Smart Cities and the journey to the “Cloud”
“Smart city” is a term with varied implications. But the underlying technology, with its ability to provide a 360° view of every aspect of a city's operations and improve the quality of life it offers, has moved beyond science fiction. Today, it offers hope for communities and aspirational urban centers.

Imagine a city where interconnected technology works seamlessly to improve public safety, transportation, energy efficiency, economic development and operating expenses. Cities such as Singapore, London and San Francisco, smart technology is already solving problems. With its ability to track everything from cleanliness to traffic, the digital infrastructure of smart cities can create safer, healthier, more informed communities while generating data of tremendous value to the public and private sectors.

But digital infrastructure is only one key part of smart city development. Another is information, the lifeblood of smart solutions. Data can provide a better understanding of every critical element of a city's progress, improving decision-making and planning. Smarter design, management and resourcing support long-term sustainability.

Smart cities mean improved operations, greater transparency and new ways to connect with citizens, businesses and nonprofits. But the creation of a smart city takes time and investment. Its long-term success depends on the quality of decisions made based on a holistic strategy, a carefully drawn roadmap and the right talent. A city can begin its smart transformation only after it has made the necessary investments in human and social capital, traditional infrastructure and disruptive technologies.

And none of this can begin without a strong vision in place. Rome wasn't built in a day, and neither are smart cities. The effort requires a strong, well-organized and knowledgeable team to unlock the full value of smart technologies for the community. From schools to public services, from transportation to energy, smart cities require a holistic vision to deliver solutions for every aspect of urban life.
Framework for Smart Evolution

Any city’s long-range plans should include smart city strategies. Deloitte has developed a framework to help cities think through relevant strategic choices and achieve three common goals:

- **Quality of Life**: One goal is to enhance every aspect of daily life, from safe streets to green spaces, from reasonable commutes to access to art and culture. A smart city can create an environment that promotes the best of urban living and minimizes the hassles of city life. Smart cities, ultimately, are great places to live.

- **Economic Competitiveness**: Cities are centers of trade and commerce that assemble diverse economic forces to drive an innovative economy. A smart city aims to be business-friendly, ensuring enough jobs and tax revenue to form a healthy economy.

- **Sustainability**: Smart cities help ensure that economic growth and quality of life are promoted not just in the short term, but for future generations as well. Wise stewardship of the environment and sustainable consumption of natural resources are essential elements of the overall smart city vision.

Smart cities exist at the intersection of digital technology, disruptive innovation and urban environments. They’re exciting places to work and live, and breeding grounds for new ideas. New ideas and new technologies can be brought to bear in concrete ways that enhance the lives of citizens and create a brighter future. By leveraging technology, cities can improve efficiency, sustainability, and competitiveness — offering a better economy and higher quality of life to its citizens. Smart cities are the wave of the future.
The people who live and work in cities seek a healthy environment, safety and access to transportation. Education and economic vitality also help to attract and retain talent. Building on our goals and observations of the activities of daily living, our framework includes six primary elements cities can leverage to develop their strategy:
ENVIRONMENT
Using technology to foster sustainable growth is essential. This means using technology to encourage smart choices to maximize the efficient use of resources and encourage sound decisions by everyone — the city itself, businesses, universities, hospitals, nonprofits and individuals. Sensor technology, behavioral economics and gamification can influence and improve decisions about physical infrastructure and resourcing.

EDUCATION
Education enabled by virtual learning, digitization and augmented reality transforms the way we learn. Smart learning is personalized and “unbundled,” allowing individuals to pursue only the coursework they need for their personal goals. It’s blended, combining digital coursework with traditional classroom techniques. As teachers leverage data and analytics to maximize student success, the focus shifts from digital content to real-world learning, connecting students, teachers and outside experts and paving the way for lifelong learning.

SECURITY
As crime becomes smarter, public safety and security agencies need to stay a step ahead. Law enforcement officers on the ground can use drones, wearable computers, facial recognition and video-based predictive analytics to fight crime and protect the public. Agencies are beginning to tap a variety of streams of data including social and crowdsourced information to prevent crime.

MOBILITY
In any city, transportation infrastructure is a finite resource. In a smart city, sensor-driven dynamic pricing, mobile-enabled ridesharing and other social transport apps help tackle traffic congestion and improve land usage in major urban corridors. Mobility emerges as a service relying on a digital platform that integrates end-to-end trip planning, booking, electronic ticketing and payment services across all modes of transportation, both public and private, on rivers, rails, roads and runways.

