergency planning scenarios, and more in over 70 percent of cities. AI is being deployed in a relatively small number of cities, just 11 of those surveyed. Cities such as Amsterdam and Copenhagen use AI image recognition in non-emergency resident reports to identify and issue responses based on pictures submitted. A further 14 cities are experimenting with AI, and the interviews suggest an upward trend in the years ahead. Machine learning is likely to further enhance analytical capabilities, especially when making sense of unstructured data, though there are few examples of this in practice in city government at this time.

Around one-third of cities are already using low-code platforms, but over half are not giving them any attention, making it one of the most polarizing tools. Blockchain sees the least take-up overall and has only recently started to be deployed, but in less than 10 percent of participating cities.

Data tools and COVID-19

For the first time in a global crisis, city governments have powerful tools at their disposal for data analysis, and rarely have city governments guided so many public policy decisions. GPS data from mobile operators is telling the Prefeitura de São Paulo how closely residents are following quarantine guidance. The City of Boston has been looking for patterns in the neighborhoods where positive tests are occurring. In Bogotá, the District High Council is modeling scenarios to plan the best way to reopen the city.

But could emergency measures threaten people's data privacy rights? Debates about data governance are becoming mainstream, with the use of personal data integral to technology-led approaches to tracking, surveillance, and contact tracing. Residents will face choices: Do they trust their governments with their data? Is trading off personal data worth the assumed benefits? To achieve maximum impact, new tools will have to operate at scale, and their success will depend on public confidence in data and trust in institutions.

Data tools are only part of the story. Timely access to information to identify vulnerable people, meet medical needs, or report virus cases can literally save lives. But in many places common barriers to data sharing remain: standards and data infrastructure are lacking, data is not integrated, and regulation and working culture is still playing catch-up.[22] Rapid responses to future resurgences of the virus are likely to hinge on how information is shared.[23]

[22]Copeland, E. (2020), Beyond the crisis: How might [UK] local government build a positive legacy after Covid? https://medium.com/loti/beyond-the-crisis-how-local-government-can-build-a-positive-legacy-after-covid-3ac6e3d32a24 [accessed August 3, 2020].

[23]Mostashari, F. & McClellan, M. (2020), Data Interoperability and Exchange to Support Covid-19 Containment, Duke University: Margolis Center for Health Policy, healthpolicy.duke.edu/sites/default/files/2020-06/data_interoperability_and_exchange_to_support_covid-19_containment_final.pdf [accessed August 3, 2020].

Cities' experience in deploying technologies to support city operations and services

All cities involved in the research are extensively digitizing their operations and services. For many, this has been a long and incremental journey. Some have been slow starters but with a strong mandate have accomplished much in a short time.

Since 2015, the Prefeitura of São Paulo has digitized an estimated 300,000 paper-based processes annually and trained over 40,000 members of the 120,000-strong Prefeitura staff to use new systems and processes. In Pune, the Municipal Corporation began a similarly drastic transformation journey in 2016; over 80 percent of its systems are now hosted on the cloud.

The City of Milan estimates significant cost savings from digitized services – reducing the cost of a transaction from €4.40 in person to €0.20 online.

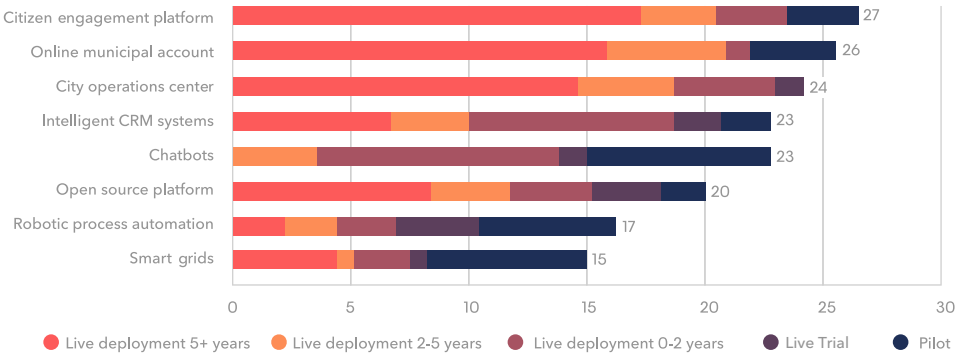
Helsinki, a city doing leading work in this area, has a lofty goal that goes beyond digitization and shifting interactions to primarily online channels. The Finnish Ministry of Economic Affairs and Employment states, "We are on the road to a society that is proactively identifying service needs and that can better and more effectively respond to varying needs of every citizen."

This research has focused on digital tools and technologies, less on aspects that relate to culture, practices, and processes. Many cities espoused the benefits of human-centered service design to better meet residents' needs. Of all the technology themes reviewed, culture and practices are especially likely to influence outcomes in city operations, as opposed to deploying a new system or tool.

"I believe as we push the envelope in providing technology that will be useful in creating more efficient citizen-based services, we will continue to see a rise in adoption and implementation across the City of Atlanta. **Technology will be instrumental in providing services in our current climate and beyond.**"

Gary Brantley,
Chief Information Officer,
City of Atlanta

Figure 10: Distribution of experience with tools for city operations and services



The most established tool used to deliver municipal services is the online municipal account. Present in over three-quarters of cities, it offers a one-stop-shop for city services once a resident has logged in. Of the cities surveyed that do not yet have a single account, many are planning to establish one in the near future. Tel Aviv's DigiTel platform, an online residents club, began as an engagement tool and is evolving into a platform for city services.

Despite the success of Tel Aviv's resident engagement platform, not all cities are moving in this direction, and there is some question whether it is the right approach. "Whenever we've done the user research, it's always come back fairly conclusively that no one really wants that," says Carrie Bishop, Chief Digital Services Officer for the City of San Francisco. "People are task-driven when they come to the city website. They are not there to engage with the city in any particular way. They are just trying to do that one thing."

Around one-third of cities are currently experimenting with chatbots to enhance services, but many retain a healthy skepticism. While chatbots can support residents in multiple languages, this has been a particular challenge in the linguistic melting pot of Pune – where the sheer number of local languages has stalled the first attempt at deploying a tool. Other cities are not convinced chatbots are worthwhile when better website content management could render them unnecessary.

Automation in back-office processes is becoming more common. Within the last two years, almost one-third of cities have adopted Customer Relationship Management (CRM) systems that have built-in intelligence. Robotic Process

Automation (RPA) is being trialed by one-third of cities but is only being actively used in seven.

City operations centers are being actively deployed by around 80 percent of cities. Initially, security and transport management were the most common uses, but in recent years the improved availability of data and visualization tools has enabled cities like São Paulo and Tel Aviv to view and manage the performance of city services.

Attitudes toward open source platforms are mixed. Paris's Lutece platform was launched in 2014 and now hosts over 70 city services. While more than 50 percent of cities use open source platforms, it is normally only for specific products or services, rather than for hosting applications used across the city government. Aik van Eemeren, Lead Public Tech at the City of Amsterdam, sees governing open source code at scale as a challenge that would require a dedicated and well-resourced community.

Smart energy management is where city governments have the least experience. Some cities, like Glasgow, are using demand-side energy management in public buildings and streetlight infrastructure to help meet their carbon emission targets. Smart grids are usually seen as the domain of utility companies.

City operations and COVID-19

It is difficult to imagine how cities could continue functioning during the crisis without digital technologies. Local policies, updates, and key messages from national governments are communicated via online citizen engagement channels, while city officials are carrying out their tasks remotely to keep city operations running. The efficacy of this transition has determined how quickly city governments have been able to return to a semblance of normality, albeit online. Our case study on Tallinn's response to the crisis explains the factors that have enabled the city to cope effectively with the new demands on the municipality.

Cities are still serving resident needs where digital channels exist, but not without challenges. Digital front doors do little for services that require physical intervention and have been put on hold. In many cases, city officials need to be in the office to process requests, even on digital systems. The future resilience of services will depend on their operating with minimal human intervention. Automation can be introduced to many simpler tasks such as data input and processing, and city governments will need to decide which tasks should be automated and which should not.

Beyond simply creating digital channels, services should be designed around the needs of all potential users. This means taking into account digital accessibility, privacy, and security, and usability across a variety of devices. Introducing functions such as digital identity verification and digital signatures will become more important if residents prefer to access services remotely. The biggest shift, however, will be the transition to a new working culture. Organizations that insist on transplanting their offline practices to digital channels will struggle, while those that adapt and embrace new ways of working could thrive.

Cities' experience in deploying transport and mobility technologies

5+ years

Los Angeles
Tallinn

2-5 years

Amsterdam
Atlanta
Copenhagen
Glasgow
The Hague
Helsinki
Kansas City
London
Seoul
Tel Aviv

0-2 years

Barcelona
Cape Town
Denver
Dublin
San Francisco

Live Trial

Ghent
Kobe
Milan
Paris
Pune
São Paulo
Toronto
Melbourne

Pilot

Boston
Bratislava
Bogotá
Sydney

Reducing traffic congestion and supporting residents who use other modes of transport are the most common priorities in this technology area for the cities we surveyed. For the City of Ghent, where 35 hectares of the city center are almost entirely car-free, they aim to provide "the right information at the right time so that people don't feel the need to use the car anymore to move about the city," according to Chief Data Officer Bart Rosseau.

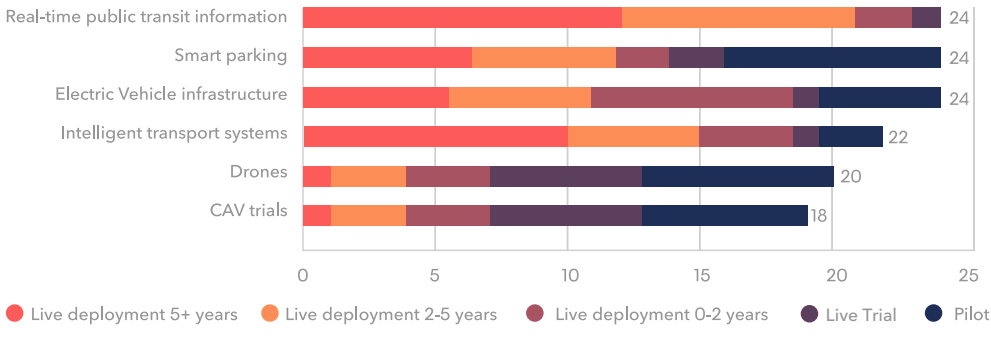
Real-time public transport information is provided to residents in 80 percent of the cities surveyed, most commonly through digital signage and transport apps where a city has made data accessible via an open API. Smart parking solutions are in use in almost half and are being tested in one-third of participating cities. Intelligent transport systems, which analyze traffic flows and configure signals in real time, have been deployed in 18 cities. Different data sources are used; the City of Seattle uses two systems: sensors installed along expressways connect to devices in vehicles to ascertain their velocity, meanwhile connected closed-circuit television (CCTV) cameras and video analysis software also monitor driver behavior.

