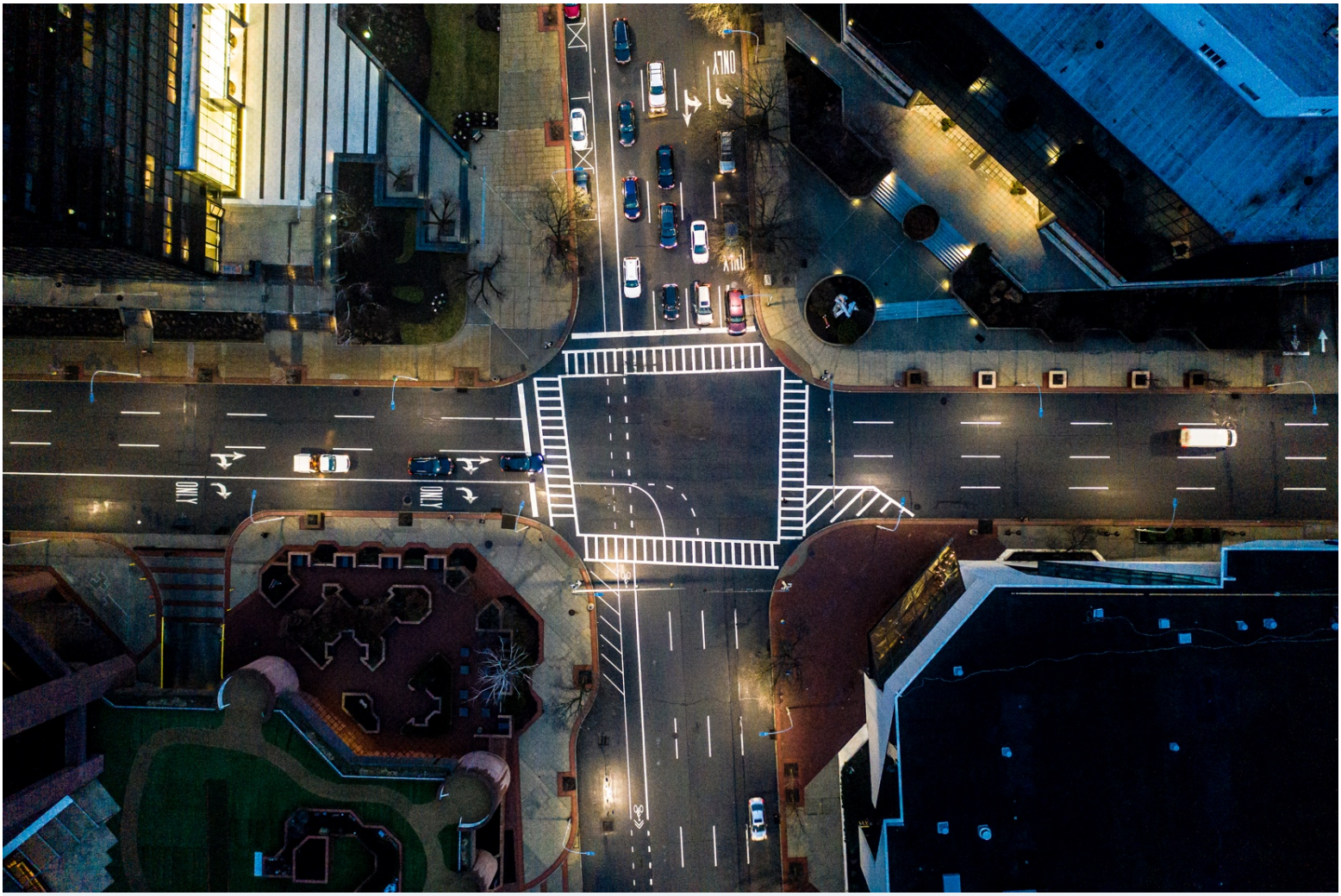

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Signify

IoT Software & Platforms

A Phased Approach to Achieving Smart Cities

What's inside

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Quick read

There are clear benefits to smart cities…

- Smart cities provide clear financial, environmental, and health & safety benefits;
- The starting point for smart cities is typically smart street lighting, but additional smart infrastructure can be added in a phased-in approach; and
- Smart cities with multiple sensors and 3rd party apps may proceed to full IoT platforms to take advantage of all of the available data.

APIs and open standards will aid system integration…

- There will be no "silver bullet" turnkey solution: system integration will occur in a phased approach with multiple systems and applications evolving gradually;
- Interoperability can only be achieved when there are open standards and a number of global initiatives are driving these; and
- IoT platforms share several key characteristics including: unified dashboards, open standards, analytics and "as-a-service" models.

Developer communities & 3rd party apps accelerate the process…

- Resources beyond the cities themselves are required: this will be a community effort with 3rd party developer communities, hacker events, universities and other stakeholders all playing key roles;
- Ultimately, the creation of data marketplaces will enable the buying and selling of city data and help 3rd party applications flourish; and
- But first there must be an enabling environment with robust privacy policies, data openness, software development kits, et al.

Challenges remain, but can be overcome…

- Cities will face political, financial, and logistical challenges implementing smart city infrastructure;
- The right IoT platform must address these challenges without adding unnecessary complexity; and
- Ultimately, strong and consistent city leadership will be needed to successfully carry out smart city projects.

What are cities saying?

"Releasing data is just half the battle. Raw data often doesn't tell you anything until it has been presented in a meaningful way and most people don't have the tools to do this. That's why we're keen for you to visualize or build apps from the data available on the site."

"As we add new end-use controllers, we're looking to tender new software, but don't want anything too complex."

"We're using data from both the government and private aggregators, as long as they are approved for security."

"A dashboard showing traffic, available parking, and transit routes has helped us develop our tourism management planning."

"You need to have APIs…but this is not rocket science."

"[We will] connect with third-party city systems or dashboards through APIs and extensive interfaces on the controller."

"There are equal roles for the government, private sector and citizens."

The benefits of smart cities

The term "smart cities" has created plenty of buzz, but even more questions for city managers. Cities are looking to smart infrastructure to reduce costs, improve sustainability, and provide better services to residents. Many cities have begun the initial steps – both in terms of investments such as smart streetlights or IT initiatives such as open data – to make smart cities a reality. In a best case scenario, these investments will open up new opportunities beyond the simple business case, much like smart phone apps created a new ecosystem beyond the initial benefits of internet-connected phones.

But cities are more complex than individuals and city managers must balance diverse interests, departments, and priorities when making investment decisions. Rapidly developing technology creates added complexity and stokes fears of getting locked in to the wrong technology choice. When implemented appropriately, an IoT platform can help assuage these concerns by reducing complexity and allowing new technologies to be seamlessly added. Given how new this market is, there are no large-scale examples of full smart city IoT platforms at work in major cities, but a path is emerging for cities to progress from initial smart infrastructure investments while leveraging 3rd party developers to create data-driven smart cities with benefits for residents, government, and local businesses.

Smart city applications and benefits

There are many definitions for what constitutes a "smart city," but for the purposes of this study, smart city applications include installing communicating devices, including sensors, throughout a city that both provide direct benefits to the city and provide data points that can be used for further benefits down the line. The primary benefits of smart city applications are:

- ***Financial benefits:*** Either by reducing costs (particularly energy and operational costs) or increasing revenues, most smart city applications have financial benefits for cities;
- ***Environmental benefits***: Smart city applications reduce energy consumption and improve efficiency, which in turn leads to reduced local pollution and carbon emissions;
- ***Health and safety benefits:*** Improved real-time awareness of city conditions allows law enforcement and other officials to better serve citizens, while faster repair times for lighting and other public infrastructure improves safety conditions.

The table on the following page shows some of the leading smart city applications, along with their likely benefits.