ECONOMY
A smart economy can be both healthy and dynamic. The growing ubiquity of digital and other technologies allows regulation to become more nimble and responsive, streamlining permitting and licensing and providing more efficient customer service to businesses.

LIVING
A truly smart city can advance the concept of smart living, a variety of approaches that enhance daily life. Cities can promote tools and technologies that help citizens monitor their health, wire their homes for improved energy use or receive human services tailored for their individual needs. Coupled with new approaches such as predictive analytics and insights from behavioral economics, smart living encourages citizens to make better choices in their lives.
Early success stories around the world

With 3 million residents spread over 78 square miles, Buenos Aires owns more than a million pieces of public infrastructure, including 120,000 public lights, 56,000 sidewalks and 28,000 stormwater drains. Maintaining such a vast infrastructure can be a challenge. The city has long allowed citizens to log complaints or service requests through a call center for everything from fixing potholes to removing graffiti. Unfortunately, the feedback mechanism was largely ineffective because the city was slow to respond; in 2011, the average response time was almost two years.

In 2010, the Buenos Aires City Hall resolved to streamline information flow and improve departmental coordination by implementing a new IT system. The city launched a mobile application citizens use to register complaints directly or via linked social media channels. The application, using integrated geographic information system (GIS) technology, sends the location of the complaint to the appropriate ministry, which then assigns the repair to the nearest vendor for resolution. The ministry uses on-screen dashboards to make sense of the real-time data as it flows in. These dashboards provide information on the status of each complaint and capture citizen ratings based on how problems are resolved.

The data Buenos Aires is collecting via sensors and crowdsourcing allows it to evolve hyperlocal solutions. For instance, the city now can predict flooding in certain areas using sensor data, such as weather reports and the speed, direction and level of water in sewer drains. These data are fed to city IT systems that set off an alarm if flooding is likely.

Buenos Aires' responsive system improved the city's quality of life. The average time to resolve a complaint fell by 93 percent without additional spending, allowing the city to fix more problems in less time. The city also has seen an uptick in almost all satisfaction indices, including green-spaces satisfaction (from 49 to 76), streets works (13 to 45), public lighting (19 to 51) and storm water drains index (19 to 56).

Kansas City, Missouri is one of the smartest cities in the U.S. Its successful use of smart city technology has been a key factor in bringing people back to Kansas City's core. Ten years ago, Kansas City had fewer than 5,000 people living downtown; that number has risen by 520 percent, while development investment has risen by 400 percent.

Along the two-mile corridor of the Kansas City Streetcar, a $15 million public-private partnership has supported the deployment of 328 Wi-Fi access points, 178 smart streetlights that can detect traffic patterns and open parking spaces and 25 video kiosks, as well as pavement sensors, video cameras and other devices. It’s all connected by the city’s nearly ubiquitous fiber-optic data network.
Before embarking on the journey

Again, the transition to a smart city takes time. Many cities have fallen short because they didn’t lay the right foundation and plan the journey.

STAKEHOLDER ENGAGEMENT
To realize the potential of smart city technologies, key stakeholders should be engaged from the start to create the vision and plan for the future. Key constituents include:

- **Government** — Local officials must be involved in setting the vision and aligning city resources and infrastructure to it.
- **Industry** — The private sector’s numerous customer experiences have built the expertise and thought leadership to guide smart city initiatives forward.
- **Academia** — As research hubs, institutions of higher learning can help identify innovative solutions for common problems.
- **Citizens** — The individual is the key to any smart city success. Citizen engagement and community buy-in are critical to both adoption and scalability.

FUNDING AND FINANCING
Cities generally begin smart initiatives with projects that can produce high public benefits with limited funding. Capital-intensive projects may require government funds to be supplemented by financing (such as municipal bonds) and external funding options.

Funding smart city programs can require creative vehicles that depart from traditional models of infrastructure finance, such as:

- public-private partnerships, which can bring financing as well as technical knowledge.
- crowdfunding, such as “green” bonds used to raise capital for energy-efficiency projects.
- user fees that can offset ongoing operational costs.
- special development funds, often used by cities that lack capital and have lower credit ratings.
- other innovative funding mechanisms, including tax increment financing, green revolving funding, etc.

POLICY CHANGES
Standards for daily living are often codified in policies and laws. Cities with “smart” ambitions should begin as early as possible to identify and update policies that can further the city’s progress.

EXPERIMENTATION
Creating the smart city is a “long game,” but regular, demonstrable wins can maintain momentum. To achieve such wins, cities should create physical and virtual testing grounds for their ideas. Successive experiments and iteration of promising ideas can maximize opportunities for the greatest benefits.
The role of technology in a Smart City

Sensor data and citizen-generated information together can help provide a better understanding of citizens’ needs.