Electric vehicle (EV) infrastructure is being progressively rolled out, and several cities have converted their own fleets to electric. Glasgow is integrating EV charging points into the design of intelligent street lighting infrastructure.

Support for connected and autonomous vehicle trials are mixed. Many cities have no experience, but over one-third are undergoing pilots and limited live trials. Several U.S. cities have been working closely with car manufacturers for a number of years. Helsinki has established an autonomous bus service, albeit on limited routes. RobobusLine runs three to six times an hour in the summer and fall months.

Finally, drones are playing an important role in maintenance and emergency response in different contexts. The Los Angeles Fire Department uses drones mounted with cameras and thermal imaging technology for fire inspections and response. In Tallinn, they help planners to develop a 3D model of the city and building maintenance teams to assess rooftop damage on public buildings. Thirteen cities are experimenting with drones, but a further 10 are not using them at all.

Figure 11: Distribution of experience with transport and mobility tools[24]



Transport, mobility and COVID-19

Transport and mobility services have been adversely affected as a result of stay-at-home measures in cities around the world. This pause has given rise to questions about how we will travel and move around when the pandemic is over; some cities are already offering glimpses of the future. More people are being encouraged to walk, cycle, or use scooters as commuters avoid public transport or work from home.

These encouragements go beyond mere platitudes: traffic lanes are being assigned to alternative means of transport to incentivize their use. Improvements in air quality and reduced carbon emissions are driving calls for permanent change; some are discussing the expansion of car-free areas in their cities.

Digital tools are tracking people's movements to observe their adherence to social distancing measures and advice not to travel. By monitoring road use and public transport demand, city governments are planning the phased reopening of city economies and attempting to manage the health risks to commuters.

Transport and mobility have traditionally received more technology investment than many other parts of urban life. But if people's habits change, will city governments and transit authorities continue to invest in the same way as before? Or are we on the cusp of an urban mobility revolution where new technologies and modes of transportation will grow in popularity?

[24] Often public transport and roads are managed outside of the city government, such as metropolitan transit authorities or the regional administrations. Municipalities that play a less direct role in mobility services have responded less confidently to some parts of this section. As an industry sector, mobility tools make use of a combination of technologies to achieve positive outcomes. A typical smart parking service, for example, may rely on IoT sensors or cameras, video, and data analytics, cloud computing, data visualization tools, and more.

Cities' experience in deploying technologies to support public safety and cybersecurity

Atlanta
Barcelona
Denver
Helsinki
Kansas City
Los Angeles
Seoul
Tel Aviv

No cities

Amsterdam
Copenhagen
Dublin
Glasgow
The Hague
Kobe
London
Melbourne
Milan
Seattle
Tallinn

Bogotá
Boston
Cape Town
Ghent
Pune
San Francisco
São Paulo
Sydney

Bratislava
Paris
Toronto

The technologies reviewed in this section fall into two categories: those used for public safety, often by municipal police departments, and those used in cybersecurity by municipal IT departments.

Nearly every city deploys a network of connected CCTV cameras. The extent of these networks varies greatly, as do attitudes to surveillance. Kansas City, Missouri, has one of the largest camera networks in the U.S.; when paired with automatic license plate recognition technology its reach makes possible the tracking of vehicles across the city. In stark contrast, in 2017 Seattle passed an ordinance that requires a Surveillance Impact Report is written for each surveillance technology used in the city to determine how privacy will be respected. This ordinance also covers the other surveillance technologies in the survey.

Mobile connected cameras are commonly used by security authorities as body-worn or dashboard cameras in around 60 percent of cities. Typical tools for crowd monitoring include automated people tracking, facial recognition in video analytics, and motion and infrared sensors. They are being deployed in 16 cities and piloted by six more.

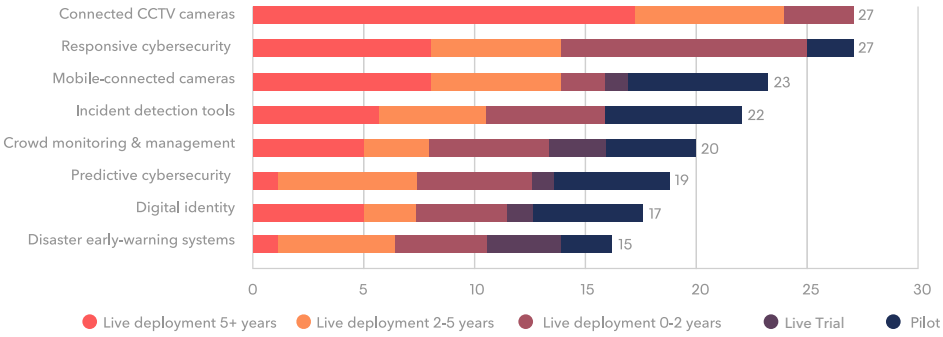
Cities have deployed incident detection tools for very different lengths of time, suggesting that a city's context determines the need. Gunfire locators are helping police departments to respond to shootings more rapidly in the U.S.[25] Advanced video analytics that use AI to recognize emerging issues such as illegal trash dumps and other criminal activity are being tested in Tel Aviv.

Disaster warning tools are concentrated in 20 cities, many of which have a history of disaster risk, including Kobe, Seoul, and Los Angeles. Typically, these are alert tools that act on data analysis to automatically trigger warnings to residents. On the U.S. West Coast, ShakeAlert pushes earthquake alerts from the U.S. Geological Survey; in Dublin, IoT sensors monitor flood risk in the city's watercourses. The 10 cities that did not respond are not situated in obviously disaster-prone regions.

City governments are facing growing cybersecurity challenges. Legacy technology systems, which all cities are still using to varying degrees, are a particular point of vulnerability. As time passes, they no longer receive the same level of product support, are updated less frequently, and are unable to keep pace with new threats.

[25] La Vigne, N.G. et al. (2019), Implementing Gunshot Detection Technology: Recommendations for Law Enforcement and Municipal Partners, The Urban Institute, https://www.urban.org/sites/default/files/publication/101161/implementing_gunshot_detection_technology_recommendations_for_law_enforcement_and_municipal_partners.pdf [accessed August 3, 2020].

Figure 12: Distribution of experience with public safety and cybersecurity tools



Overall deployment of cybersecurity products is mixed. Almost every city actively uses traditional responsive cybersecurity. Predictive cybersecurity, a newer field, is a different story. Although more than 50 percent of cities are in active deployment, only The Hague has been for more than five years. AI is the engine behind the predictive nature of these tools, and there is indeed a correlation between the two in terms of deployment to date. Five cities report no experience with this emerging technology and six did not respond at all, suggesting it may not meet a pressing need.

Digital identity has long been considered a building block of a truly digital society, but full implementations remain uncommon. Experience with deployment is polarized; 13 cities have no digital identities for residents and 11 do. Digital identity is generally managed at the national or regional level — it is unusual for a city to have its own. Tallinn leverages Estonia's long-established e-identity in all services. Milan has been using a locally applicable digital identity for residents but is still in the process of integrating SPI, the national Public System for Digital Identity, into municipal services. Every city that uses a digital identity also has a well-established online municipal account.

Public safety, cybersecurity and COVID-19

Public safety is foremost in the minds of city leaders at this time. Technology is keeping the public safe in different ways. Some cities employ tracking tools to monitor resident movements using smartphone data. Surveillance tools, including cameras and video analytics, are enabling authorities to assess how public space and streets are being used; drones have even been used to do this remotely. All of these technologies are being used to some degree in every city. Municipalities differ, however, in how they use the information collected and how strictly they enforce and penalize violations of movement restrictions and social distancing guidance.

For many, the forced shift to working from home has brought with it an increase in cyber risk. City officials working on their personal devices inadvertently increase the vulnerability of municipal information systems. Cybersecurity has historically seen less innovation than other technology areas in city government. Cyber criminals could be ready to exploit weaknesses where effective protection and risk management practices are lacking.

Digital innovation in public safety will see products developed for different purposes. All will have to tread carefully to avoid accusations of overreach. Increased surveillance may have to be accepted by residents as part of the journey toward better public health outcomes. As online transactions with public institutions become more common, security should become more of a priority. Digital identity verification, widely used only in a small number of countries at present, may be seen as more of a necessity going forward.

Trends to Watch

COVID-19 will lead to a realignment of city priorities and the recognition of the central role technology can play in achieving them. Complex challenges around data integration will remain, but engaged leaders and strong mandates may help some to surmount these.

Automation will become a routine part of many services. AI, robotic process automation, intelligent CRM solutions, and low-code platforms will all have a role to play. Aided by automation and better data analysis, city services will gravitate toward a model of proactively pushing services out to residents.

Digitizing services may not free up staff time as much as anticipated because simpler, more efficient, and accessible services tend to experience far heavier use.

Real-time data exchange and processing will become a reality, and the tools and networks that enable this will become commonplace. City data will play an even more important role in policy making and could increasingly be used by supporters and detractors to substantiate or to denounce policies.

New approaches to data governance will give residents the opportunity to be more involved in how their data is used and by whom. The COVID-19 pandemic has brought some of these conversations into sharper focus.

Cameras will play a more important role in the built environment as they become more affordable and more versatile thanks to video analytics, but privacy issues will become more pertinent and controversial. Regulatory policies concerning surveillance technology will vary from city to city.

The movement toward digital twins will continue. Where services already allow residents to explore map-based visualizations, 3D models will also become available.

"**I foresee Milan in 2025 as a city with many customized services delivered online and directly accessible from mobile.** We are currently working on boosting digital services for all and sharing the value of digital culture; technology must be accessible and inclusive."

Roberta Cocco,
Deputy Mayor for Digital Transformation and Citizen Services, Comune di Milano

City Snapshots

Amsterdam, The Netherlands

Mayor: Femke Halsema

Population: 1,139,606

Number of employees: 15,000

City Website: amsterdam.nl

Priorities:
- Mobility
- Health
- Public Space

"Data that government authorities, companies, and other organizations generate from the city and collect about the city are held in common. Everyone can use them. Everyone can benefit from them."