SMART CITY APPLICATION BENEFITS*

APPLICATION	FINANCIAL BENEFITS	ENVIRONMENTAL BENEFITS	HEALTH, SAFETY & OTHER BENEFITS
STREET LIGHTING 	Savings of up to 60 – 80% per light compared with legacy streetlights	Corresponding 60 – 80% reduced energy usage and emissions; no need for random patrols of streetlights that produce auto emissions	Streetlight outages replaced sooner and better lit streets reduces accidents and crime; law enforcement can control lighting in emergency situations
SMART PARKING 	Increased revenue through greater willingness to pay and better enforcement	Emissions reductions due to less time spent searching for parking	Reduced traffic
VIDEO MONITORING 	Improved enforcement and fine collection	Could be used to enforce environmental regulations	Improved public safety through crime monitoring
AIR QUALITY MONITORING 	Indirect economic benefits of improved air quality; cheaper than larger air quality sensors	Improved environmental data can help make the case for investments and improve ability remediate when problems occur	Improved health from lower local pollution
PUBLIC EV CHARGING 	Ability to provide high-density charging at low cost; potential to charge customers for EV charging	Reduced use of internal combustion vehicles	More convenient for EV drivers to charge
SMART WASTE BINS 	More efficient truck routes lower costs	More efficient truck routes lower auto emissions	Eliminates unhealthy conditions due to overfull waste bins
OPEN DATA APPS 	Data marketplaces can create revenue; some apps help local economy	Examples include apps showing trends for local conservation efforts	Examples include crime and other safety trends made available to public

Non-exhaustive

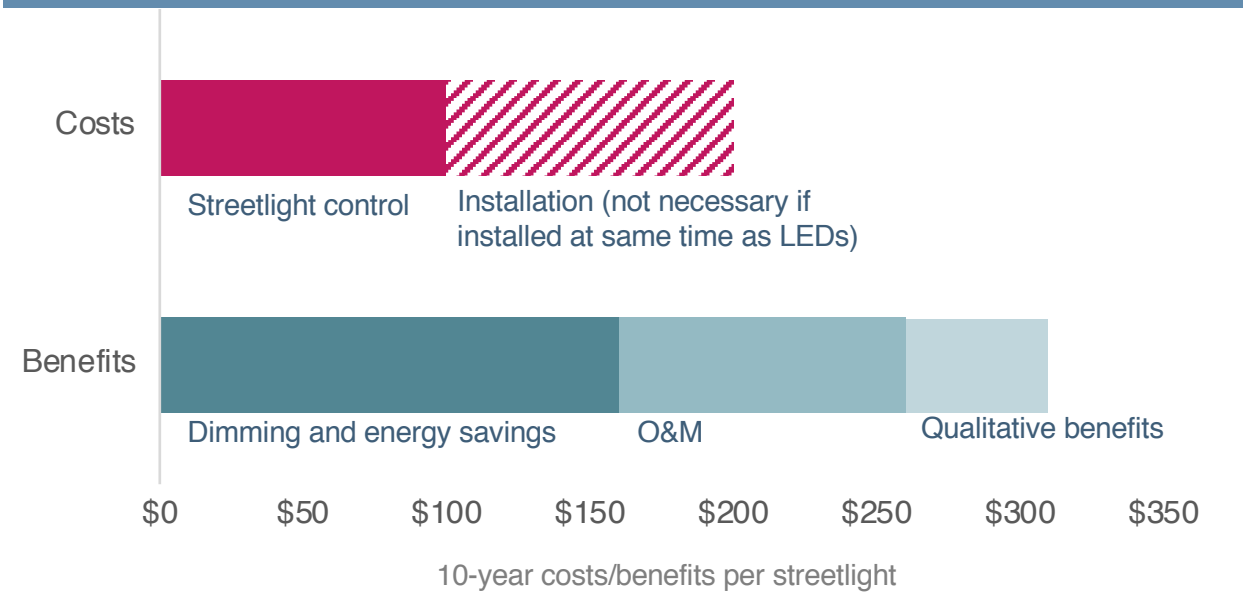
Street lighting as the key entry point to smart cities

The clearest smart city business case is for street lighting. Through smart street lighting, cities can earn immediate benefits while laying the groundwork for future applications.

The case for smart street lighting starts with LED lights, which are now the standard throughout cities across the world and have clear benefits. When cities change their streetlights to LED, they have the opportunity to add controls, further increasing the benefits. Smart streetlights require installing new hardware and software, so there will always be an added upfront cost (smart controllers are more expensive than legacy photocells). But for most cities, the savings from smart streetlights will outweigh the costs over a ten-year period, as shown below.

The case for smart streetlights is based primarily on reducing energy usage through accurate on/off switching and dimming, therefore reducing costs and CO_2 emissions. Dimming both reduces energy usage on a daily basis and extends the life of the luminaire, providing clear return on investment. Additionally, smart streetlight systems provide quantitative and qualitative benefits by allowing cities to monitor their streetlights in real time. Smart systems identify streetlights that are burned out, allowing cities to immediately replace them, reducing customer complaints and truck rolls while improving public safety. Law enforcement can also access these lights, increasing or decreasing brightness as necessary for emergency situations. Installing a smart streetlight system requires a communications network and a basic software solution (Central Management System, or CMS). These investments can then be leveraged to develop a phased in approach to smart cities.

10-YEAR COSTS & BENEFITS OF SMART STREET LIGHTING



Smart cities are sustainable cities

One of the clearest benefits of smart city infrastructure and associated software is its impact on environmental sustainability. By improving the efficiency of cities, smart infrastructure reduces energy usage, automobile emissions, local pollution, improves resiliency, and more.

Reduced energy usage

- Smart streetlights average a 60-80% reduction in energy usage compared with non-connected conventional lights, leading to significant CO_2 emissions reductions. Smart systems can also be linked to building energy usage, leading to further reductions.

Reduced automobile emissions

- Smart parking reduces time spent looking for parking spaces;
- Smart traffic management improves traffic flow and emissions;
- Smart waste bins improve garbage truck route efficiency;
- Smart streetlights reduce truck rolls for outages; and
- Public EV charging encourages use of zero-emission vehicles.

Lower levels of local pollution

- Increased and improved measurement of air quality through sensors on streetlights will help cities better identify and address local air pollution; and
- Fewer auto emissions will reduce localized pollution.

Improved resiliency

- Sensors can improve flood monitoring and measure water quality and water levels; and
- Smart streetlights and pole tilt sensors identify outages and downed infrastructure rapidly after storms.

Developing a phased-in approach to an integrated solution

Lighting can serve as an effective entry point to additional smart city applications. Many lighting control offerings now come with the option to include air quality monitoring, video monitoring, EV charging, and more, as part of "smart poles." Additional applications include seawater sensors in Stavanger, Norway, dog counters in Paris, and social media analytics in Pune, India. But most cities do not yet have a plan in place to utilize all of these applications. Smart cities applications therefore create a dilemma for many city managers: is it better to invest now to reap immediate benefits at the risk of technology changing, or better to wait to see how the technology develops, while missing out on near-term benefits?

While the answer will be different for each city, the likely best solution is a phased-in approach. For example, most cities are now deploying LED streetlights because the business case is abundantly clear. In developed countries, the labor costs to change out the streetlights are nearly as expensive as the streetlights themselves. It therefore makes sense install streetlights with embedded controls, or to add streetlight controls at the same time (even if there is not yet a communication network in place) as sending out a separate crew to install streetlight controls (which is likely at some point in the next decade) doubles the cost of the smart streetlight network. Once smart streetlights are in place, the city will haver a communications network and a basic software platform (central management system, or CMS). With communications and software in place, a city can begin to trial additional applications, enable 3rd parties to access the data, and eventually determine which ones make sense and invest in larger deployments. Finally, cities can establish a larger IoT platform and perhaps data marketplace based on these applications.