Most smart city solutions rely on a combination of core technologies such as computing, storage, databases, data warehouses and advanced technologies, including analytics on big data, real-time streaming data, artificial intelligence, machine learning and the Internet of Things (IoT). The AWS Cloud can lower barriers to entry by allowing cities to optimize their use of these technologies to improve existing or create new services that positively affect their residents’ quality of life.

Smart cities generate enormous amounts of streaming data from sensors and other devices. Ingesting, storing and analyzing this real-time data typically requires significant computing capacity. Data intake must take millions or even billions of devices into account. This capacity also must scale based on the amount of input (such as traffic data at rush hour vs. 3 a.m.) and the type of analysis performed (i.e. real-time vs. batch). The solution should be able to scale easily based on demand.

This can be accomplished by using AWS IoT, Amazon Kinesis, Amazon Kinesis Firehose and Amazon Kinesis Analytics that integrate with one other and can ingest trillions of messages from billions of devices, all without having to wait for additional hardware. It’s a game-changer for the quick implementation of smart city solutions.
A smart city also needs to ensure data security, privacy and reliability, while keeping the need for coding very limited. AWS IoT, as a managed cloud, provides that balance. It has full device management and security capabilities and can allow connected devices to interact with cloud applications, Kinesis and Kinesis Analytics, which process and run real-time analytics on data ingested through AWS IoT. These services also can deliver data to other AWS services, such as Amazon Simple Storage Service (S3) and Amazon DynamoDB, efficiently; AWS Lambda eliminates the need to write complex code. In all, then, a city can begin analyzing data and making real-time decisions without employing a large contingent of developers.

For proactive traffic management, for instance, it’s important to understand traffic patterns through deep analytics. Traffic data stored in the data lake is consumed by the analytics and visualization layers to derive value from the data. Analyzing large data sets typically requires significant compute capacity that can scale. Amazon EMR (Elastic Map Reduce), a highly distributed computing framework, can provide capability for analyzing such data in near real time as well as through batch.

Cities generally prefer open-source platforms, and most Amazon services have been built on such platforms. Amazon EMR, for instance, uses Apache Hadoop, an open-source framework, to distribute data and processing across scalable cluster. One of the key components of the analytics layer is its use of machine learning for performing predictive analytics, either batch or real-time. Amazon Machine Learning service provides this capability and it can make it easy to create machine learning models without the need to learn complex ML algorithms/technology.

It's useful to note that the data volume of smart cities will almost certainly expand substantially. It may require inexpensive and secure archival. That's where AWS’ extremely low-cost, secure and reliable cold storage service called Amazon Glacier comes in.

It's also important to build dashboards and other visual representations for easier and more effective analysis. Amazon Redshift is a fast, fully managed data warehouse that makes it simple and cost-effective to store transformed (structured) data. It allows users to query petabytes of structured data using sophisticated query optimization and massively parallel query execution. For analytics, Amazon QuickSight offers a cloud-powered service that makes it easy to build visualizations, perform ad-hoc analysis and quickly gain business insights. It allows a city to build real-time dashboards for all connected, on-street assets.

Implementing security at scale for a smart city solution is always a top-of-the-mind issue for any city leader. Security includes AWS Identity and Access Management (IAM), data encryption and key management, device authentication and platform API security. IAM and Amazon Cognito provide fully managed services for identity and access management. AWS Key Management Service (AWS KMS) allows server-side or client-side data encryption for data stored in Amazon S3. The connected devices are authenticated using certificates.

Other AWS services used in the AWS Smart City reference architecture are:

- **AWS Lambda**: AWS Lambda lets you run code without provisioning or managing servers.
- **Amazon Workspaces**: Amazon WorkSpaces is a fully managed, secure Desktop-as-a-Service (DaaS) solution that runs on AWS.
- **Amazon Route53**: Amazon Route 53 is a highly available and scalable cloud Domain Name System (DNS) web service.

The architecture shown above assumes an all-in AWS build out using native services. However, most cities start with multiple solutions. AWS is built to easily accommodate those.

This architecture also facilitates the following for a Smart City: Command and Control of real-time systems, integration with on-premises data center infrastructure, large scale data ingestion for video, and edge computing capabilities.
The benefits of a cloud-based approach

Two of the most common barriers cities face when implementing smart city solutions are the in-house capacity to design, implement and manage cutting-edge technology and the funding needed for these efforts. Cloud-based solutions allow cities to use managed services to scale their limited resources and reduce the total cost of ownership (TCO) for smart city solutions.