Tada.city
Data Manifesto Principle 6

Digital Leadership

Ger Baron is the Chief Technology Officer of Amsterdam. His mandate includes city innovation, technology, and data policy. Chief Information Officer Mark Crooijmans runs IT operations; Chief Data Officer Berent Daan works on data strategy and analytics. In total, more than 900 people work in technology, data, and innovation-related roles in the city government.

Putting citizens at the heart of digital and data programs

The City of Amsterdam's digital programs align around three ambitions: a free digital city, an inclusive digital city, and a creative digital city. New approaches to data governance are being pioneered through the Amsterdam Data Exchange and the EU-funded Decode project in collaboration with the Barcelona City Council. Recognizing that city data is most often collected and used by the private sector, the Tada.city manifesto on data is the basis for a data commons that demands "people stay in control of the data, and not the other way round."

The Responsible Sensing Lab, a partnership between the City of Amsterdam and the Amsterdam Institute for Advanced Metropolitan Solutions (AMS), is shifting the narrative on policy making from "data-driven" to "citizen-driven," with a high regard for privacy and personal data rights. Data analytics are helping city officials to achieve a deeper understanding of urban life, including correlations that point to the causes of childhood obesity like the presence of unhealthy food vendors close to schools.

The city is investing in open source tools and exploring new applications for AI. The Object Detection Kit (ODK.ai) is an image recognition software used with cameras and video analytics to scan images of objects from the city's streets to detect issues such as graffiti, trash, and broken streetlights. In the future, it will be used in non-emergency reporting so residents can simply upload a photo rather than filling out a form. Several municipalities have collaborated to develop the tool, which is now available as open source software.

Atlanta, USA

Mayor: Keisha Lance Bottoms

Population: 506,811

Number of employees: 8,612

City Website: atlantaga.gov

Priorities:
- Gentrification
- Homelessness
- Sex Trafficking

"Being able to have data will allow us to speak more intelligently about our placemaking policies and our economic development strategies."

Lillie Madali,
Smart City Program Director

Digital Leadership

Gary Brantley is the Chief Information Officer for the City of Atlanta. He is supported by an executive team comprising a Chief Technology Officer, a Chief Information Security Officer, and several deputy CIOs. Lillie Madali is the Director of Atlanta's Smart City Program.

Internet of Things and video analytics support the collection of city data

Tracking tools are helping to promote transparency by visualizing progress toward policy goals. One example is an affordable housing dashboard that shows the proportion of affordable units built as part of new developments across the city. This tracker enables the city to monitor and hold developers accountable in accordance with an ordinance mandating that all rental developments must set aside a certain percentage of units for affordable housing.

Atlanta's smart street lighting pilot program has been run in partnership with Georgia Power. In 2017, 200 "smart nodes" were installed on utility poles around the city. These nodes are equipped with atmospheric sensors and cameras that link to video analytics software, which can automatically detect incidents using image recognition supported by AI. The cameras have been tested on several transport and law enforcement-related use cases.

The opportunities identified in the transport pilots are promising: unlike in-person transport studies, which take place twice a year over a single day at specific intersections, the nodes collect data around the clock, allowing the city to better understand the behavior of drivers, cyclists, and pedestrians. It is hoped that the new data collected will inform transportation planning decisions in the future.

Barcelona, Spain

Mayor: Ada Colau

Population: 1,628,412

Number of employees: 15,000

City Website: barcelona.cat

Priorities:
- Social Inclusion
- Mobility
- Sustainability

"Now, you need to ensure that every policy you are performing is effective. One way to ensure that is to implement a smart city and ensure that you are measuring the results of your policy."

Marc Pérez-Batlle,
Head of Innovation Projects,
Municipal Institute of
Information Technology

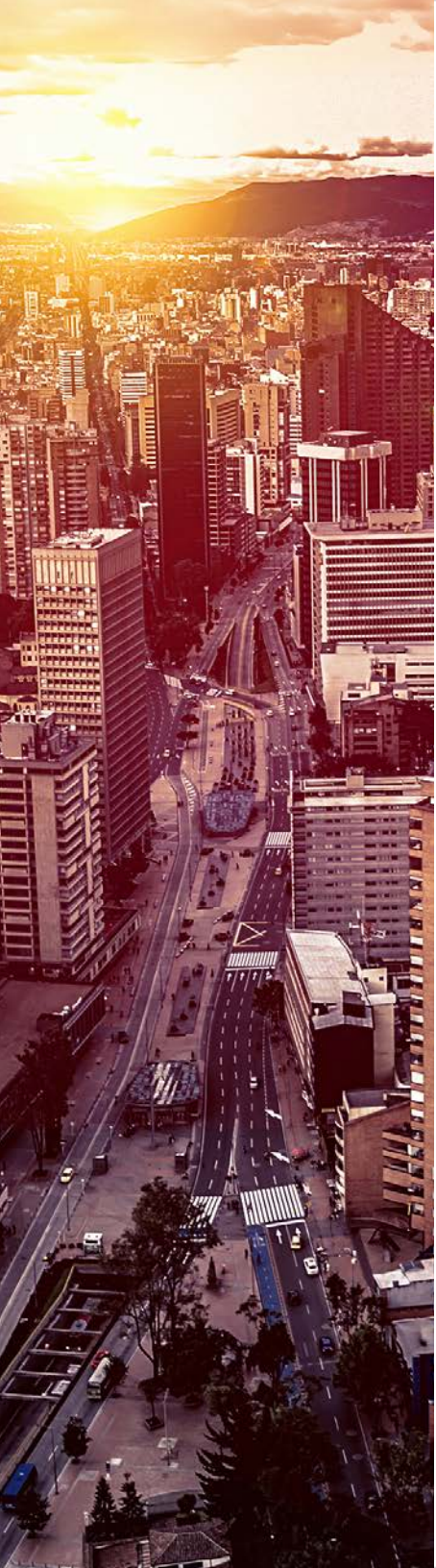
Digital Leadership

Commissioner for Digital Innovation Michael Donaldson was appointed by Mayor Ada Colau to oversee the municipality's strategy and policies for digital innovation. Marta Continente, the Director of Innovation, bridges the gap between tech policy and operational agendas, while Francisco Rodriguez, as the Director of the Municipal Institute of Information Technology, is the city CIO. Barcelona Activa, the economic development agency for the city council, is responsible for digital economy and digital inclusion programs.

Sensor data informs city management and policy making

The Barcelona City Council has installed a comprehensive sensor network across the city over the past 10 years. They are now starting to reap the benefits. Environmental data and infrastructure data are orchestrated through Sentilo, an IoT brokering tool developed in-house. The municipality pushed its suppliers to develop products compliant with the platform, which has resulted in an effective ecosystem of apps and services that make use of the city's sensor network. The data feeds into Barcelona's CityOS, which is helping city departments to better manage operational processes and allows policy makers to draw on evidence when designing and testing new approaches.

The city is at the forefront of thinking around 5G-enabled urban infrastructure. With well-established connectivity and sensor networks already in place, the city's current focus is on interpreting EU legislation to ensure the right regulatory conditions and infrastructure is in place for public and private organizations. The city has also been leading work across Europe looking into the ethical use of citizen data.



Bogotá, Colombia

Mayor: Claudia López Hernández

Population: 8,363,671

Number of employees: 140,000

City Website: bogota.gov.co

Priorities:
- Public Health
- Public Safety
- City Data

"Our vision in these four years is to create a policy for a smart territory in Bogota."

Felipe Guzmán Ramírez,
District High Councilor for ICTs

Digital Leadership

Felipe Guzmán Ramírez is the Alto Consejero Distrital (District High Councilor) for Information and Communication Technologies (ICTs) and leads the Alta Consejería Distrital (District High Council) for ICTs. This strategic body manages the delivery of the digital strategy across the 15 city government secretariats. It also provides a link between national and local technology policy.

Digital tools support citizen solidarity during COVID-19

Bogotá's District High Council for ICTs is playing an important role in responses to the COVID-19 pandemic. Working with teams across the city government, they have launched three initiatives: Learn from Home (Aprende en casa) makes education tools available online for everyone; Solidarity at Home (Bogotá Solidaria en Casa) encourages neighborhood solidarity by enabling people to make monetary donations; and the Caring Citizens Network (Red de Cuidado Ciudadano) allows residents to volunteer to help to those most in need.

The Council for ICTs is using data analytics to track and contain the spread of the virus and to model different scenarios out of the crisis. The city will increase its data sources in the future through a planned IoT network, which the municipality will deliver in partnership with the Empresa de Telecomunicaciones de Bogotá (ETB), a national telecommunications provider based in the city.

Bogotá already has a track record of making data open. Datos Abiertos Bogotá (Open Data Bogota) is a mature open data platform with curated data presented in 33 thematic areas. The city's IDECA (Spatial Data Infrastructure) platform provides a set of standards, protocols, and policies for the publication of geographic information. Spatial data in 19 categories, ranging from education to social inclusion, can be viewed by the general public for free through a web-based map.

Boston, USA

Mayor: Martin J. Walsh

Population: 692,600

Number of employees: 22,000

City Website: boston.gov

Priorities:
- Transportation
- Affordable Housing
- Technology in Schools

"Our goal is to create a Citywide strategy for the use of sensor technologies that is people-centered, problem-driven, and responsible."

Boston Smart City Playbook[26]

[26] City of Boston (N.D.), Boston Smart City Playbook, monum.github.io/playbook [accessed August 10, 2020].

Digital Leadership

Boston's Department of Innovation and Technology (DoIT) is led by David Elges, Chief Information Officer; he was appointed by the Cabinet. Elges is supported by several senior colleagues in the DoIT: Daniel Rothman is Chief Technology Officer; Jeanethe Falvey is Chief Digital Officer; Stefanie Costa Leabo is Chief Data Officer; Greg McCarthy is Chief Information Security Officer; and Michael Hamel is Chief of Enterprise Applications. Elsewhere in the city government, Chief of Streets, Transportation & Sanitation Chris Osgood was also appointed by the Cabinet and plays an important role in technology and smart city projects in the public realm.

Data analysis and geolocation improves the resolution of non-emergency 311 resident reports

The City of Boston is introducing a linear referencing system to provide more granular street location information. This will pinpoint the precise locations for resident requests such as 311 non-emergency reports and applications for street occupancy permits. At present this is usually done using the cross street, which is often an imprecise measure.

Digital identity management is already being used by employees; a future step for the city will be to expand identity and access management to resident services to enable a more streamlined user experience. Data analytics in performance management have improved the resolution time for 311 non-emergency reports. IoT trials are under way to monitor noise and environmental pollution and to measure traffic congestion.