The figure on the following page shows the benefits of this phased-in approach. Unlike a wait-and-see approach, the city saves immediately on labor costs and energy costs associated with street lighting. But by not investing in everything all at once, the city reduces the complexity of the project as well as the upfront costs associated with applications that may have less applicability in a given city. This approach also gives 3rd party developers time to experiment with the data provided by IoT sensors helping the city determine which needs are being met and which need increased investment. Perhaps most importantly, this approach also allows the city to select the appropriate communications network for each use case. In some cases the same network can be used for multiple segments (e.g. street lighting, parking, air quality sensors), while in other cases latency and bandwidth requirements will necessitate a different network. A phased approach allows city departments to make this decision on a case-by-case basis, while the different segments can still be integrated through APIs and an IoT platform as they are deployed.

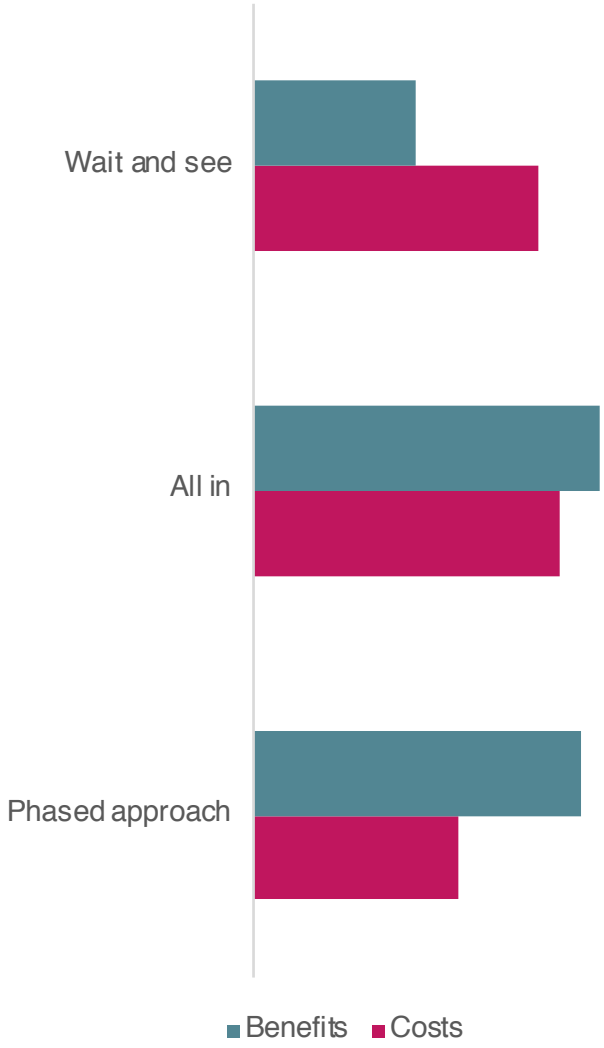
COSTS & BENEFITS OF A PHASED-IN APPROACH

Deploying smart infrastructure now brings cities immediate benefits, but can also raise questions and add complexity to already functioning systems, while many of the benefits won't be realized until IoT platforms and 3rd party developers are in place. A phased-in approach limits some of the upfront costs while ensuring the benefits from low hanging fruit investments such as smart street lighting are realized.

LED now, wait and see for the rest: Costs could be higher if streetlights are not embedded with controls, as there would be additional labor costs to install streetlight controls and additional smart city applications. Meanwhile, benefits are lower since there are no smart city applications in the first few years.

Full IoT platform with several applications now: This could be an option for an advanced city, but is likely to be challenging. Costs are higher due to the complexity of developing multiple applications at once and the likely recurring SaaS costs of the IoT platform. Benefits are also higher, but only marginally so unless a city is ready to utilize all of this data.

Phased-in approach: Lowest cost option, although there will be added labor costs if new sensors are installed. Benefits are among the highest, as smart city applications are only rolled out at large scale once the benefits are fully understood.



Smart city roadmap case study: London

London is a global city that many look to for leadership in the smart cities domain. Historically, the city has been a leader in developing progressive solutions – for example introducing congestion charges to reduce traffic and pioneering a number of other programs. Now, the city has launched its **Smarter London Together** initiative which is its strategy to make London "the smartest city in the world" through its five missions (see below), which are tracked through its report card. Each task has anticipated completion dates that serve as a roadmap for smart city development.

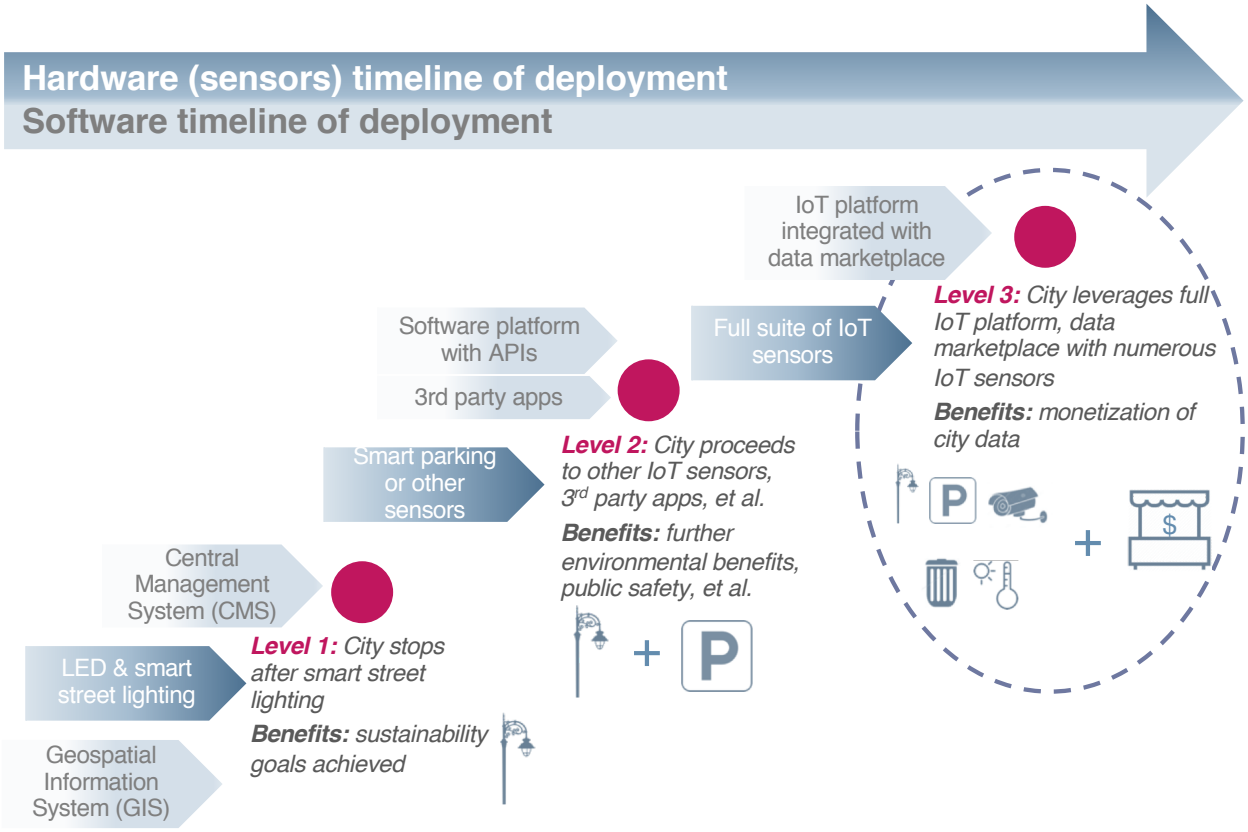
In addition, the city has launched its **London Datastore** which has the goal of "freeing London's data." The data is available for free to any stakeholder who wants to access it. Importantly, the city acknowledges that:

"Releasing data though is just half the battle. Raw data often doesn't tell you anything until it has been presented in a meaningful way and most people don't have the tools to do this. That's why we're keen for you to visualise or build apps from the data available on the site."

