Hype Cycle for Smart City Technologies and Solutions, 2020

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A smart city is designed to achieve holistic objectives, representing an intelligent urban ecosystem. This research helps local government and business CIOs, urban planners and strategists assessing emerging technologies and solutions to deliver sustainable societal outcomes.

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Analysis

What You Need to Know

A strategic view of a smart city or intelligent urban ecosystem applies a digital approach to foster collaboration and engagement across citizens, industries and governments. Disruptive forces consisting of pandemic, political, environmental and demographic challenges are increasing and will determine the reach and speed of interactions across this ecosystem. A concerted effort, using data sources, can successfully resolve the challenge of citizens living a full life in a healthy society in an urban environment. Smart city governance empowers individual and business innovation.

The 2020 pandemic and its aftermath will reach far into the coming years. City CIOs and urban ecosystem partners will have to prioritize between political agendas, budgets, engagement and operational maturity with digital citizen equity and new industrial development, which is often coined the "Fourth Industrial Revolution." CIOs are providing the tools that can link isolated events in our current disconnected environment into a story for citizens, using disruptive enablers like artificial intelligence (AI) and chatbots. They are the new narrators for our future.

The Hype Cycle

The 2020 Hype Cycle for Smart City Technologies and Solutions tells the emerging stories of buildings, circular economy and urban operations adopting the streamlining and optimizing holistic ecosystem approaches through data exchanges and digital twin use cases. Data becomes the critical fuel to unlock and orchestrate fact-based decisions relative to resilience and citizen-focused issues. Digital ethics, together with approaches on sustainability- and community-driven strategies, are peaking, while digital security is morphing into a framework and therefore expiring before reaching the plateau. Intelligent street poles are evolving from smart lighting and street efficiency to improved citizen environment and safety, due to an emerging ecosystem of sensors and technology.

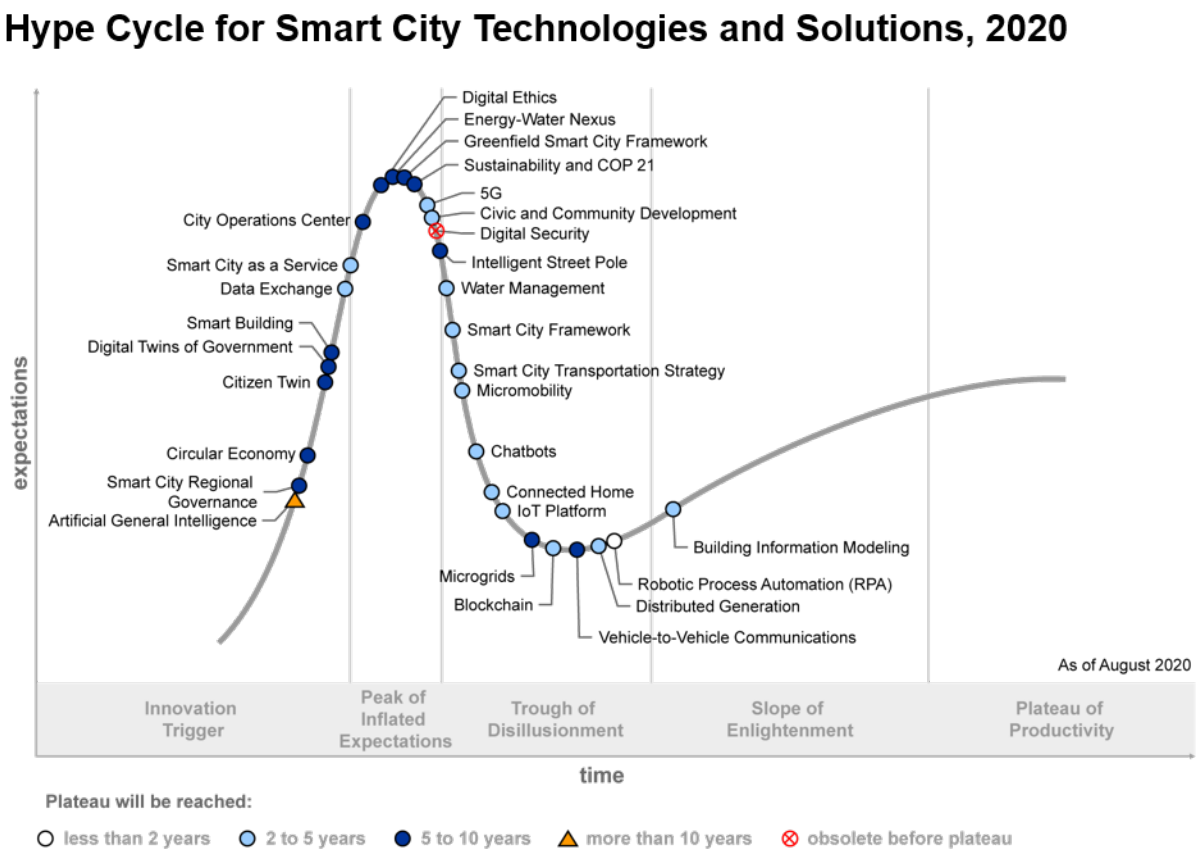
Mobility and urban transportation strategies have moved into the Trough of Disillusionment, as platforms and service offerings are extended from citizens to last-mile logistics. Before COVID-19 struck, mobility services were a remedy for congestion and air pollution.[1] Nowadays, given social distancing mandates, mobility services and transportation strategies have to include location-based information, passenger velocity and disinfection status, while still maintaining service levels for availability.[2] Often, micromobility is becoming the selection of choice.