A housing search application is currently in development. When launched, it will bring disparate information currently available on different parts of the city website into a single, consistent platform where every listing is vetted and verified by the Department of Neighborhood Development. The tool has been through a user-centered design process over the past year and should launch in the summer of 2020.

Bratislava, Slovakia

Mayor: Matúš Vallo

Population: 432,500

Number of employees: 700

City Website: bratislava.sk

Priorities:
- Citizen Services
- Public Space
- Climate

"Since the corona outbreak we have had to change our plans. We are now focusing more on the digitalization projects that came out of our Innovation Track such as local neighborhood management and engagement tools."

Petra Dzurovcinova,
Chief Innovation Officer

Digital Leadership

Mayor Matúš Vallo has placed strong emphasis on innovation and taking a holistic approach to city operations and services since his election in 2018. In January 2019, Bratislava appointed its first Chief Innovation Officer, Petra Dzurovcinova, and, in April 2019, its first Chief Data Officer, Pavol Skapik. In 2020, the city will launch a suite of initiatives including the Bratislava City Lab, a vehicle for innovation that will run collaborative projects with university partners and test the viability of new technologies and business models.

Digital innovation gains traction in pursuit of environmental goals

The COVID-19 pandemic has stimulated the City of Bratislava to focus on how digital innovation can support citizen engagement, neighborhood management, and environmental objectives. A digital engagement platform is in development. It will enable residents to play a more active role in shaping their local environment and greening their neighborhoods.

Despite an estimated budget shortfall of nearly €40 million (almost 10 percent of the city government's annual budget) as a result of the pandemic, environmental sustainability remains a top priority. A key mayoral initiative to plant 10,000 trees in the city continues. The engagement platform supports this immediate objective and serves as a key building block that will underpin a digital account for resident services in the future.

During the outbreak, the city has seen a big drop in public transport usage, and more people have started to cycle. In response to the changing habits of residents, the city is developing a new mobility app. The app will provide information about public transport options, bike paths, bike sharing, and other micro-mobility services. The city is also starting a parking sensors pilot to improve accessibility of drop-off zones and to improve adherence to the parking rules.

Cape Town, South Africa

Mayor: Dan Plato

Population: 3,859,500

Number of employees: 26,225

City Website: capetown.gov.za

Priorities:
- Public Health
- Transport
- Safety and Security

40,000 people work in the tech sector in the Cape Town region, more than any other city in Africa.[27]

[27] Cape Town CCID, (2018), The State of Cape Town Central City Report, p. 16. www.capetownccid.org/about-ccid/publications/The-State-of-Cape-Town-Central-City-Report/61 [accessed August 10, 2020].

Digital Leadership

Omeshnee Naidoo is the Director of Information Systems for the City of Cape Town. She is responsible for running the city's IT operations and delivering the city's digital strategy. The provincial Western Cape Government's Digital Economy Unit runs a series of initiatives to support the regional tech ecosystem.

Investing in infrastructure to support the digital economy

The City of Cape Town is implementing a digital city strategy based on four pillars: digital government, digital inclusion, digital economy, and digital infrastructure. They have worked closely with internet service providers to offer broadband connectivity to hundreds of public buildings. The Connect Pilot Project is providing high-speed fiber to 1,000 buildings in the central business district and free WiFi for visitors.

These initiatives provide a digital infrastructure backbone that will make it easier and cheaper for commercial operators to lay their own connections to residential dwellings. By providing world-class connectivity, the city also hopes to support and attract innovative businesses.

Digital tools for enterprise resource planning are improving the management of the city's water infrastructure when responding to service requests and scheduling maintenance. In the future, the city plans to equip sensors to remotely monitor the supply and use data analysis to gain insights into consumption habits.

Copenhagen, Denmark

Mayor: Frank Jensen

Population: 632,340

Number of employees: 40,000

City Website: international.kk.dk

Priorities:
- Citizen Welfare Services
- Climate Change
- Urbanization Challenges such as Congestion and Air Quality

"The nut that we have to crack is that we have a data bias that leans toward cars ... but it's pretty hard to get access to data about cyclists."

Rasmus Bertelsen,
Specialist Consultant,
Office for Digitalization

Digital Leadership

The Office for Digitalization, led by Maria Antonsen, was established in 2018. Based in the lord mayor's department, the office coordinates strategic interventions across the seven departments in the municipal administration and informs citywide policy decisions. Each department has its own digitalization unit. A shared service function, led by a CTO, provides IT infrastructure and operational support for the departments. The city is represented by the lord mayor on the board of KL, the association for local governments in Denmark; KL works with other municipalities and liaises with the national government on the digital agenda.

Investments in artificial intelligence can support city operations and citizen welfare

The City of Copenhagen has earmarked an annual budget of DKK 400 million (over US$ 55 million) for innovating and implementing smart solutions that support administration and citizen welfare services. Investments have been made into tools that use AI. The case worker's assistant used in welfare services takes information on a person's skills and job history and offers support and suggests employment opportunities. Automatic document recognition is used for passports and other forms of identification to speed up the verification process for criminal records checks.

Big steps forward have been made in reducing incomplete applications for building permits: previously 70 percent were invalid in some way. The city is developing a solution wherein AI screens all applications for errors — they are only passed on to the city's building permits team when complete. Copenhagen benefits by being able to integrate city services with NemID, the national digital identity service.

Bicycles outnumber cars five-to-one in Copenhagen and can create their own congestion issues. The municipality is looking to apply Intelligent Transport Systems, initially developed with motor vehicles in mind, to cyclists. The goal is to better understand cyclist behavior and to improve digital signage and route planning options.

Denver, USA

Mayor: Michael Hancock

Population: 727,211

Number of employees: 14,000

City Website: denvergov.org

Priorities:
- Affordable Housing
- Mobility and Transportation
- Population Growth

"We currently spend 90 percent of our time trying to track down the data, and only 10 percent making use of it. We want to flip this around."

– David Edinger,
Chief Information Officer

Digital Leadership

David Edinger is the CIO of the City and County of Denver, where he leads the Technology Services department. He is supported by several colleagues in key positions: Deputy CIO Christine Binnicker, Chief Technology Officer Chris Todd, Chief Data Officer Paul Kresser, Chief Applications Officer Chad Mitchell, and Chief Marketing Officer Jenny Schiavone. The Technology Services team manages a $10 million annual Innovation Fund (iFund), which is used to tackle large citywide challenges that span different service areas. The governance group is made up of heads of different departments.

Digital permitting speeds up buildings permits

The iFund has commissioned a Data Hub that will consolidate disparate datasets into a single platform so the city can make better use of data insights and analytics.

Denver's population growth is well above the national average, and housing supply is a key challenge. New digital tools are being used by the Department of Housing Stability to better manage the city's current supply of 20,000 affordable housing units by streamlining key reporting, application, and invoicing processes. With less administrative work, housing inspectors can now spend more time effectively enforcing regulations.

The City and County of Denver have made significant progress in digitizing the permitting and plan submission services. In the summer of 2017, electronic submittals were launched for "quick permits," including those for roofing, siding, and water heaters. In 2019, electronic submittals could also be made for more complex projects and trade permits that must be reviewed by multiple city agencies. By April 2020, nearly 80 percent of permit requests were being made online. Planning submissions have also seen a sharp rise. Partly driven by the closure of in-person counters as a result of COVID-19, electronic plan submissions increased by 30 percent between March and April 2020.

Dublin, Ireland

Mayor: Lord Mayor Hazel Chu

Population: 1,214,700

Number of employees [Dublin City Council]: 5,900

City Website:
smartdublin.ie
dublincity.ie

Priorities:
- Traffic Congestion
- Environmental Monitoring
- Urban Planning and Design

"We need to be adaptable and resilient, but we also need to remember to be inclusive. Challenges of digital literacy and access to digital supports and services still exist, and finding solutions to bridge the digital divide should also be at the top of our agendas."

Nicola Graham,
Smart City Operations Manager

Digital Leadership

Smart Dublin is a joint initiative across the four Dublin Councils. It has a dedicated team as well as representatives from the partner councils. Smart Dublin aims to address challenges facing the region by utilizing data and new smarter technologies and by garnering support from businesses, universities, other public bodies, and citizens. Within Dublin City Council, Jamie Cudden is the Smart City Program Manager and Eileen Quinlivan leads the Transformation Unit, which focuses on organization-wide opportunities for internal digital transformation.

Smart Districts serve as testbeds for new technologies

One of Smart Dublin's flagship programs is the creation of three "Smart Districts." They are demonstrator areas for new technologies and business models in the city. The districts provide a space for start-ups to propose and test new solutions and for the city councils to partner with larger companies – like Mastercard and Google – to make better use of commercial and environmental data in order to guide decision-making.

Smart Docklands is the longest-established district and focuses on connectivity and IoT solutions. A 3D model within the district is allowing new conversations to take place by whisking residents into a virtual reality environment where they can view proposed developments and engage in planning discussions. In May 2019, a 3D Data Hack investigated other uses of the model using augmented and virtual reality tools. A proposal from Dublin's Fire Brigade uses the model to pinpoint the location of fire hydrants so crews are better prepared when they reach a fire.

Dublin City Council is exploring new ways to identify flooding incidents and to alert city officials in real time using IoT sensors and automated notifications. A collaboration with University College Dublin is developing a predictive model for flooding by collecting detailed baseline data from local watercourses; this data will feed into future flood mitigation strategies.

Ghent, Belgium

Mayor: Mathias De Clercq

Population: 260,341

Number of employees: 5,000

City Website: stad.gent

Priorities:
- Housing
- Mobility
- Poverty and Economic Issues

"We can provide so much information. … the right information at the right time, so that people don't feel the need anymore to use the car to move about the city."

Bart Rosseau,
Chief Data Officer

Digital Leadership

Sofie Bracke is the Vice Mayor responsible for digital affairs. The city is currently in the process of reorganizing its technology structures. Previously, IT services were delivered via Digipolis, a public company founded by the cities of Ghent and Antwerp in 2003; by the end of 2020 Digipolis will serve the cities separately. Johan Vander Bauwhede is the Director of Digipolis Ghent and the CIO for the city. Within the Strategic Office of the Stad Gent (the city administration), Bart Rosseau leads digital projects in his role as Chief Data Officer.

Technology supports a car-free city center

Stad Gent is encouraging its residents to reduce their car use through a number of ambitious programs promoted by the Vice Mayor for Transport, Filip Watteeuw. This includes the largest pedestrianized zone of any city in Europe and the recent introduction of a low-emission zone.