Smarter London Together Report Card & Five Missions

Mission 1: More user-designed services	**Mission 2:** A new deal for city data	**Mission 3:** World-class connectivity	**Mission 4:** Enhance digital leadership	**Mission 5:** Improve city-wide collaboration
· Civic innovation challenges · Renew civic platforms and mount digital campaigns · New approaches to digital inclusion	· Establish data analytics program · Develop cybersecurity strategy · Support open ecosystem by opening the capital's data	· Accelerate take up of smart infrastructure · Support public WiFi in streets · Guidance on common standards for smart infrastructure	· Support public service digital leadership · Support digital skills · Explore a knowledge hub to fill digital skills gaps in London	· Explore new tech partnerships and business models · Collaborate with other cities · Establish London Office of Technology and Innovation

ILLUSTRATIVE PHASED-IN APPROACH TIMELINE



Hardware and software for smart cities will develop simultaneously. In some cases, such as a CMS system for street lighting, there will need to be coordination and investment in larger IoT platforms will depend in part on the scale of IoT investments. For larger cities, a roadmap with clear progress markers such as London's will be critical. Other cities may choose to stop at only investing in smart street lighting and corresponding software given the clear benefits and limited complexity. But larger smart city benefits will open up when more data is generated.

A popular expression that has arisen over the past few years is that *"data is the new oil."* This is to say that data is now the most valuable commodity on the planet. If data is truly replacing extractive industries, then the extraction of value from data is the linchpin to supporting this argument. Data has the potential to transform municipal infrastructure, processes and services to achieve the lofty potential of smart cities.

Taking the analogy one step further, if an oil refinery produces the final value-added petroleum product, then the equivalent for city data would be the software platform. This software platform takes raw, unfiltered data and processes it into actionable intelligence, which has great value for cities. For now, smart city projects are just beginning and most IoT platforms are incomplete. But by stimulating innovation from third parties and the potential for urban data marketplaces, IoT platforms can help realize the potential embedded in the buzz of smart cities.

System integration issues, APIs and open standards

What does an ideal integrated solution look like?

In an ideal world, a municipal IoT platform solution would be very simple with total interoperability. There would be one system of record. All various IoT sensors and data feeds would integrate into this single system and there would be one interface for all city personnel. As new infrastructure is added, it would integrate seamlessly. One vendor would handle all of this in a "turnkey" solution. Of course, the reality is messier.

One complexity has to do with timing: cities implement new solutions in a phased approach, with different vertical applications deployed at different times. Another complexity has to do with vendor management: there are almost always a number of diverse vendors deeply entrenched within the city's infrastructure and processes. And yet another–and perhaps most important–complexity has to do with technology: there are a number of diverse IT systems co-existing at the same time. Legacy systems that cannot simply be ripped out and replaced with another system without major disruption to workflows. This leads to the need for systems integrators.

Two critical elements that help to overcome some of these challenges are **Application Programming Interfaces (APIs)** and **open standards**. Neither is a silver bullet, but they are both widely acknowledged as key enablers for cities to simplify things as much as possible. Broadly defined, APIs very simply enable different applications to communicate with each other. An API is not an actual dataset or database but rather it is code that is written to enable access to that data. It is a way for one application to access the data of another application for its own functionality. Many large tech companies offer APIs to facilitate access to their data and now cities are also following suit, especially when it comes to making their open data readily available for a number of applications. One example is New York City which offers APIs to access New York City services. Another example is Pune, India with its goal to "*connect with third-party city systems or dashboards through APIs and extensive interfaces on the controller*."

APIs also play a key role within cities for their diverse IT systems. IoT platforms rely on APIs to enable integration with other city systems, dashboards and applications. For example, a city's smart street lighting central management system (CMS) may have an API that allows it to integrate seamlessly with its main IoT platform.

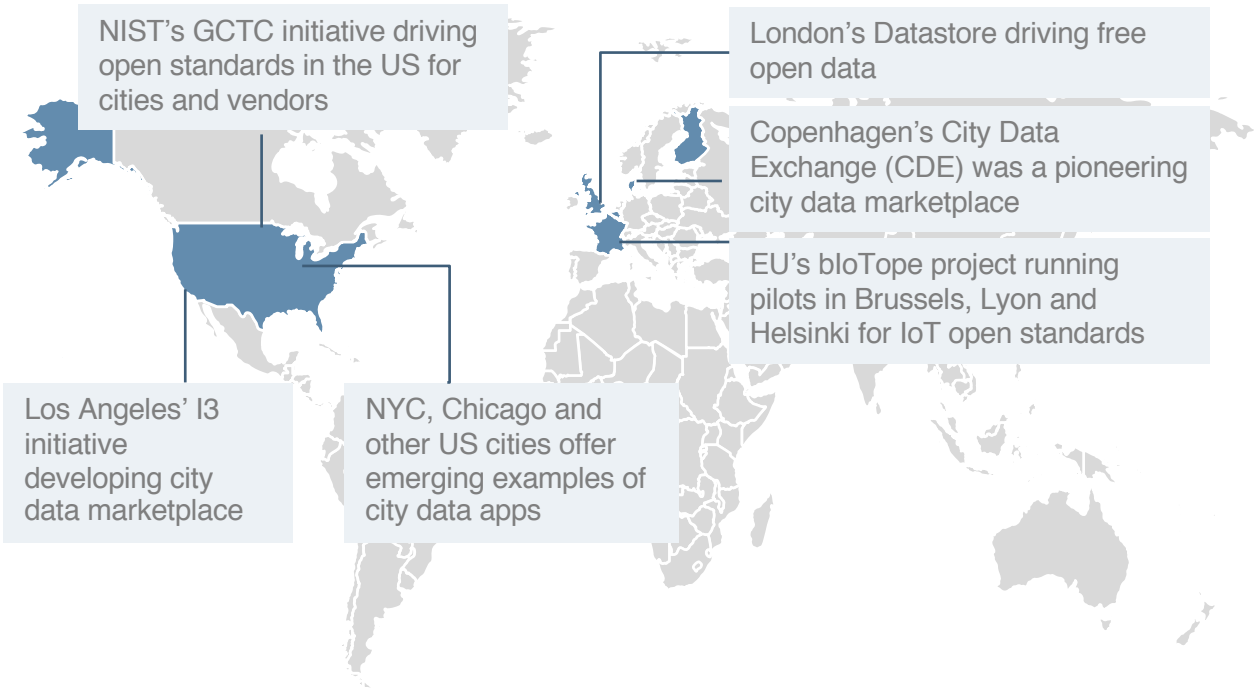
The importance of open standards is equally important. This was one of the key findings from Copenhagen's City Data Exchange initiative, as well as countless other studies covering the smart cities market. One key initiative that is helping to drive open standards in the smart city and IoT segments is the Global City Teams Challenge (GCTC) from the National Institute of Standards and Technology (NIST), part of the US Department of Commerce.

The GCTC was founded in 2014 to ensure both cities and vendors develop solutions with open standards. This ensures they are "replicable, scalable, interoperable" and that cities don't get locked into proprietary solutions. Since its founding, the US Department of Homeland Security Science and Technology Directorate (DHS S&T) has joined the program to focus on ensuring solutions have robust cybersecurity and privacy components.