Innovation profiles like water management, microgrids, energy-water nexus, and sustainability and COP 21 experience a high priority in the smart city framework discussion around cities' climate change charters. Initiatives by the World Economic Forum seek to rebuild society after COVID-19 with a "Great Reset" facilitated through the Fourth Industrial Revolution in urban centers, and project that sustainability *and* business development, especially in cities, will increase. Especially in Europe, regional prioritization (for example, the European Green Deal) will provide extensions to the circular urban environment approach.

As in previous years, the Hype Cycle also reveals the maturity of the technology solutions and platforms is farther ahead than the business and city outcomes that they are promising to generate.

Internet of Things (IoT) platforms, blockchain, chatbots, building information modeling and robotic process automation (RPA) are moving toward the Slope of Enlightenment, becoming mainstream options for intelligent use cases.

Figure 1. Hype Cycle for Smart City Technologies and Solutions, 2020



Source: Gartner
ID: 450328

The Priority Matrix

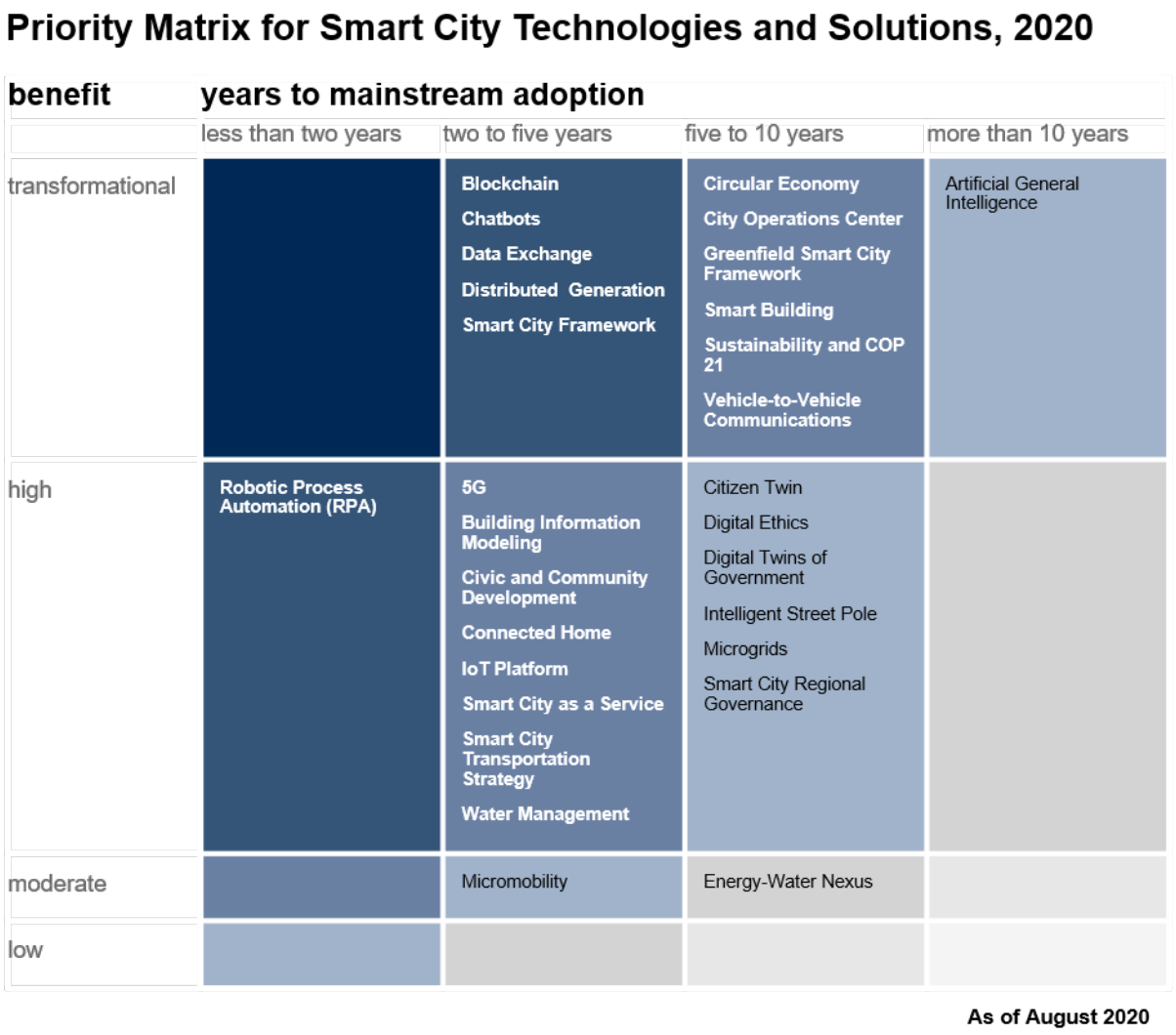
Many technologies have a transformational or high impact on smart cities, but will take a longer time to realize. Consequently, city CIOs and urban planners will implement the solutions over longer periods of time to generate outcomes and ROI. Much of the benefits can be supported using data analytics and data exchange to optimize city operations, together with the intelligent urban ecosystem, or to drive long-term sustainable and inclusive outcomes.

Innovation profiles like data exchanges, blockchain and chatbots are transformational and will be mainstream in the next five years. This acceleration is critical as, in an ecosystem, the ability to rapidly increase automated transactions will support contextualization of service delivery at the location where the service is needed. For example, this acceleration is needed for smart buildings,