The municipality's goal is to make the right transport information available to residents at the right time, so that they don't feel the need to use their cars to move around the city. By collaborating with other organizations delivering transport services, the city is collecting, managing, and sharing data better, while ANPR (Automatic Number Plate Recognition) cameras are making the operation and enforcement of the low-emission zone a reality.

Inside City Hall, Stad Gent is taking steps to ensure greater consistency across all departments by establishing a common dashboard for KPIs and standardized definitions of key terms. By improving how they use existing data, the city aims to take a more proactive approach to welfare payments that support vulnerable residents.

Glasgow, Scotland

Mayor: Lord Provost Philip Braat

Population: 629,086

Number of employees: 19,000

City Website: glasgow.gov.uk

Priorities:
- Environmental Sustainability
- Skills
- Health and Well-being

"I would advise any council to think about defining the responsibilities for their digital leadership role and where it sits in the organization."

Colin Birchenall,
Chief Digital Officer

Digital Leadership

Colin Birchenall is the Chief Digital Officer for Glasgow. He divides his time between leading the Digital Glasgow program and a separate role as Chief Technology Officer for the Digital Office for Scottish Local Government, through which knowledge is shared with other Scottish cities. The 11-person Digital Glasgow Board provides oversight of the implementation of the Digital Glasgow Strategy and is made up of elected councilors drawn from across the political spectrum and senior officers from the Council. Councillor Angus Millar, Convener for Inclusive Economic Growth, is the dedicated political sponsor for the Digital Glasgow program.

Connected street infrastructure and capability development support the city's aspirations

The Digital Glasgow Strategy sets out a vision for Glasgow to become one of the most innovative and pioneering smart cities in the world. Building upon its experience as the UK's Future Cities Demonstrator, Glasgow continues to innovate and scale up its smart city infrastructure. Intelligent street lighting now covers the entire city center, while further EU funding is supporting a Smart Streets project. The new network of street lights also provides electric vehicle charging points. Meanwhile, smart energy ideas such as demand-side energy management that better manage consumption at peak times are being tested in public buildings and social housing.

The Connected Learning Program concentrates on the opportunities that digital technology can create for young people. More than 50,000 iPads have been given to school-age students, the largest program of its kind in the world.

The Glasgow City Council is upgrading its existing 3D model to a more feature-rich digital twin of the city, which will be published as open data and used for scenarios ranging from planning and development to tourism. Underpinning all of the City Council's programs is a focus on building greater capability for digital leadership and skills, data analytics, open data, and open innovation.

The Hague, The Netherlands

Mayor: Jan van Zanen

Population: 546,335

Number of employees: 10,000

City Website: denhaag.nl

Priorities:
- Mobility
- Safety and Security
- Livability

"If you want to solve something you first have to make everybody aware that there's a problem."

Marijn Fraanje,
CIO and General Manager
of Information and IT

Digital Leadership

Marijn Fraanje, the city CIO and General Manager of Information and IT, is responsible for IT operations and services and smart city programs. Among others, he is backed up by a Chief Data Officer, a Chief Information Security Officer, a Chief Enterprise Architect, and a Data Protection Officer. The Hague collaborates with counterparts through the Association of Netherlands Municipalities (VNG) and a network of CIOs from the four largest cities, which provide platforms for collective procurement, knowledge sharing, training, and policy recommendations.

Experimentation zone trials new technology solutions to local problems

The municipality has installed comprehensive digital infrastructure as part of the redevelopment of the Scheveningen Beach district, transforming the area into a living lab to trial new technologies. Local stakeholders have been asked what problems they would like to see solved using the new infrastructure. From the 147 use cases that were identified in Scheveningen, they are now working on 16 pilot projects.

Among these are providing sustainable electricity to beach bars via solar panels and excess electricity from other buildings rather than using noisy gas generators, trialing an autonomous beach cleaning robot, and monitoring local wildlife using connected cameras. The city is developing its "urban operator" role as facilitator of digital innovation processes between citizens, government agencies, and private parties for key social challenges in the area. These pilot projects are being explored as potential interventions that could be scaled elsewhere.

Leveraging its central role, the municipality is coordinating better digital innovation practices based around a transparent and inclusive approach. To achieve this, the city is working closely with its business community and providing locations and funding for The Hague Security Delta, The Hague Tech, and Yes!Delft! communities for start-ups and scale-ups. The municipality aims to create a diverse ecosystem that encourages innovation to tackle city challenges.

Helsinki, Finland

Mayor: Jan Vapaavuori

Population: 655,395

Number of employees: 37,000

City Website: hel.fi

Priorities:
- Digital Services
- Climate Change
- Ageing Population

"We are on the road to a society that is proactively identifying service needs and that can better and more effectively respond to the varying needs of every citizen."

Finnish Ministry of Economic Affairs and Employment

Digital Leadership

Mikko Rusama is the Chief Digital Officer for the City of Helsinki and the Chairman of the Board for Forum Virium Helsinki, the city's innovation company. Forum Virium Helsinki works on research and innovation programs across the industry and with international partners. The city has recently appointed a Head of Data, Kimmo Karhu, who leads the delivery of Helsinki's data strategy. The Digital Management Team, led by Rusama, is defining common citywide capabilities and platforms that can be used across city operations.

Using data to adopt a more proactive approach to citizen services

The City of Helsinki focuses on digital services and making better use of data. Digital twins and a 3D model of the city are helping to inform planning decisions; a next step is to bring the different datasets and streaming data together into a federated model of the city. In health care, the city is exploring how to move toward a more preventive approach using health, social, and urban data of citizens in response to the growing and ageing population.

Helsinki aspires to proactively offer services to residents. For instance, they are transforming how parents apply for preschool places for their children. Traditionally, this has been done via an application form, but the city is trialing a new approach whereby they proactively contact families via SMS message concerning availability.

Helsinki continues to experiment with autonomous vehicles, most recently via two active seasonal bus routes. The city-owned energy company is allowing them to directly encourage smarter and more cost-effective electricity use; in the near future, the city plans to improve data analytics capabilities by placing more emphasis on data science.

Kansas City, Missouri, USA

Mayor: Quinton Lucas

Population: 495,327

Number of employees: 4,400

City Website: kcmo.gov

Priorities:
- Infrastructure Maintenance
- Service Delivery
- Violent Crime

Kansas City, MO, has 54 square blocks of free public Wi-Fi, complete with interactive kiosks, sensors, and smart street lights and traffic signals.[28]

[28] City of Kansas, Missouri (N.D.), Emerging Technology Initiative (Smart City), https://www.kcmo.gov/programs-initiatives/emerging-technology [accessed August 17, 2020]

Digital Leadership

David Evans is the city's CIO, responsible for IT operations and core services. Some IT management is decentralized to individual departments. Kate Bender is the Deputy Performance Officer for Data KC. Her role involves accessing, analyzing, and reporting data to support city management. Kansas City is currently establishing an Emerging Tech Governance Board. This group will be made up of citizens, business leaders, and academics who act as a sounding board for conversations around new technologies and projects that the city is considering.

Using data to adopt a more proactive approach to citizen services

Kansas City is a dispersed city – technology helps city officials to stay on top of issues that are occurring in different places. An extensive network of connected CCTV cameras provides support to the police department. By integrating this with automatic license plate recognition, they can track vehicles across the city. This has proven to be an important tool for tracking persons of interest.

The city is combining data from multiple sources, including on-street IoT sensors, to inform planning decisions. A significant program to upgrade sidewalks is using this data to help the city to direct investment toward the places that will see the greatest benefit.

Data is also enhancing understanding of important mobility questions. For example, the bus system is underused, yet 10 percent of the population does not own a car. Kansas City has established an extensive electric vehicle infrastructure and is now exploring how best to manage and integrate e-bikes and e-scooters. Currently, two traffic corridors in the city use sensors and intelligent signaling to optimize the flow of traffic and prioritize buses over private vehicles.

Kobe, Japan

Mayor: Kizō Hisamoto

Population: 1,537,272

Number of employees: 21,185

City Website: city.kobe.lg.jp

Priorities:
- City Services
- City Data
- Geospatial Information

27 percent of Kobe's population is aged 65 or over.

Digital Leadership

Kozo Mori is the Director of the Information Strategy Department for the Kobe City Government. Taisuke Matsuzaki, Director of ICT Development, supports the sharing of city data for corporate use. Innovation Specialist Hisashi Nakazawa leads several programs with the goal of engaging start-ups and tech businesses in developing solutions for the city's most urgent challenges.

Innovation programs engage businesses to solve citywide problems

Against the backdrop of a declining urban population, Mayor Hisamoto is spearheading an open government approach to attract and retain young, creative minds by encouraging new businesses to apply innovative approaches in addressing key city challenges.

This approach is primarily being orchestrated through Urban Innovation Japan. Formerly called Urban Innovation Kobe, it provides a platform for start-ups and SMEs to work in partnership with the city government on specific problems. The program sees around 20 projects developed each year – on average 70 percent of these go on to become operational. The success of the program has attracted interest from 15 other cities, and it is beginning to scale across the country. Kobe is fast becoming a regional center for innovation; the city is also host to the United Nations Office for Project Services' Global Innovation Centre and the 500 Kobe accelerator program.

My Condition Kobe, a tool developed by a local start-up called Link and Communication, allows people to monitor and manage their own health via a personal health record. Residents log health examination results and details like their blood pressure, body weight, and exercise routines, and receive tips and health advice in return. By opening up its data, the City of Kobe is beginning to see the private sector step in to provide solutions. For example, Code for Kanazawa develops digital tools to support residents, such as the 5374.jp app, which allows residents to look up the trash collection schedule for their area.

London, UK

Mayor: Sadiq Khan

Population: 8,961,989

Number of employees: 1,000
[Greater London Authority]

City Website: london.gov.uk

Priorities:
- Reducing Heavy Freight Journeys
- Air Quality
- Violence Reduction

"The Datastore is foundational for all data. Sitting alongside it are a few quite intensive projects that require a lot of data. The Datastore complements these."

Theo Blackwell,
Chief Digital Officer

Digital Leadership

Theo Blackwell is the Chief Digital Officer for London. He is based at the Greater London Authority (GLA), the strategic body for London. Each of London's 32 boroughs operate autonomously with their own digital leadership. In most cases, this is led by a Chief Digital or Information Officer. The Metropolitan Police and Transport for London (TfL) also have their own leadership; TfL has a dedicated transport Innovation team. Other significant public organizations are the London Office for Technology Innovation (LOTI) and the London Office for Rapid Cybersecurity Advancement (LORCA).