A similar initiative is also being rolled out in Europe, funded by the European Union. The **bIoTope project**, with a €9.4 million budget, was begun in 2016 to drive interoperability and openness for IoT solutions for cities. Among its objectives include "standardized Open APIs to enable interoperability" and also a framework for security and privacy, among others. As part of the bIoTope initiative, a dozen smart city pilots will be deployed in Brussels, Lyon and Helsinki to validate its effectiveness.

The ideal integrated solution is one with open standards and APIs. Both the NIST's GCTC and the EU's bIoTope initiatives are working to ensure that all stakeholders realize the importance of open solutions.

GLOBAL EXAMPLES OF CITY DATA INITIATIVES

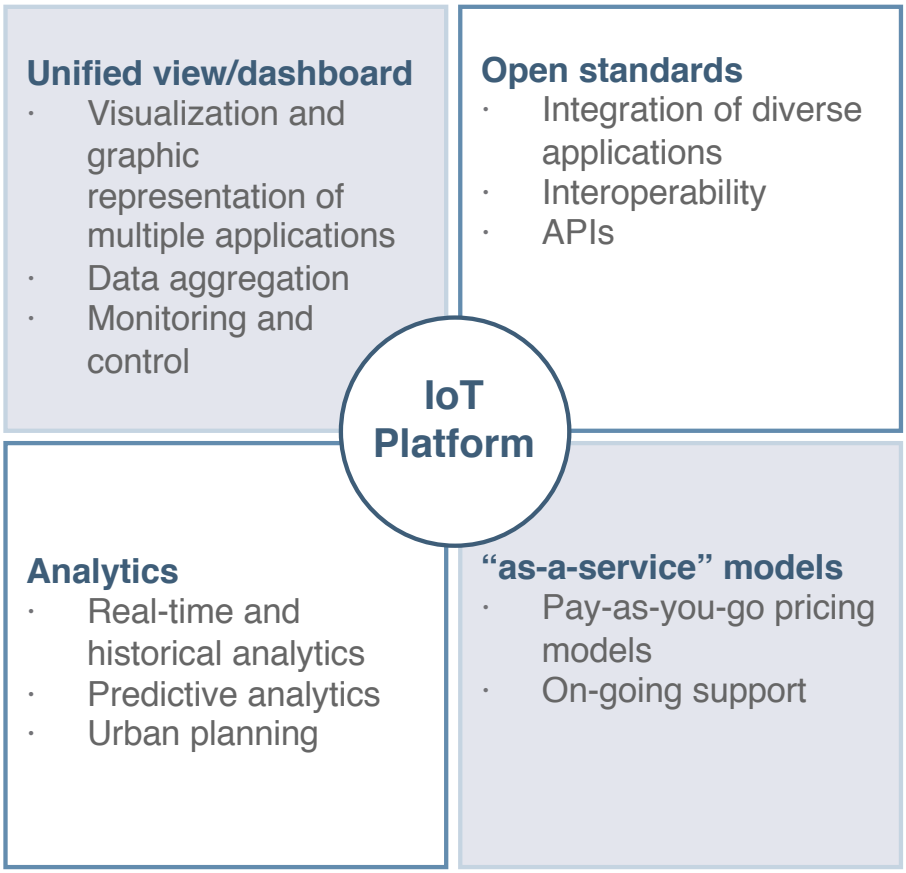


What current solutions are available?

Many of the largest IT companies in the world offer sophisticated IoT platforms. These include household name companies as well as lesser known specialized providers. Most solutions include the same functionalities and a common set of attributes. There are four key components to most IoT platforms, including:

1. Unified view, or a "dashboard" of city infrastructure and operations;
2. Open systems approach and the ability to integrate diverse applications;
3. Analytics; and
4. "as-a-service" models.

IOT PLATFORM KEY COMPONENTS



The four key components that nearly all IoT platforms feature are:

1. One dashboard / unified view of all sensors

Each IoT platform solution features one unified view of a city's IoT sensors and diverse applications. Many refer to this as a single dashboard providing an overview of city activity in one view. Such a dashboard could be the main screen found in a city's control room and should ideally provide not only monitoring but also control of city infrastructure. In order to provide this unified view, the dashboard is able to aggregate data from a number of different city applications. This is enabled by open standards which is discussed next.

2. Open standards / ability to integrate diverse applications

The various IoT platform solutions also offer open standards and the ability to integrate diverse applications. This is critical to enable the unified view offered by the dashboard. As previously discussed, this is made possible through APIs and open standards. Some of the key applications that integrate into the IoT platform include:

- Smart street lighting
- Smart parking
- Air quality and environmental sensors
- Public safety applications
- Smart waste management
- e-Mobility / EV charging infrastructure
- Any number of other city applications.

3. Analytics

Once multiple applications are unified into a single dashboard, the ability to perform analytics is the final piece of the puzzle. Once a city manages to integrate everything, analytics is the mechanism that allows it to identify problems, recognize trends, and provide the required insight to address them. Analytics will include rich graphical representations of the data to help identify trends, historical data for back testing hypotheses, and predictive capabilities to help identify where in the future there may be problems that need to be addressed. Analytics should also lay the foundation for more effective urban planning and leveraging the new IoT data to improve this process. The analytics engine will also be the platform for publishing datasets to data marketplaces and making it available for third-party app developers.

4. "as-a-service" models

Lastly, IoT platforms typically are offered through "as-a-service" models where cities pay on a monthly or quarterly basis and receive ongoing support and software upgrades. At times these ongoing payments are bundled into one upfront charge if that is preferred by the city. These cloud solutions simplify the IT infrastructure required by Cities to enable these Smart City systems.

Third-party applications and developer communities

The role of third-party applications and examples

Smart city developments will not come from the city alone. Similar to how 3rd party apps have transformed smart phones, 3rd party developers can create beneficial programs for cities based on the data and infrastructure being developed today.

In the past, software vendors only featured their own applications with their products. But more than a decade ago, a shift occurred where platforms began opening up to third parties. Perhaps the best known example of this is Apple opening up to third-party applications for its iPhone and other iOS devices, which expanded the number of apps available from only 500 or so to over 2 million today. Many now argue that the App Store was one of the greatest strategic moves by Apple that created the consumer app landscape we know today. Similarly, back in 2006 (pre-dating Apple), the Salesforce AppExchange transformed the landscape for business-focused app development and many have argued it also transformed the distribution of software and development of the SaaS and cloud business models.

Clearly, an open platform model has stimulated innovation and led to the creation of a diverse set of new applications. The market for city data apps is still young, but aided by large-scale IoT investments, it could soon follow in the footsteps of consumer and enterprise apps.

Consumer Apps

Google Play

Apple's App Store is perhaps the best known app marketplace, along with Google Play (formerly Android Market)

Enterprise Apps

appexchange

shopify app store

quickbooks QuickBooks Apps

ArcGIS Marketplace

A number of app marketplaces covering CRM software (Salesforce), accounting (QuickBooks), eCommerce (Shopify), GIS data (ESRI) et al.

City Data Apps

NYC Developer Portal

Emergent with some early examples available from select cities such as New York City which includes an "App Showcase" with some 15-20 apps

Focus of study

CITIES ARE ALREADY PROVIDING DATA FOR APPS

How's Business?

Dashboard of Chicago's local economy, using open data from City of Chicago, Bureau of Labor Statistics and Woodstock Institute.

Best Parking

A parking search engine that highlights cheapest parking garages and lots in 100 cities and 115 airports.

Crime in Chicago

A data visualization highlighting crime trends in Chicago's 50 wards, using open data from the Chicago Police Department.

WaterOnTheGo NYC

Helps users locate various drinking water fountains in NYC.