city operations centers or vehicle-to-vehicle communications. Those will be maturing, together with the circular economy, in 10 years or less.

High benefits will be generated in up to five years from innovation profiles such as 5G, in conjunction with IoT platforms, or building information modeling in smart buildings and campuses. CIOs will require those technologies to capture data and analyze this data for operational efficiency (for example, in transportation and micromobility), and for energy and resource management. Digital representation of urban situations through digital twins will show benefit over an extended period of time of up to 10 years, as joint governance on urban objectives and vision turn into actionable roadmaps.

Figure 2. Priority Matrix for Smart City Technologies and Solutions, 2020



Source: Gartner
ID: 450328

Off the Hype Cycle

The following profiles were removed from the Hype Cycle:

- **Autonomous driving Level 5:** The use case of how the autonomous driving level will be impacting mobility, governance and transportation is included in the respective service innovation profiles in "Hype Cycle for Connected Vehicles and Smart Mobility, 2020."
- **Blockchain business models:** Blockchain is a transparency enabler for smart city transactions, and blockchain business models will be incorporated in smart buildings, transportation, mobility and so on as an outcome.
- **Data for good:** With the emergence and depth of the data exchange and marketplace, data will be pulled from all different sources for smart city service creation and innovation.
- **Data marketplace:** We renamed this to data exchange.
- **Smart lighting:** Lighting has reached its maturity plateau. However, we included intelligent street poles that, in most cases, include lighting, as well as many other service interfaces.