Facilitating citywide collaboration to develop common outcomes

Each London borough works independently, so cross-borough working and collaboration can be a challenge. To help overcome this, LOTI was created in 2019 with initial focus areas that included digital apprenticeships and common approaches to data governance. It serves boroughs through a membership model; 15 boroughs joined when the office launched in June 2019, and others have since joined. During the COVID-19 pandemic, LOTI has been playing a vital role in supporting knowledge exchange and consistent approaches between the boroughs.

The London Datastore, the central register of open and secure data in London, is being revamped with a view to (re)launch in 2020. Citywide, live trials are running for data projects that map underground infrastructure and air quality. There is a plan to install a network of IoT-enabled sensors to make air quality data available as close to real time as possible via the London Datastore.

By introducing better data sharing and analytics between different organizations in the city, the GLA hopes to make targeted interventions to tackle violent crime and to provide more meaningful communications to citizens.

Los Angeles, USA

Mayor: Eric Garcetti

Population: 3,979,576

Number of employees: 50,000

City Website: lacity.org

Priorities:
- Climate Change
- Homelessness
- Mobility

In Los Angeles, public transit ridership is at about 36 to 38 percent of pre-COVID levels, while other cities have seen this drop as low as 10 percent of pre-pandemic levels.[29]

[29] KCRW Greater LA Podcast (July 2020), Public transit ridership is better in LA than some other U.S. cities during pandemic – quoting an interview with Alissa Walker, Urbanism Editor at Curbed. www.kcrw.com/news/shows/greater-la/condors-coronavirus-tracing-public-transit/metro-ridership [accessed August 10, 2020].

Digital Leadership

Los Angeles has several key digital leadership roles. Miguel Sangalang is the Deputy Mayor for Budget and Innovation, who works to help transform City operations by connecting core government functions to new technology and innovative practices. Ted Ross is the city's CIO, Amanda Daflos is the city's Chief Innovation Officer, and Jeanne Holm works both as Chief Data Officer and Senior Technology Advisor. Elsewhere in the city, the Chamber of Commerce provides advice to local businesses. Through the Data Science Federation, professors and students from the city's universities and colleges work in partnership with city government to address some of LA's biggest challenges.

New technologies support public safety and emergency services

LA is an active testbed for future technologies such as autonomous vehicles and even autonomous helicopters. The fire department uses drones for inspections; the water and power utilities are using drones for maintenance in hard-to-reach parts of their infrastructure. This experimentation is enabled due to the city's live 5G network, which has covered the majority of the city since 2018.

Mobility is a key area of innovation. In November 2019, Mayor Garcetti launched Urban Movement Labs, a unique public-private partnership that aims to accelerate transportation innovation across Los Angeles to better meet the mobility needs of all residents. The city is encouraging the adoption of shared mobility solutions such as electric bikes and scooters. As low-emission modes of personal transportation, these solutions are also seen as important contributors to LA's urban sustainability agenda. Mayor Garcetti currently serves as Chair of the C40 Cities global initiative to combat climate change.

The City of Los Angeles is currently trialing technologies that monitor pedestrian, bike, and scooter movement through major intersections and inform signaling in order to improve traffic flow and pedestrian safety. The data collected is guiding efforts to make streets more pedestrian-friendly to meet the city's Vision Zero goal.

Melbourne, Australia

Mayor: Lord Mayor Sally Capp

Population: 178,955

Number of employees: 1,700

City Website: melbourne.vic.gov.au

Priorities:
- Population Growth
- Climate Change
- Operational Efficiency

"You can't talk about digital and smart cities without talking about infrastructure and systems."

Rebecca Marson,
Team Leader Smart City Strategy

Digital Leadership

Michelle Fitzgerald is the Chief Digital Officer for the City of Melbourne. As the head of the recently merged technology services and smart city office teams, Fitzgerald is ultimately responsible for both internal IT operational and external digital innovation programs. Brenden Carriker is the Director of CityLab, the city's internal center for design-led innovation. The Victoria State Government also plays an important role in technology-enabled projects in the city.

Smart city testbeds explore governance in addition to technology viability

The CityLab and digital technology teams are working to mainstream human-centered design approaches across city government. Melbourne has a strong GIS capability that is growing to incorporate more 3D data and is now looking ahead to how building information modeling can support planning and building management.

Melbourne's *City DNA* program is using augmented and virtual reality to engage residents with the history and culture of the city during citywide public engagement events. The ultimate goal is to use these digital tools to foster a new kind of civic participation.

An emerging technology testbed program is under way to explore the possibilities presented by IoT and 5G in the city, making ready for the live deployment of 5G networks in 2020. By bringing together 26 partner organizations from different industries, they are collaborating on a series of pilots on topics such as telehealth, intelligent transport systems, and smart energy systems. The partnerships are underpinned by a governance-led approach, which puts legal frameworks and data sharing front and center. As well as being a platform for learning about tech use, the program is contributing to the design of technology policy, data protocols, and standards.

Milan, Italy

Mayor: Giuseppe Sala

Population: 1,686,013

Number of employees: 14,374

City Website: comune.milano.it

Priorities:
- Resident Well-being
- Digital Services
- Data-driven Policy Making

In three years, the city has gone from having 30 percent of services online to 68 percent of services online.

Digital Leadership

Roberta Cocco is the Councillor for Digital Transformation and Citizen Services at the Comune di Milano. She works closely with Mayor Beppe Sala on the strategic approach to technology and service delivery. On the operational side, the Director of Information Systems and Digital Agenda manages IT operations and infrastructure and is responsible for data in the municipality.

Putting digital services into the pockets of residents via a mobile application

The Comune di Milano places a lot of emphasis on the digitization of services. Three years ago, just 30 percent of services were online, but now that figure is 68 percent. The benefits to the city are significant. By digitizing services, the cost of a face-to-face transaction is reduced from at least €4.40 to €0.20. Beyond saving time and money in City Hall, Milan also recognizes the wider benefits for citizens, which include fewer CO_2 emissions due to a reduction in traffic congestion when physical appointments are no longer necessary. Milan's digitization push is supported by a comprehensive program of digital inclusion and digital skills training for residents.

In May 2020 Milan launched a mobile app that brought all city services together and put them into residents' pockets, allowing them to view their transaction history, receive relevant notifications, and make requests and payments through the app. The municipality takes digital identity very seriously and currently manages more than 533,000 digital identities. The long-term plan is to fully integrate SPID – the national Public System for Digital Identity – into all services. This supports a wider service integration agenda that will enable a greater understanding of each resident's different interactions with the municipality.

Milan is in the early stages of IoT experimentation and making more use of sensor data in the city. The vision is to use data from the city, from residents, and from services to guide all policy decisions.

Paris, France

Mayor: Anne Hidalgo

Population: 2,148,271

Number of employees: 52,000

City Website: paris.fr

Priorities:
- Digital Services for Residents
- Public Space and Environmental Management
- Inclusivity and Social Housing

The City of Paris has built more than 70 citizen services on Lutece, their open source platform for city services.

Digital Leadership

Digital leadership responsibilities in Paris are divided between internal and externally focused capabilities. First Deputy Mayor Emmanuel Gregoire's Cabinet leads on digital services and IT, where Nejia Lanouar is the CIO. She is aided by Jean-Philippe Clément, the Chief Data Officer, and Pierre Levy, who directs open source software development projects, including Lutece. Externally focused smart city initiatives are led by Deputy Mayor Jean- Louis Missika's Cabinet where Sabine Romon is the Chief Smart City Officer.

Platforms for open source software and GIS integrate different city services

Over the last five years, Paris has built more than 70 digital services on Lutece, their open source software platform. The platform, which was developed in-house, frees them from proprietary software and lengthy contracts, giving flexibility and autonomy with their suppliers that they didn't have before.

Significant steps have been made to consolidate GIS technologies by bringing all geospatial information into a common platform. This now offers an integrated view of city data, which is helping to improve responses to fires, flooding, and other emergencies. It also allows the city government to monitor demand for services and analyze the effectiveness of their interventions. In the future, they plan to bring this data into a 3D model of the city.

In 2018, the city government decided to establish and operate its own data center, which was previously outsourced. This enables the city to directly manage their resident data and has proven to be an economical choice. The cost is shared with other public organizations, such as the Parisian Hospitals Foundation, which leases co-location services from the city.

Pune, India

Mayor: Murlidhar Mohol

Population: 6,501,957

Number of employees
Pune Municipal Corporation**:**15,000

City Website: pmc.gov.in

Priorities:
- Citizen Engagement
- City-level Operations Management and Planning
- Service Delivery

80 to 90 percent of Pune Municipal Corporation's systems are now hosted on the cloud.

Digital Leadership

Rahul Jagtap heads the Pune Municipal Corporation's IT department. As the city's CIO, he manages the organization's IT infrastructure and operations and oversees work around open data. The Tata Trust philanthropy provides external support on data operations, led by City Data Officer Anita Kane. Pune Smart City Development Corporation, which has a strong focus on external projects and is funded through the national government's 100 Smart Cities Mission, is led by Chief Executive Officer Kolte Patil. Aniruddha Shahahpure is the city's Chief Knowledge Officer.

A comprehensive digitization program reduces demand for in-person appointments

Pune Municipal Corporation (PMC) started a significant move to digitize processes and services in 2016. Now, over half of resident services are available online, and they are identifying ways to improve the usage of data for organizational needs. PMC's open data platform features more than 450 datasets, including environmental and transport data. It has already laid the groundwork for innovation and analytics, which the city encourages through hackathons and partnerships with local universities.

The PMC uses a mixture of open source and proprietary technologies; proprietary software is preferred where sensitive information is involved. Public Wi-Fi is being rolled out across the city to encourage digital literacy across 300 locations, which is aided by relationships with local NGOs that deliver skills programs. The IT Department is experimenting with chatbots, but the diversity of languages present in the city has been a barrier. They have had more success in direct communications with citizens using social media channels where previously a single source of reliable and up-to-date information from the municipality was lacking. The overall program to digitize services is seeing greater transparency in the services delivered and less demand for in-person appointments with city officers.

San Francisco, USA

Mayor: London Breed

Population: 881,549

Number of employees: 50,000

City Website: sf.gov

Priorities:
- Digital Equity
- Customer Experience
- Housing

"If you have some things that really need fixing, they have to be done at an organization-wide level. They can't be done department by department."