The path blazed by the consumer and enterprise app marketplaces has created an opportunity for city data apps. Already, there are emerging examples of these city data apps from the likes of New York, Chicago, London (through its Datastore) and other cities. These have largely relied on the open data programs of these cities, leveraging data from municipal IT systems, police departments, GIS and other data sources. This first generation of city data apps is paving the way for a second generation of apps that will leverage IoT data.

IoT platforms will supercharge existing data sources and datasets with vastly expanded streams of new sensor data that second generation city data apps will leverage. Streetlight-based sensors monitoring vehicle and foot traffic, acoustics, parking, air quality, road temperatures and a host of other factors will provide a new and rich source of intelligence. Similar to their predecessors, these second generation apps will address both the consumer and enterprise markets. Citizens will benefit, but so too will city employees leveraging apps to do their jobs better or faster, city contractors using expanded datasets and apps to more effectively complete their work and other stakeholders who will benefit from the growth of city data.

Ultimately, many are predicting the rise of city data marketplaces with the potential for the monetization of city data. IoT sensor data will have a clear value to a number of diverse potential customers. And a city data marketplace will enable the buying and selling of this data. There are complex issues associated with this, such as those around privacy, but the potential is clearly there.

Some cities have even begun to dip their toes with new initiatives. Copenhagen, Denmark launched its City Data Exchange of public and private data. It was one of the first initiatives to create a marketplace for diverse datasets to be bought and sold. Also, the city of Los Angeles is developing a similar initiative, in partnership with the University of Southern California.

Data marketplace case study: Copenhagen

The city of Copenhagen in Denmark is one of the first to experiment with a data marketplace through its City Data Exchange (CDE). This forward-looking initiative began all the way back in 2013 between public and private sector partners. The CDE helped provide insights into which data use cases are viable, the market value of actual city data and new external data sources. The CDE was aimed specifically at app developers, transport providers and similar parties and had 140 different datasets available.

A key finding from the initiative was that the most sought after data was that covering, "…*how people move around in different places, and times in an area*." Data sources for this included cell phone tracking, wireless connection counting, camera image counting and traffic sensors.

An important takeaway was that this data on people movement often needed to be paired with other datasets to be truly insightful and valuable for customers. These other datasets included fields such as gender, age, education and income level, weather, transportation mode, et al. This reinforced the importance of having multiple data sources in the exchange but also the perils of protecting personally identifiable information (PII).

A final report on the CDE project made three recommendations:

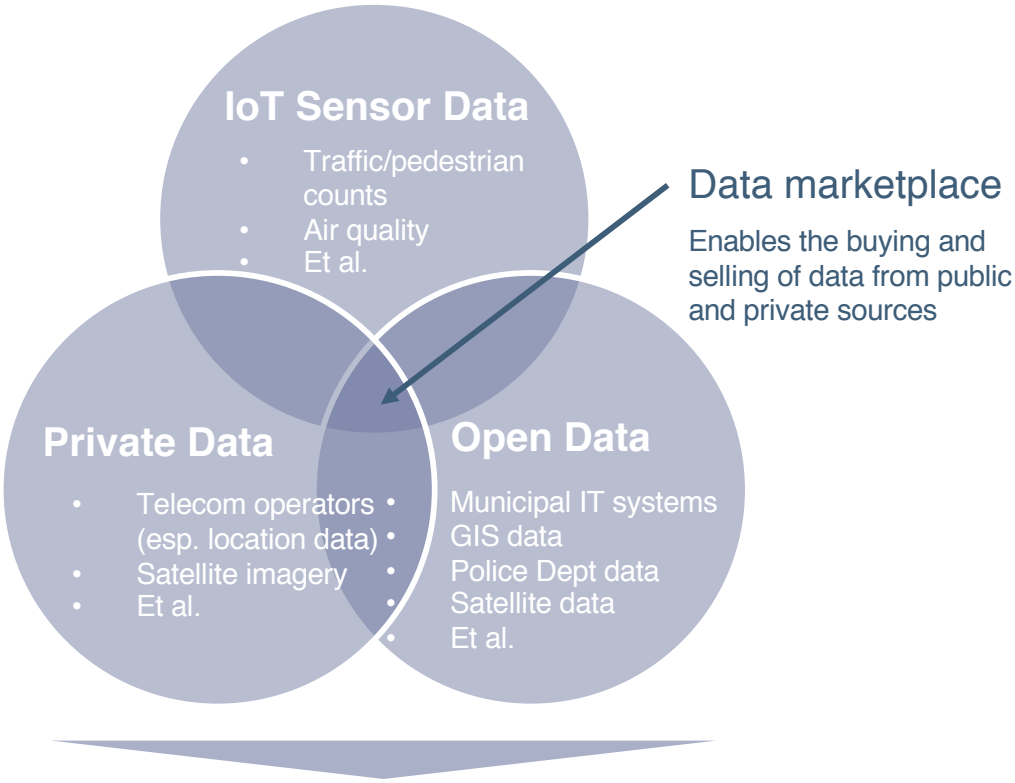
1. *Establish solid use cases* – these should be grounded in a solid business case and show clearly how public/private data can be leveraged;
2. *Create a regional/national data community* – this includes the creation of a platform to facilitate discussions, create use cases and prove the value in exchanging data; and
3. *Establish common standards for data sharing* – including common dataset formats and guidelines for protecting privacy and data security.

Source: "City Data Exchange – Lessons Learned From A Public/Private Data Collaboration," Municipality of Copenhagen and Capital Region of Denmark.

City data marketplaces have the potential to be major catalysts to stimulate third-party innovation in order to extract value from the data resources of cities across the world. It is still early days for these city data marketplaces and beyond the case studies from Copenhagen and Los Angeles, other real-world examples are few and far between. Many cities across the globe are discussing them and waiting for more concrete use cases before launching their own versions. Complex issues such as clear guidelines on data ownership need to be worked through and the early marketplaces have suffered from low liquidity but they are an important first step.

One thing that cities and vendors are well aware of is that third-party apps and data visualization tools will be critical to achieving the full potential of data marketplaces. Indeed, after the CDE project, Copenhagen started a new project with the vendor Cisco and its "Kinetic" IoT platform, focused on how best to combine different data sources and effectively visualize the data.

DATA SOURCES FOR DATA MARKETPLACES



Data sources will feed third-party apps and data visualization tools

Data marketplace case study: Los Angeles and I3

Housed in the University of Southern California, the Intelligent IoT Integrator (I3) initiative in the city of Los Angeles has at its core the goal to develop a data marketplace. A key principle of the program is the separation of the activities of IoT sensor deployment and application development. Developers can access data without needing to physically deploy sensors and those deploying sensors are compensated based on how their generated data is used and monetized.

I3 works to enable community-based IoT networks through testing and evaluation, the building of trust between independent device owners and aiding in a common evolution of the market. The open source I3 software is the middle ground between IoT devices and owners and applications and developers. In effect, it is "*a data governance tool*."

The I3 Consortium is comprised of dozens of stakeholders such as municipal entities and industry players including Amazon, Cisco, ESRI, EY, Microsoft, Nokia, Oracle, Verizon and a host of others.

Source: i3.usc.edu

How can third-party application development be stimulated

The potential for third-party application development is clear. The challenge is how to stimulate their development and set the wheels in motion for numerous applications that improve the lives and welfare of city citizens. There are three key means of stimulating third-party application development: city data hacker events, developer communities and engagement by universities and other institutions.

City data hacker events

A number of cities across the US have established hacker events and weekly or monthly hacker nights in order to serve as a catalyst for innovation involving city data and also third-party application development. These events typically include a diverse cross-section of stakeholders such as developers, designers, policy experts, academics, activists, journalists, city employees and others.