On the Rise

Artificial General Intelligence

Analysis By: Saniye Alaybeyi

Definition: Artificial general intelligence (AGI) is the hypothetical intelligence of a machine that has the capacity to understand or learn any intellectual task that a human being can. It is also referred to as strong AI.

Position and Adoption Speed Justification: Tangible progress on AI continued to be limited to narrow AI this year. On the philosophical front, no viable, agreed upon criteria to define AGI was in place. On the technical front, very small steps toward AGI were taken, such as IBM-MIT collaboration on neuro-symbolic concept learners, Microsoft and OpenAI partnership with $1B investment, and DeepMind, owned by Google, declared as its mission to build AGI. AGI safety is even less understood than AGI benefits, which makes AGI even further challenging and hypothetical. Therefore, this year, we keep AGI's position on the Hype Cycle the same. Today's AI technology cannot be proven yet to possess the equivalence of human intelligence (the lack of agreement about a test to prove such intelligence is itself a problem). It may, at some point, be possible to build a machine that approximates human cognitive capabilities, but we are likely many years away from completing the necessary research and engineering.

User Advice: End-user organizations should ignore AGI, however, until researchers and advocates demonstrate significant progress. Until then, ignore any suppliers' claims that their offerings have AGI or artificial human intelligence — these are generally illusions created by programmers.

Focus on narrow AI, not on AGI. Special-purpose AI will have a huge and disruptive impact on business and personal life. Deliver business results enabled by applications that exploit special-purpose AI technologies, both leading-edge and older.

- Look for business results enabled by applications that exploit a full range of AI techniques, represented in this Hype Cycle.
- Experiment with less proven AI technologies that have precedents of success and give you competitive advantage.

Business Impact: AGI is unlikely to emerge in the next 10 years, although research will continue. When it does finally appear, it will probably be the result of a combination of many special-purpose AI technologies. Its benefits are likely to be enormous. But some of the economic, social and political implications will be disruptive — and probably not all positive.

There are currently no vendors of systems that exhibit AGI, but many companies are engaged in basic research. Examples are DeepMind (owned by Google), OpenAI, Vicarious, Numenta, Project AGI, OpenCog.

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Recommended Reading: "Emerging Technologies and Trends Impact Radar: Artificial Intelligence"

"Maverick* Research: Being Human 2040 — The Life of the Architected Human in a More-Than-Human World"

Smart City Regional Governance

Analysis By: Bill Finnerty; Bettina Tratz-Ryan; Cathleen Blanton

Definition: Smart city regional governance implements decision making to coordinate evolution of systems that extend across the intelligent urban ecosystem, such as public safety or transportation, and may involve both public- and private-sector organizations. Regional collaboration enhances opportunities to coordinate initiatives and hold participants accountable for achieving smart city goals and objectives that make a region a better place to live, work and play.

Position and Adoption Speed Justification: Constituents want seamless coordination of services as they move from home to work to social events. To meet this need, governments must coordinate efforts across the intelligent urban ecosystem, crossing the political and organizational boundaries that blur into a metropolis. Smart city regional governance provides the mechanism to engage the public and private sectors in cross-jurisdictional, intragovernmental and cross-organizational initiatives. Coordination across the silos of government has been a significant challenge for moving from individual IoT or data projects to an effective smart city, which is only further complicated when also engaging the private sector. Establishing a common set of goals, decision-making criteria and

KPIs provides a framework for building the trust necessary to sustain efforts that span the greater ecosystem.