Carrie Bishop,
Chief Digital Services Officer

Digital Leadership

The city's Chief Information Officer is Linda Gerull; the city's Chief Digital Services Officer is Carrie Bishop. Jason Lally is the Chief Data Officer. The Committee on Information Technology is a leadership forum within the city government that defines related policies and strategies and has an overview of key programs. As an Enterprise Department, the San Francisco Municipal Transportation Agency operates outside the city government structure and is responsible for technology implementation in transport and mobility services.

Collaboration between city departments supports better services for residents

San Francisco's governance model is highly federated, with different departments operating independently in their own areas. This can present unique challenges. For example, 12 different city departments issue permits and licenses for property in the city. The process can be inefficient if a resident needs to apply for multiple permits at the same time.

The Digital Services team has been streamlining the process for residents and departments. By pulling data held in each department into a central database via a series of APIs, they have eliminated the need to manually move paper forms from office to office. In an exemplar project on "accessory dwelling units," they have reduced the number of forms an applicant needs to complete from 16 down to just one.

Through an innovation challenge initiated by two departments – the Mayor's Offices for Innovation and for Housing and Community Development – the municipality has developed a digital affordable housing service from scratch. Launched in late 2015, it is built around the needs of residents and now receives 97 percent of affordable housing applications.

São Paulo, Brazil

Mayor: Bruno Covas

Population: 12,252,023

Number of employees: 120,000

City Website: capital.sp.gov.br

Priorities:
- Service Delivery
- Inequality
- Mobility

50,000 of the 120,000 staff working for the Prefeitura de São Paulo have been trained in the use of digital devices and processes over the past five years.

Digital Leadership

Juan Quirós is Secretary of Innovation and Technology, though technology leadership in the Prefeitura is decentralized. The city has 23 secretariats, 32 district administration offices, and 15 agencies that each have their own IT management. The central IT Office is led by André Tomiatto, Coordinator of Information Technology and Communication Management. The office plays an important role in setting the technology strategy for the city and is responsible for IT governance and a central repository for city data. The office often works on projects in partnership with other city departments.

Data visualization gives city managers better information about service performance

The Prefeitura of São Paulo embarked on an ambitious digitization program in 2015. Since then they have digitized an estimated 300,000 paper-based processes every year; five years on and the transformation is 99 percent complete. A big part of the program has been training staff to work with digital systems and in new ways; between 40,000 and 50,000 staff have been trained.

Two important tools have become a mainstay of back-office operations: a Customer Relationship Management (CRM) system and the municipality's data analytics platform. First, an integrated CRM structure and dedicated team are contributing greatly to the efficiency, effectiveness, and overall smooth running of São Paulo's different government agencies, for example, when responding to "156" non-emergency reports that are made using a variety of channels.

Second, SP360, the municipality's data analytics platform, is used to publish the data once it has been cleaned. The platform combines data to show requests made to different services. It is helping São Paulo to identify bottlenecks at key moments so that departments can take corrective action and start to anticipate when demand for certain services is likely to spike. These performance analytics then inform policy decisions made by the Mayor's Office.

Seattle, USA

Mayor: Jenny Durkan

Population: 753,675

Number of employees: 13,615

City Website: seattle.gov

Priorities:
- Homelessness
- Affordable Housing
- Transportation

16 influential technology companies based in the city make up Seattle's Innovation Advisory Council.

Digital Leadership

The city's Chief Technology Officer is Saad Bashir, who is part of Mayor Jenny Durkan's Cabinet. Jim Loter, Director of Frontline Digital Services, is responsible for IT operations and support. The city is currently recruiting for a Director of Service Modernization. Elsewhere, the city's Innovation and Performance team sits within the City Budget Office and collaborates with city departments and businesses to creatively solve problems. Seattle's Innovation Advisory Council (IAC) was established by Mayor Durkan in 2018. Made up of the city's most innovative and influential technology companies, it brings industry knowledge to bear on city challenges through pro bono support.

City challenges are addressed in collaboration with locally based companies

The Innovation Advisory Council has helped the city to successfully address key challenges. NavApp 2.0, a collaboration with Microsoft and its partner REV Tech LLC, is helping the Police and Human Services departments to provide more support for the homeless living outdoors. The first version of the tool was used for recording and quantifying the size of the problem. In addition, Chatbox created a texting tool that enables individuals to access real-time information about the availability of beds and resources at homeless shelters around the city.

The Seattle Affordability Portal, a collaboration with Expedia, Tableau, and F5, centralizes information about the social benefits provided by the city into a single website. An elegant eligibility tool further simplifies the service for residents by establishing a consistent metric across departments.

The topography of Seattle presents unique mobility challenges. The majority of arterial highways run north to south, in accordance with the city's orientation. Moving east to west is more difficult because narrow roads intensify traffic congestion. A comprehensive network of sensors was added to the seven principal arterials to configure traffic signals with real-time data.

Seoul, South Korea

Mayor: Seo Jung-hyup (acting mayor)

Population: 10,013,781

Number of employees: 10,356

City Website: seoul.go.kr

Priorities:
- Traffic
- Safety
- Environment

The number of public-access Wi-Fi points in Seoul will increase from 11,900 in 2020 to 23,750 by 2022.

Digital Leadership

Weonmok Lee is the Chief Information Officer for the Seoul Metropolitan Government (SMG). He has a wide view across city services and operations, not just on internal systems. He is supported by five directors who work in the planning, big data, information systems, GIS, and information communication & security divisions. The CIO receives further support from the city's Smart Cities Committee, which is made up of 20 industry experts. The SMG created the Seoul Digital Foundation, a think tank and innovation agency that applies digital approaches to tackling some of the city's biggest challenges.

City data helps Seoul to identify and meet resident needs

Seoul's smart city framework was updated in 2019 to place even greater emphasis on public Wi-Fi and digital inclusion. The goal is to make the Wi-Fi speed four times faster and to increase the number of access points from 11,900 to 23,750 by 2022. This is part of a concerted effort to extend connectivity infrastructure to low-income neighborhoods.

The metropolitan government is also rolling out assisted living technologies that monitor the health and well-being of elderly people living on their own and without access to specialist care.

A partnership with Korea Telecommunications has yielded new insights into nighttime mobility flows. As a result, the SMG identified an unmet need for night buses, which now operate along nine popular routes between 1 a.m. and 5 a.m. and serve around 17,000 passengers every night.

SMG is making air quality data publicly available and notifying parents and schoolteachers when pollution is more intense. This helps to both inform and manage expectations, so fewer people contact the municipality to raise their concerns.

Sydney, Australia

Mayor: Lord Mayor Clover Moore

Population: 246,343

Number of employees: 2,000

City Website: cityofsydney.nsw.gov.au

Priorities:
- Citizen Engagement
- Environmental Performance
- Safety

"Our first generation of digital services was very much an inside-out design, and our next generation will be outside-in."

Olivia Simons,
Executive Manager Digital Innovation & Development

Digital Leadership

Tom Gao is the Chief Technology and Digital Services Officer in the city government, with responsibility for IT infrastructure and operations and for citizen-facing services. Olivia Simons is the Executive Manager for Digital Innovation & Development, a role that covers internal digital transformation, business applications, and smart city strategy implementation. Mark Goleby is the Chief Officer for Data and Information Management; Kate Deacon is the Executive Manager for Strategy and Urban Analytics.

Putting resident needs front and center of digital service design

Digital services in Sydney are currently undergoing a significant redesign and redevelopment. The process embraces the principles of human-centered design that have become embedded in the organization recently. The service redesign puts customer centricity and security at its heart and aims to provide a more personalized experience for residents via digital channels. Digital identity management will offer secure authentication when engaging and transacting with the city and will put people in control of their own privacy and communication preferences so they can receive information that is most relevant to them.

The City of Sydney's Smart City Strategic Framework, published in 2020, sets out the required outcomes of smart city initiatives. The framework provides a road map to guide the city in harnessing the potential of data and technology to deliver better outcomes for the people, businesses, and the city economy into the future.

Tallinn, Estonia

Mayor: Mihhail Kõlvart

Population: 444,970

Number of employees: 14,000

City Website: tallinn.ee

Priorities:
- Social Services
- Security
- Spatial Planning

Tallinn serves 270 city departments and 14,000 employees (12,500 workstations) with a technology team of 37 people and an annual budget of €10 million a year.

Digital Leadership

Deputy Mayor Aivar Riisalu has political accountability for Tallinn's city innovation programs. Director of IT and city CIO, Martin Männil, manages technology infrastructure and operations, internal platform services and external-facing e-services. Elsewhere in the city government, Toomas Türk, Chief Innovation Officer, leads smart city and digital economy projects.

Digital infrastructure provides the foundation for data and systems interoperability

The City of Tallinn leverages Estonia's national digital infrastructure to make 100 percent of its services available to residents online. The national government provides all citizens with an ID card linked to a digital identity. All public services – whether managed by city or national agencies – integrate with the "X-road," a nationally supported secure data exchange layer. Data is accessed via a centrally managed catalogue that links to thousands of data registers.

This data and systems interoperability allows aspects of many city services to be automated, which permits Tallinn's IT service to operate with a team of 37 and a budget that is a fraction of the size of most comparable cities.

Urban planning services are digital – integrated digital maps provide planners and architects with a single view of area plans and the context for new buildings. Digital tools have improved the speed and transparency of the process, with residents and developers able to track the progress of proposed developments online.

Tallinn still suffers from traffic congestion and some challenges where public transport services have not kept up with the city's growth. The municipality is using mobility data to better understand traffic flows so they can introduce tools such as smart traffic lights and intelligent transport management systems.

Tel Aviv, Israel

Mayor: Ron Huldai

Population: 451,520

Number of employees: 12,000

City Website: tel-aviv.gov.il

Priorities:
- Real-time Management of the City
- Citizen Engagement
- Cybersecurity

"By changing our relationship with our residents, we are able to offer them services that other cities simply can't, in areas that other cities don't even think about."

Itzik Ben David,
Chief Information Officer

Digital Leadership

Mayor Ron Huldai is a strong backer of technology to improve city operations. Itzik Ben David, the Chief Information Officer, is responsible for internal technology operations and external initiatives such as smart city projects. He is supported by Chief Technology Officer Hilay Selivansky and Chief Knowledge Officer Zohar Sharon. Rinat Guy, the city's Chief Innovation Officer, works on internal innovation and organizational change. Several enterprise companies related to city operations are run independent of City Hall. They have their own structures for technology management and receive support from Ben David's team team.

Digital engagement and real-time information support city management

Tel Aviv-Yafo Municipality has taken a bottom-up approach to digital and smart city projects, characterized by a resident-first focus, a modular approach to in-house technology development, and several large-scale technology investments in the public realm.