The frequency and format of these events differs but overall, the goal is to help create an environment and platform for knowledge-sharing in order to spark innovation. A popular image may be the all-night civic hackathon to develop a single solution but just as common are regularly scheduled meetings that create an ongoing environment for learning.

City data developer communities

Another catalyst can be developer communities. These are not necessarily mutually exclusive: hacker events can be a place where members of developer communities meet or exhibit their work. But unlike hacker events, developer communities are not bound by the confines of a specific event or physical space. These communities are fluid and engage in knowledge sharing without necessarily having a business motive, end goal or desire to hide trade secrets.

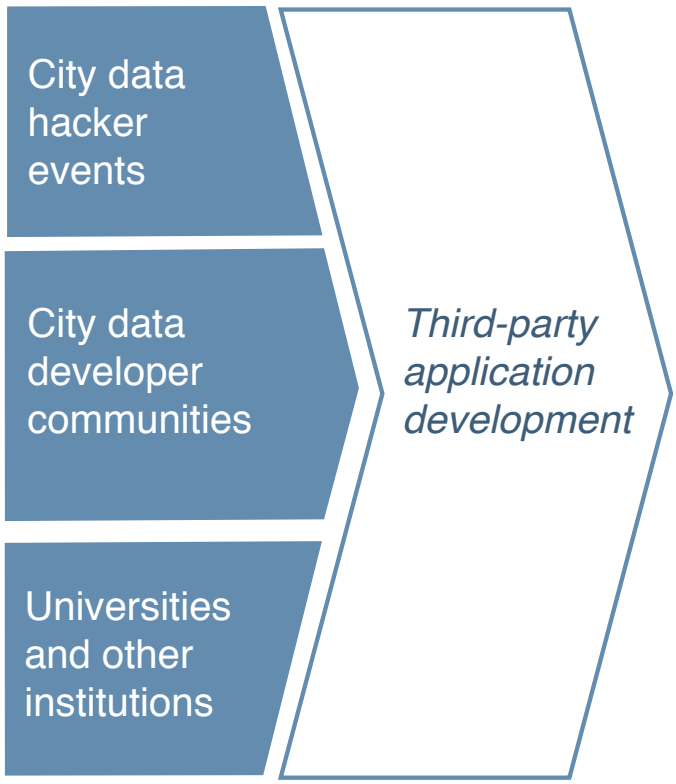
Case study: Chicago

Every Tuesday night, the city of Chicago holds its **Chi Hack Night** in which participants "build, share and learn about civic tech." Chi Hack Night was recently reorganized into a formal non-profit organization with a Board of Directors.

Participants in the hack nights include designers, web developers, academics, data journalists and other stakeholders. Some projects that have emerged include:

- **Slow Roll Chicago - Bike Equity Project** – focuses on the visualization and analysis of bike lanes in the city. Includes bike infrastructure investment analysis and correlation with socioeconomic and health indicators.
- **Petcoke Alerts** – a project to monitor air quality in the city, specifically looking at petroleum coke, or "petcoke."
- **Is There Sewage in the Chicago River?** – notifications regarding sewer overflows and excess wastewater into the lake and river.

Developer communities tend to be open and seek to publicly share their insight, with their knowledge being free. Some of the more well-known developer communities include Github, Google Developers, Dzone, Reddit Programming, StackOverflow and a host of others. Developer communities focused on city data are more limited to-date but as the availability of data from IoT sensors and other data sources grows, so too will those communities specialized in this area. One example is the "City of Chicago Developers" website which has resources such as APIs (covering city health data, police data, transportation data, et al.), API documentation, developer documents, links to the City of Chicago's GitHub page and other tools to help cultivate a developer community. These initiatives to cultivate developer communities focused on city data will be critical to helping drive progress in the field.



Universities and other institutions

The third key way to stimulate third-party application development is active engagement from local universities and other educational institutions. A good example of this is the University of Southern California's involvement with the I3 initiative in the city of Los Angeles to develop a data marketplace. Some of the best collaboration and innovation occurs when there is a vibrant academic community in a city where students, companies and city government can all come together to develop new solutions. These three elements–city data hacker events, developer communities and universities–are by no means mutually exclusive. Their lines blur considerably, as universities themselves may host hacker events, have students that are active in developer communities and a host of other interconnections between the three.

What must a city have in place for successful integration of third-party applications?

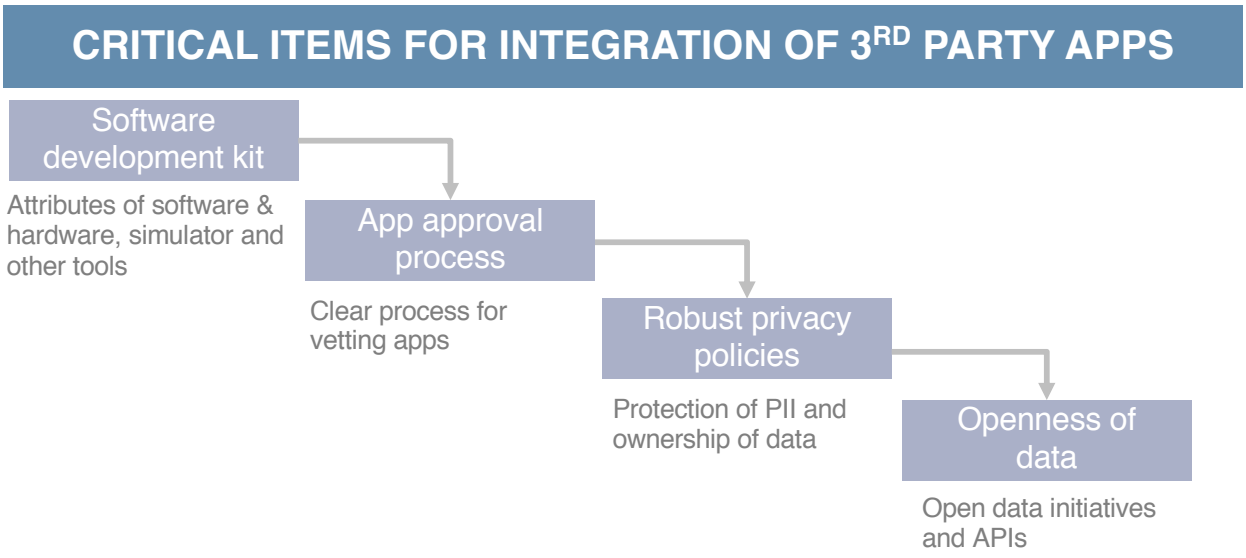
A city can facilitate the integration of third-party apps by making sure a few critical items are in place. Depending on the maturity of the city with regards to data, it can make these tools available either on its open data platform, through its data marketplace or as part of its IoT platform. These include relevant tools and policies such as a software development kit (SDK), a clear app approval process, robust privacy policies and openness of city data for use by developers.

One key element for third-party developer is the software development kit (SDK). The SDK is typically a free download for developers and includes things such as the attributes of software and hardware, a simulator to test the app in development, and other tools to help developers. The SDK provides aids and instruments for app developers as they proceed along the development cycle.

Another important element is the app approval process. Once apps have been developed, they need to be vetted by the platform as per guidelines typically spelled out in the SDK. The app approval process should provide a clear roadmap for developers on what steps they need to take to have their app approved for use.

Robust privacy policies and procedures must also be in place. Foremost should be the protection of personally identifiable information (PII) to protect citizen's privacy. Taken a step further, the city should also ensure that multiple datasets cannot be combined or aggregated in such a way that then releases PII. Ownership of data should also be clearly established.