User Advice: Smart city leaders can improve outcomes for their communities by establishing regional governance to coordinate smart infrastructure, IoT and data projects. A community-driven approach to determining smart city goals and objectives provides the ecosystem with a focal point to ensure that activities are inclusive, a vital differentiator for user acceptance. Members must be able to:

- Identify who can/will participate in the intelligent urban ecosystem.
- Define the rules of engagement.
- Collaborate on shared capabilities.
- Be able to define the value to the ecosystem and the participants.

The digital ecosystem model documents the participants, value exchange, shred capabilities and rules for using those shared capabilities. The defined value exchange needs to ensure that:

- The private sector is motivated to participate and can maintain competitive advantage.
- The government's investments are fair and effective.
- Citizens benefit without undue risk or cost.

Receiving value from participating in the smart city digital ecosystem also requires that participants trust each other. Some have competing interests, and most have different missions.

Establishing an environment of trust takes a focused effort for regional coordination, and the rules governing the ecosystem participants' usage of shared capabilities provide a structure in which that trust can be developed and matured. Smart city leaders should design and implement the governance processes to empower decision-making efforts through the lenses of cost, value and risk, and hold participating members accountable through establishing smart city KPIs.

Business Impact: Smart city regional governance provides an opportunity to leverage investments, resources and activities from across the ecosystem in achieving community goals and objectives. Smart city regional governance provides the mechanism to improve lives of those who live, work and play throughout a region through improved constituent experience, streamlined coordination of services and the better use of data in decision making across the ecosystem. Smart city regional governance supports a more focused, productive dialogue across leadership: civic, city, government department, business and citizen advocacy. This dialogue engenders trust by building on an explicit foundation of shared goals that are discussed and developed as the ecosystem is formalized and evolved.

Examples of efforts that benefit from regional governance include:

- Multimodal ticketing for end-to-end smart transit
- Real-time crime centers that coordinate multiple agency responses

- Smart education initiatives to drive next-generation employment opportunities
- Air quality monitoring to improve health conditions for residents
- Homeless response efforts that can benefit from regional data-sharing marketplaces

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Adolescent

Recommended Reading: "Turning Smart Cities Into Intelligent Urban Ecosystems"

Circular Economy

Analysis By: Sarah Watt

Definition: "Circular economy" is an economic model that separates the ability to achieve economic growth from the consumption of primary natural resources. The circular economy is based on three principles. Firstly, designing out waste, toxicity and pollution from products to ease materials recycling, remanufacturing and reuse. Secondly, materials are kept in use for as long as possible, which may lead to adjustments in business models. Lastly, when materials are returned to the environment, this is done in a way that has a positive impact.

Position and Adoption Speed Justification: Gartner identified the circular economy as an emerging concept in 2017 and a leadership trend in 2018. Its position on the 2020 Hype Cycle is based on our understanding of companies' priorities over the next two years, also considering the impact of the European Green Deal. In a 4Q19 Gartner survey, 70% of respondents stated that they are investing in the circular economy. However, only 27% of respondents have integrated the circular economy into existing business unit and growth strategies. Although some companies are pursuing this strategy, it is by no means at scale; although for Europe-based organizations the Circular Economy Action Plan under the Green Deal may act as an accelerator. The circular economy has the potential to provide improved raw material availability and a hedge against material price volatility, but these benefits are achieved only through systemic change.

User Advice: Now is the time to investigate how applying the circular economy may provide a potential competitive advantage to your organization. First movers are already advancing, but there are plenty of opportunities to innovate, disrupt your market and engage your customers.

CSCOs are advised to:

- Become familiar with fundamental circular economy concepts, such as the design principles that underpin the models and the various types of business or product/service models that become possible through the application of circular design.
- Engage the supply chain to lead your company's circular economy strategic planning by setting up a program office. Give the team the goal of becoming the company's experts in circular

economy concepts and models. Ask them to deliver a series of options to advance the circular economy. Define measures of success for the circular economy strategy (see “Metrics for the Circular Economy: If You Can’t Measure It, You Can’t Manage It”).