AWS Cloud offers scalability, security, compliance and a significantly reduced TCO. Considering the proliferation of sensors and the enormous amounts of data generated from sensors and citizens, it's very important that city management select the right solution for the long term.
**SCALABILITY**
AWS provides highly scalable services to meet application performance and capacity needs. For example, AWS IoT service can scale automatically to support billions of devices and trillions of messages, while Amazon Redshift (a fully managed data warehouse) can scale up to petabytes of data. Processing real-time streaming of sensor data at scale is important to a smart city solution. AWS IoT, Kinesis, Amazon EMR, Amazon ML, Amazon Redshift analytics and Amazon S3 scale automatically to support varying volumes of data processing and storage.

**SECURITY**
At AWS, cloud security is the highest priority. Customers can benefit from a data center and network architecture built to meet the requirements of the most security-sensitive organizations. A key advantage of the AWS Cloud is that it helps customers scale and innovate while maintaining a secure environment. AWS is responsible for protecting the infrastructure (hardware, software, networking and facilities) that runs all the services offered in the AWS Cloud.

**COMPLIANCE**
With more data comes more compliance responsibility. Many regulations must be followed: for personal data, PII; for financial data, PCI; for healthcare data, HIPAA; and so forth. AWS Cloud provides readymade compliance as it already has most of the necessary compliance certification.

**TOTAL COST OF OWNERSHIP**
Given the funding challenges cities face when planning and implementing smart city solutions, AWS’ lower TCO helps cities find reasonable funding solutions.

**AGILITY**
(TECH/POLICY/FUNDING/GOVERNANCE)
Smart city solutions need to react to change continuously. Cloud services can dynamically react to changing needs regardless of the driver of the change, whether it’s technology, policy, funding or regulation.

**PARTNER ECOSYSTEM**
Another critical success factor is the acquisition of experienced partners and solution providers. The partner must have a demonstrated level of technical proficiency and proven customer success in specialized solutions and vertical focus areas. Often this can be validated via their relations with other partners. AWS maintains a formal global partner program that ensures a high level of proficiency in the use of cloud services, technical accreditations, certifications and specialized training to validate partner competency and interoperability — critical considerations in the execution of large projects.

AWS Marketplace hosts many smart city solutions, built by AWS partners, which have a high degree of interoperability and pre-integration. Solution acquisition via marketplaces such as AWS Marketplace tend to simplify and reduce risk in the acquisition process.

In many ways, a smart city is the quintessential example of an ecosystem in which the diversity and complexity of challenges and solutions requires the participation of partners. Often, a smart city solution is built upon an open platform or cloud provider that makes it possible to collect, share and disseminate data and information securely and efficiently. With better scalability, security, compliance support, total cost of ownership and agility, smart cities are positioned to be the future of commerce and community.
Where should a city start?

Smart city solutions do not arrive pre-assembled with a common go-live date. They grow over time. They’re transformational initiatives. As with any major initiative, smart-city programs can suffer from common pitfalls.

- Planning for perfection can lead to inaction. Continuous strategy pondering and changing priorities might hinder or stop smart city programs.
- Skewed perspectives that don’t align with residents’ goals can lead to inadequate outcomes. A simplistic view of community challenges can lead to solutions with insufficient features.
- Too much focus on design and not enough on delivery can lead to project delays, cost overruns and lackluster delivery.

Cities should take seven steps to avoid these common hurdles:

1. Start with a compelling business case. Present an idea constituents can easily understand.
2. Develop, document and communicate a clear and compelling vision of the future. Create a picture everyone can rally around.
3. Run it like a portfolio. Include discrete projects, each with its own business case.
4. Authorize the Program Management Office to make decisions. Establish standards, manage issues and risks, make decisions and move forward.
5. Take a phased approach with many small “wins” over time. Cluster and sequence projects based on outcomes, priority, staffing and funding.
6. Don’t underestimate change management and communications. Double your time estimate, then double it again.
7. Focus on achievable results. Pick three things you want to announce as successes one year from now.

While there’s no one-size-fits-all formula to becoming a smart city, these are critical steps for all cities on this journey.

By leveraging the smart city framework and understanding the cloud solutions available to support each element of the project, cities can become smarter, provide a higher quality of life for their residents, enhance sustainability and create and retain a vibrant economy.
REFERENCES:

1. http://smartcity.deloitte.com/about/
11. Interview with Deloitte Argentina project team, November 8, 2016

CONTACTS

Rana Sen
Deloitte Consulting LLP
rsen@deloitte.com

Mark Price
Deloitte Consulting LLP
maprice@deloitte.com