The city has notable strengths in data analytics. Each department has its own dashboard to monitor its operations. A real-time information map of the city combines data from key information systems such as reports from municipal field teams, residents, and IoT sensors. The map is used as a basis for managing city operations.

Launched in 2013, Tel Aviv's acclaimed DigiTel platform provides residents with tailored lists of public events and direct access to city services. The platform continues to evolve; machine learning algorithms track residents' behavior to understand changes in their preferences and to push more appropriate opportunities in their direction. The DigiTel card is going completely digital via a smartphone app that allows residents to make discounted bookings and manage a wallet of tickets electronically. Currently, an estimated 230,000 people in the city are signed up to the platform.

Toronto, Canada

Mayor: John Tory

Population: 2,956,024

Number of employees: 30,000

City Website: toronto.ca

Priorities:
- Affordable Housing
- Mobility
- Financial Sustainability

"To support the financial sustainability of the city, we're asking: How do we automate processes, how do we use data and AI to find risk profile patterns so that we can target just the areas that need targeting?"

Alice Xu,
Manager,
Smart City/Connected Community

Digital Leadership

Lawrence Eta is Toronto's Chief Technology Officer. He manages technology services, including IT operations, network infrastructure, and the Connected Community (Smart City) program. The Transportation Services department within the Toronto city government has focused on innovation and has a specific data analytics team. Elsewhere in the city, Toronto's Civic Accelerator Program engages the local start-up community with citywide challenges.

City data provides the evidence base for future policy decisions

The City of Toronto is developing a Digital Infrastructure Plan (DIP) to guide day-to-day decisions and long-term planning directions. At present, several internally focused policies regulate specific digital infrastructure topics, such as personal information and privacy, security, data management, procurement, intellectual property, and consumer protection. The DIP will build on these existing regulations to enable a consistent approach to evaluating digital infrastructure policies and proposals.

The City of Toronto is applying data-driven approaches to key challenges, for example, tackling urban poverty and understanding changing transportation behavior. Data also offers an evidence base for future policy, with pedestrian and vehicle flows around a trial traffic management configuration being observed in the popular King Street thoroughfare. The data will allow planners to decide if it should become a permanent fixture and potentially be tested elsewhere.

In a collaborative project, the Tech Services, Public Health and Housing departments are starting to use AI to look for predictive elements within their data on residents. By understanding which residents are vulnerable, they aim to proactively connect them to city services and community support organizations before they fall into crisis.

Glossary of Terms

Connectivity

Broadband (sometimes referred to as *Superfast Broadband*) refers to a fixed-line [cable or DSL] broadband internet connection with a minimum download speed of 25 Mbps and a minimum upload speed of 3 Mbps (megabits per second).[30]

Fiber-optic broadband is a type of high-speed broadband that sends pulses of light through fiber optic cables, which are better at transferring data than standard copper cables. Typical fiber-optic data transmission speeds far exceed standard fixed-line broadband speeds.[31]

Fiber to the Premises (FTTP) refers to a fiber-optic broadband network that delivers internet connectivity via fiber-optic cables directly to a building or household, as opposed to a local node where the final stage of the network is completed with copper cables.

Geolocation services help to identify the actual geographic location of objects. Methods include using Global Position Systems, mobile network location data, and identifiers such as MAC (Media Access Control) or IP (Internet Protocol) addresses.

IoT Network is a collection of interconnected devices that communicate with other devices without the need for human involvement. Examples of IoT devices include sensor nodes, autonomous vehicles, and smart street infrastructure.[32]

Next-generation mobile communication refers to the devices and infrastructure that conform to the 5th Generation technology standards for cellular networks, which began commercial deployment in 2019 and will be the successor to the 4G Long Term Evolution (LTE) standards. 5G connectivity should see faster data rates, lower latency, and greater capacity across the network, with data speeds up to 10,00 times faster than 4G.[33]

Public WiFi refers to any location where wireless connectivity technology both exists and is available for use to the public or consumers. In some cases the wireless access is free, and, in others, wireless carriers charge for Wi-Fi usage.[34]

Smart street furniture and *Connected street infrastructure* are physical objects in the public realm that are connected to the internet, often via IoT or public WiFi networks. These objects vary greatly and perform different functions. Common examples include sensors that collect atmospheric data or footfall data, connected security cameras, public WiFi hotspots, adaptive street lights, and signage that provides the public with relevant information in real time.

Data

Advanced data analytics is a part of data science that uses high-level methods and tools to focus on projecting future trends, events, and behaviors.[35]

Artificial intelligence refers to computer systems that are able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, pattern recognition, decision-making, and translation between languages.[36]

Blockchain refers to a digital, public ledger that records online transactions. A blockchain ensures the integrity of information by encrypting, validating, and permanently recording transactions.[37]

City dashboard refers to a visual way to track progress toward city objectives and to display key information such as atmospheric data and the performance of road and public transport networks. Data is often displayed in real-time via a web application and can be private or public facing.

Cloud computing is the on-demand availability of computer system resources, especially data storage (cloud storage) and computing power, without direct active management by the user.

Data lake refers to a centralized repository for storing structured and unstructured data in different formats and at different scales. Data lakes are important when working with large datasets where it is not possible to define an information architect or metadata in advance. Typical examples include data received by IoT sensors.[38]

Data marketplace is a platform created for the buying and selling of data. [39]

Digital twin refers to a digital replica of a physical entity. It exists primarily as data and may be visualized as a *3D city model* using data visualization tools and a consistent data schema.

Data visualization is the graphic representation of data and information.

Data warehouse is a technology that aggregates structured data from one or more sources so that it can be compared and analyzed for greater business intelligence. Data warehouse architectures are defined in advance so that data can be easily retrieved and queried.[40]

Edge computing locates information processing and data storage closer to the physical place where it is needed. Doing so improves processing speeds, supporting the real-time transfer of data vital to the effective functioning of IoT networks and, in the future, to complex automated systems such as Connected and Autonomous Vehicles.

Low-code platform refers to a tool that uses visual interfaces with simple logic and drag-and-drop features instead of extensive coding languages. These tools are intuitive and allow users with no formal knowledge of coding or software development to create applications for many purposes like mobile apps and business apps.[41]

Machine learning is an application of artificial intelligence. Machine learning algorithms build mathematical models based on sample data to identify and "learn" trends in order to make predictions or decisions.[42]

Open data is data that can be freely used, re-used and redistributed by anyone.[43]

Open data platform is an online repository where city governments and other public and private organizations can publish open data.

City Operations and Services

Chatbot is a software application designed to simulate human conversation through voice commands or text chats, or both.[44]

Citizen engagement platform or portal is a web or mobile application that provides a means for people to engage with their community, the city government, and wider civic life.

City operations centers allow multiple systems and image and data feeds to be integrated into a single interface to enable real-time work between city departments. Common uses of city operations centers include traffic management, policing and public safety, and monitoring service performance.

Customer Relationship Management system refers to feature-rich CRM solutions, which include the ability for users to easily program logic into their processes, and to apply built-in process automation tools.

Online municipal account refers to a personal online account, usually accessed via a municipal website, through which a resident can interact with city services.

Open source refers to software people can modify and share because its original source code is publicly accessible.[45]

Open source platform for apps and services refers to a hosting platform created using open-source technology and information architecture.

Robotic process automation refers to software that can be easily programmed to do basic, repetitive tasks across applications. It does this through a software "robot" with the ability to launch and operate other software.[46]

Transport & Mobility

Smart grid refers to a network consisting of controls, computers, automation, and new technologies and equipment working together with the electrical grid to respond digitally to quickly changing electric demand.[47]

Connected and autonomous vehicle trial refers to live self-driving car trials that are taking place on city streets. For the purpose of this research, no distinction has been made between the six levels of vehicle autonomy.[48]

Drone is an unmanned vehicle, usually operated remotely by a human controller. For the purpose of this research, no distinction is made between remotely-operated and autonomous drones.

Electric vehicle infrastructure refers to networks of charging points and stations that are embedded in the built environment.

Intelligent transport system (ITS) refers to the integration of advanced communications technologies into transportation infrastructure and into vehicles. ITS encompasses a broad range of wireless and traditional communications-based information and electronic technologies. Tools that contribute to the running of these systems can include electronic toll collection, ramp meters, red light cameras, traffic signal coordination, transit signal priority, and passenger information systems.[49]

Real-time public transit information refers to transport data made information available to the public instantaneously via digital signage and digital applications.

Smart parking systems use cameras and sensors to detect whether parking bays are free, and then communicate this information to drivers via mobile applications.

Safety & Security

Closed circuit television (CCTV) cameras record video, which is transmitted to a specific place and a limited number of screens via a coaxial cable. *Connected CCTV cameras* or *IP (internet protocol) cameras* upload images to an internal network via the internet, rather than recording and storing them locally. They are often characterized by their wireless connectivity.

Crowd monitoring & management tools can be used for a wide variety of purposes: to monitor and analyze both crowds and transport – to identify how they move, how environments can be planned around them, and the source of any issues or unusual behavior. Common data sources include IoT sensors and data collected by mobile operators.[50] Video analytics and facial recognition technologies are emerging tools within this categorization.

Digital identity in the context of this report is information that can be used to legally verify a person's identity online.

Disaster early-warning system refers to a specific type of incident detection tool used to generate and communicate timely and accurate warning information relating to an immediate threat to life in order to give people more time to react. Examples include systems that detect seismic activity, tsunamis, and missile launches.

Incident detection tools refers to a range of technologies that fulfil different purposes. They are characterized by a "sense and actuate" function that relies on tools such as atmospheric sensors, video cameras, and video analytics to identify a concern and trigger an alert. These tools are often developed with a specific function in mind, such as gunshot detection technology, which uses noise sensors and audio analysis to pinpoint the location of a discharged weapon. Other examples include video analytics technology that applies artificial intelligence, which is trained to identify specific issues such as over-full trash cans and graffiti.

Mobile connected camera is a type of camera, often used for security purposes, that connects to the internet via wireless technologies. Common examples include body cams (cameras mounted onto clothing) and dash cams (cameras mounted onto a vehicle's dashboard) that are used by law enforcement and emergency services.

Predictive cybersecurity tools monitor networks in real time to identify potential vulnerabilities and apply predictive analytics to calculate the likelihood of future attacks based on past events.

Responsive cybersecurity tools detect and react to incoming security threats and cyber attacks.

Video analytics software helps to review surveillance video footage. It can be programmed to search for and identify specific imagery and incidents.

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