- Organize a cross-functional strategy team to explore opportunities, business cases and good practices. Initiate conversations around analyzing customer pain points and defining new customer experiences.
- Identify collaborators and partners that can develop, deliver and scale the capabilities required to execute your circular economy model. For example, suppliers may be able to reprocess or remanufacture product of materials (see “4 Practical Steps to Engage Suppliers in Circular Economy Models to Improve Raw Material Availability”).
- Extend the benefits of your digital investments by pinpointing the potential intersections between your company’s digital business strategy and circular economy strategy (see “Employ Digital Technology to Enable a Circular Economy”).

Business Impact: The business impact depends on how a company chooses to apply circular economy principles to its operating model. Some companies first create a closed-loop system to support material recovery for a single product while continuing to deliver other products conventionally. In other instances, the company’s entire business model is based on the circulation of a single asset between multiple users.

Any transition will require systems thinking, collaboration and learning agility. Teams from across the enterprise must work together to identify and design the outcomes that customers really want, while reducing waste and the dependency on additional natural resource inputs to deliver them

However, the circular economy may happen sooner than we think, as economic stimulus during and following the COVID-19 crisis may be tied to “green” low-carbon options.

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Recommended Reading: “Driving Value Through the Circular Economy”

“Circular Business Models Position Supply Chain as a Growth Partner”

“Retail Supply Chains Embrace the Circular Economy”

“Preparing for 2029, When Consumer Product Supply Chains Cannot Produce Waste”

“Video: Johnson & Johnson’s Circular Economy Partnership Supports Growth in Emerging Markets”

“Future of Supply Chain: Reshaping the Profession”

Citizen Twin

Analysis By: Alfonso Velosa; Marty Resnick

Definition: A digital twin of a citizen is a virtual representation of an individual. Governments use citizen twins to support new or enhanced citizen services or government missions such as pandemic or safety management. The citizen twin has model, data, a unique one-to-one association, and monitorability. It integrates data into the twin from siloed public and commercial sources such as health records, social media, phone location logs, and physical infrastructure such as cameras and wearables.

Position and Adoption Speed Justification: Governments are increasingly developing digital twin models of citizens to monitor and help address health, safety, travel, membership, and social media impacts on society. The citizen twin can be used to build profiles, personas, and scores helping stakeholders make decisions, such as aligning medical treatment, managing transportation resources, or taking sensor data to try to understand the health of passengers arriving on an airplane. Aggregated versions of the anonymized citizen twin will be used to understand broader societal patterns, drive government resource allocation and utilization, and impact societal behavior.

Precursors already exist. In western countries, financial organizations provide citizens with credit rating scores. Retailers model shoppers. China has a citizen social credit system. A variety of airport and retail vendors are developing passenger and shopper tracking solutions.

User Advice: CIOs need to help their governments or enterprises take advantage of this emerging trend to serve citizens and customers better. At the same time, CIOs must protect their citizens, governments, and enterprises from misuse of citizen data. Key steps include:

- Transparently develop robust privacy and digital ethics policies
- Establish clear benefits to citizens such as certifying children in a classroom are all healthy or simplifying medical triage to get a citizen to medical care.
- Develop sensor and IoT monitoring capability.
- Invest in integration skills to connect into a diverse set of data sources.
- Use AI to build and test the usefulness of a variety of citizen-twin-based scores.

Business Impact: Governments' safety initiatives will increasingly aggregate citizen data across the world, as they seek to serve citizens, to protect them from pandemics or other crises. This will have a range of key impacts, including:

- Increased debates over privacy and the merits of government access to citizen data, although this has been difficult due to politization in a variety of western countries.
- Expect scope creep as government bureaucracies increase the types and quantity of data collection.
- Government curation of aggregated citizen data a security risk for government data and possibly a safety risk for the individual citizen.

- There will be increased regulation to balance the government use of the data with the citizens' respective rights to privacy.
- As governments work to collect more data on citizens, this may drive a dialogue to get more services and other financial benefits in return to citizens, but it will expose a lack of integration skills across data sources — and political infighting over data siloes.