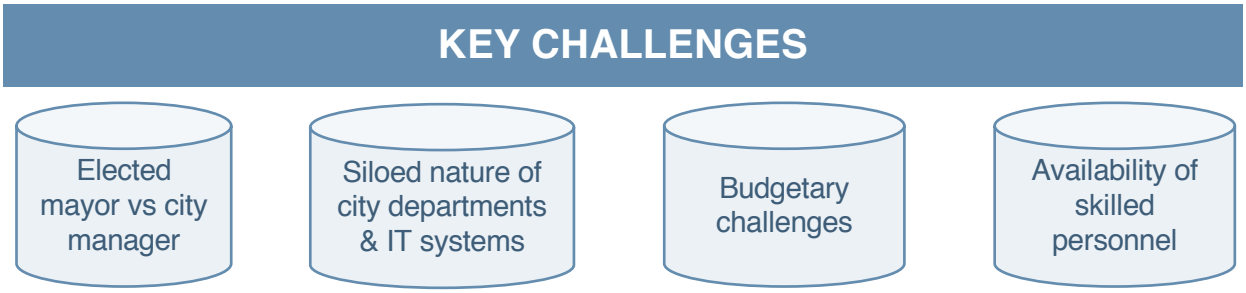
Lastly, the city needs to provide an openness to its data for developers to use it. This can take the form of open data initiatives, the publishing of APIs and other steps to ensure that the city's data is open and available to third-parties.



Challenges and potential solutions

Political, process and practical city challenges

Establishing an effective IoT platform in a city is not without its challenges. One of the first big challenges could be political in nature. City leadership is structured differently depending on the jurisdiction and this could impact the chances of success in implementing an IoT platform. One such political challenge is whether there is an elected mayor versus a city manager driving the project. Other key challenges include siloed city departments and IT systems, budgetary challenges, and the availability of skilled personnel.



Elected mayor versus city manager driving project

Success or failure of a project may depend on who is driving the project. In some instances an elected mayor may be the catalyst for an IoT platform project, likely as part of a broader smart cities program they have promised to implement. In the event this mayor is voted out of office–or is unpopular while in office–the project could be abandoned. A city manager (sometimes referred to as a city administrator) is typically non-partisan and enjoys a more secure position from which to drive projects to completion.

Siloed nature of city departments and IT systems

Another key challenge involves the often siloed nature of city departments and their IT systems. Municipal departments tend to have their own unique processes, IT systems, and budgets. This can create a challenge when trying to integrate them all onto one IoT platform. Individual city departments may squabble over who pays for the IoT platform, it may prove challenging to integrate disparate IT systems, and process redesign may be required on a department-by-department basis.

Budgetary challenges

In addition to the potential challenge of a fragmented budgeting process discussed above, there is also the broader challenge of tight budgets in general. Municipal budgets tend to be under pressure and new projects such as an IoT platform may compete with other priorities. Fortunately, there are a number of flexible mechanisms to overcome this challenge–for example as-a-service pricing models–that are being employed.

Availability of skilled personnel

As cities embrace data-driven decision-making and increasingly utilize sophisticated IT tools and systems, it can be challenging to find personnel with the requisite skillsets. Data scientist skillsets tend to be lacking among existing city employees. However, as cities deploy increasingly sophisticated technology, they will be become more attractive places to work for data-savvy talent. Already, we are seeing cities with a number of data initiatives that have attracted top rate talent with PhDs and other advanced degrees.

Data privacy & cybersecurity challenges

IoT platforms represent an evolution in the capabilities of cities and the data they gather on citizens will present new privacy and cybersecurity challenges. City data governance is an emerging field and many in the industry have expressed the view that rules are being "developed on the fly" in many instances. The stakes are high, especially since citizens cannot "opt-out" of walking down the street in a city similar way to how they may be able to opt-out of signing up for an online service. The area that tends to receive the most coverage in the news surrounds facial recognition software and fears surrounding the idea of an Orwellian surveillance state. Cities across the world are considering banning the use of facial recognition software. San Francisco recently banned its use by the police and other agencies. Others have followed suit, including Oakland and Berkeley in California and Somerville, Massachusetts. On the other end of the spectrum, China extensively employs the use of facial recognition across the country.

But facial recognition is not the only personal data being captured by some cities. A number of other personally identifiable information (PII) attributes are being collected. Acoustic sensors deployed across cities are capturing gun shots but also potentially voice conversations between citizens. License plate reading technology is capturing citizen's movements in their vehicles. These are just a few attributes of PII that have the potential to be collected and risk being disclosed in the public domain or sold to third parties.

To mitigate the potential for accidental disclosure of PII, the anonymization of data is critical, along with clear policies and procedures for how PII data is protected. Furthermore, with more sophisticated initiatives such as data marketplaces where multiple datasets can be bought and sold, there need to be mechanisms in place to ensure that PII is not disclosed when multiple anonymized datasets are combined. On their own, each dataset may be properly sanitized from disclosing PII, but when combined together, it may be possible to triangulate PII.

Beyond the steps surrounding privacy and the anonymization of data, there must also be robust cybersecurity protections in place so systems are not hacked into and PII stolen and/or shared without authorization. Cybersecurity defenses must include protection of the communication networks cities are using for their IoT devices, the devices themselves and also the protection of data. These cybersecurity measures should protect against unauthorized access and any misuse or criminal activity. A single, robust IoT platform – provided by reputable companies that emphasize cybersecurity with the latest standards – will ultimately provide greater cybersecurity protection than multiple ad hoc software systems. Any system is only as secure as the weakest link in the whole system. Reducing these vulnerabilities – through a single, reputable platform – will be critical to cybersecurity.

KEY CHALLENGES

CHALLENGES	POTENTIAL SOLUTIONS
POLITICAL: Project may be abandoned if mayor not re-elected or is unpopular	Involve city manager/administrator at early stage of project for buy-in and continuity in the event of political change
SILOS: City departments and IT systems that are siloed in nature	APIs, open standards and skilled system integrators are helping overcome this IT challenge
BUDGETARY: Fragmented department-by-department budgeting process and overall general pressure on municipal budgets, potential to be aggravated by any recession	Solutions such as vendor financing and "as-a-service" offerings reduce budgetary pressure as no up-front investment required
SKILLED PERSONNEL: Still very rare to find data scientists employed by cities	Foundation-funded city data initiatives are attracting top talent and data scientists to work for cities
DATA PRIVACY: Huge datasets and pervasive IoT sensors and cameras pose challenges for the protection of PII	Robust processes and policies for anonymization of data and protection of PII, with multi-stakeholder buy-in
CYBERSECURITY: IoT sensors and communications networks could be vulnerable	Adoption of cybersecurity standards developed by international standards bodies; reduce vulnerabilities through single, reputable platform

Potential solutions

Cities face several challenges but they also are resilient and fully capable of finding creative solutions. It starts with leadership and continuity in that leadership. An initiative will be more successful if it has built-in protections against changing political winds. For example, a city manager/administrator should have bought into the project to ensure it continues after a mayor may leave office. The burden of legacy IT systems that operate in silos and are funded with budgets that are developed department-by-department can also be overcome. Effective solutions include the use of open standards and APIs to ensure interoperability. Vendor financing and newer "as-a-service" models are helping to overcome the funding challenge. Data scientists traditionally have been attracted to the higher salaries of the private sector but new foundation-funded data initiatives within cities are proving effective in attracting top talent. A growing civic-mindedness among the younger generation is also beginning to take hold and those with data skills are seeking jobs with municipal governments. Lastly, data privacy and cybersecurity are top of the list of stakeholder's concerns with smart city projects. As such, they will receive their fair share of attention and planning with mitigation strategies being formulated with great care.

About Northeast Group

Northeast Group, LLC is a smart infrastructure market intelligence firm based in Washington, DC with expertise in the smart cities and utility infrastructure sectors. We publish in-depth research studies, datasets, notes and offer custom research services.

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