Benefit Rating: High

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Sample Vendors: Alibaba Cloud; Apple; Google; Tencent; VANTIQ

Recommended Reading: "Getting Started With a Digital Twin of Government"

"Top 10 Plausible Directions Resulting From COVID-19"

Digital Twins of Government

Analysis By: Bill Finnerty; Milly Xiang

Definition: A digital twin of government is a virtual representation of government and partner assets, people and operations to provide real-time analysis, operations automation and scenario-based planning. Key features will include a single point of visualization and access to supporting data, APIs for issuing commands to things and processes, and the ability to use AI for scenario planning and urban modeling. As a digital twin of government matures, it becomes a system of systems requiring strong integration capabilities.

Position and Adoption Speed Justification: Digital twins of government are starting to appear in jurisdictions around the globe. This emerging solution provides a single interface to the operations of a jurisdiction. Many start as GIS models or business operating systems; a fully realized future state will:

- Include command-and-control capabilities.
- Leverage AI for scenario planning at scale.

A number of challenges to digital twins of government may impede their implementation and growth. Foundationally, they are integrated systems that will span the silos of government, silos being an ongoing challenge for governments. This requires both coordination on data standards and integration capabilities. Expectations are high. However, sustaining interest, budget and business unit participation in developing a digital twin of government will require focus over multiple administrations.

Advances in offerings from vendors, progress on governmental standards in the U.K., Australia and other countries and the growing number of digital twins of government (such as Virtual Singapore,

New South Wales [NSW] governments Spatial Digital Twin, the Dutch government's digital twin of The Hague and others) have advanced digital twin of government's position on the Hype Cycle.

CIOs planning for digital twins of government will need to address fundamental questions of any emerging technology — privacy, ethics and business value.

User Advice: Government CIOs must create a long-term vision for a digital twin of government by establishing clear expectations, setting an implementation timeline and communicating regularly with executives and business leaders to ensure they do not become fatigued and lose interest. CIOs leading the development of a digital twin of government must:

- Define the vision in business terms to maximize understanding and buy-in.
- Use future planning exercises, such as scenario planning, to develop potential use cases that can be used to prioritize investments and communicate the "art of the possible."
- Establish the protection of citizen data as a guiding principle through the implementation of privacy controls and end encryption capabilities.
- Be mindful that the digital twins of government need not be a complete clone of the jurisdiction. They can be, particularly in the early stages, a digital manifestation of a single aspect. For instance, Transportation-related digital twins have been created for rail stations in China and the U.K., and in Colombia for city mobility.
- Have a vision that extends beyond currently available capabilities. For example, repurposing a 4D GIS map as a digital twin of government can lead to confusion. It is important to clarify the difference and the ways in which these solutions complement each other.
- Access relevant vendors or solutions that could support your vision based on their ability to integrate with existing systems, use of nonproprietary data standards, ability to scale using cloud services and vendor technology roadmaps.
- Focus early efforts on scenarios that can deliver high business value but present low urgency and risk.

Business Impact: Digital twins of government will provide single interfaces for awareness and operational control for jurisdictions in the future. Business impact will extend across government tiers and jurisdictions and the ecosystem. In the short term, governments will need to identify a focused use case for a proof of concept of a digital twin of government. In the midterm, governments will leverage digital twins for command-and-control operations, many of them automated, requiring fewer staff to respond to incidents. Over time, digital twins will be used to test scenarios related to policy and legislation, providing opportunities to model proposals based on historical and projected data.

Use-case examples include:

- Using a digital twin of road and transportation systems to automate traffic management for incidents, weather and emergency response

- Creating a digital twin of a school campus to model student movement for maximizing space utilization and minimizing utility costs

In the wake of the COVID-19 pandemic, digital twins of government are being used to model community health, including the individual's.

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Sample Vendors: Cityzenith; Esri; Estudios GIS; Eutech Cybernetic; IBM; Idrica; OSIsoft; View; Worldsensing

Recommended Reading: "What to Expect When You're Expecting Digital Twins"

"Governments Are Developing a Unique Kind of Digital Twin"

"Getting Started With a Digital Twin of Government"

"Use 4 Building Blocks for Successful Digital Twin Design"

Smart Building

Analysis By: Gavin Tay

Definition: A smart building is a facility where multiple functions cooperate to achieve sustainable outcomes through the analysis of contextual and real-time information, shared among Internet of Things (IoT), information and communication technology (ICT), and operational technology (OT) systems.

Position and Adoption Speed Justification: Much of what has made a building "smart" (mostly operational efficiency) has been heavily reliant on building management systems (BMSs), even up to the present day. Due to the legacy nature of how BMSs are implemented, adoption rates are fairly slow. New hardware for HVAC and lighting that is implemented with new construction has a lifetime of 10 to 20 years. Retrofits take place only when a system fails and needs updating.

IoT and AI has the potential to speed up the implementation of more IT into the BMS space by extending and augmenting existing equipment. Depending on the age of the equipment, BMS software companies can often tap into the data stream or APIs. If the system is older, it is possible for sensors to be economically placed on boilers, chillers, air conditioning units and other hardware to enable real-time monitoring of legacy equipment. Wireless connectivity can reduce the installation overhead of this retrofit. Cost savings that can be achieved by integrating the sensors with BMS software could help to accelerate the adoption of integrated BMS in older buildings. In some cases, it might be more economical to upgrade rather than adapt an older system.

By 2028, Gartner estimates that there will be over four billion intelligently connected IoT devices in commercial smart buildings. CIOs will struggle with provisioning them, managing them, connecting

to them and analyzing their data. Adding to existing complexity, there will be no dominant IoT platform in any smart building, so CIOs will need to compose end-to-end IoT solutions from multiple providers.

User Advice: According to ENERGY STAR, the average building wastes 30% of its energy through inefficiencies in lighting, heating and cooling areas that are not occupied. Much of the energy from these inefficiencies can be recovered by using real-time data from the IoT and IT infrastructure to enable communication between the different BMS in a building. CIOs, real estate and facilities professionals can leverage the significance of IoT to build holistic, engaging employee experiences while increasing building competitiveness. CIOs should opt for flexible payment methods instead of treating such investments as a capital liability. Channel savings obtained — from building efficiencies to the repayment of these solutions or services — make it an operating expense instead.

Gartner predicts that, by 2022, the IoT will save consumers and businesses $1 trillion a year in maintenance, services and consumables. CIOs must assemble an IoT business solution to alleviate the potential business and technical challenges of creating a smart building. An end-to-end IoT business solution is a heterogeneous mix of IT and OT assets, including IoT endpoints (often many), one or more IoT gateways (optional) and one or more IoT platforms. All assets including building management systems are integrated with existing enterprise systems and big data, and may include newer forms of unstructured data such as surveillance footage. Performance monitoring backed up by predictive maintenance, using AI, will not only improve the efficiency and effectiveness but reduce operational expenses.

In assembling a smart building, IoT business solutions require a clear vision from CIOs of its foundational architectural building blocks, beginning with the IoT platform and an understanding of the privacy and data security implications. Delivering digital experience, given limited exposure to governing all moving parts and the flow of activities in smart buildings can be diverse and complex. CIOs will need to become accustomed managing the complexity of a multivendor IoT landscape and technology architecture.

Business Impact: Post-COVID-19, much of what real estate and facilities managers have to deal with when managing a building will involve the CIO or their ICT counterparts. Today, the operating elements of a smart building typically include space, environment and maintenance management, along with wellness, energy management and sustainability. Such rapid evolution of smart buildings means that facilities and real estate professionals will want to leverage the ICT expertise that is part of the CIO portfolio. Integration will be a key component and remains difficult for data residing in various custom-made BMS repositories to interact with one another. As the demands and expectations of workers shift from merely going to an office that has good air, temperature and now hygiene to a place where they have work-life ambience, a smart building experience requires the exploitation of an ever-growing number of IoT business solutions.

Being able to learn human preferences that are constantly adjusted based on human activities, emotional states and reactions in real time can be used to optimize a building's performance and improve predictive maintenance. Smart buildings are able to constantly respond to change, which results in healthy, delighted and productive tenants. Such insights can only come from multiple

sources of information, further calibrated by understanding the behavior of workers and how they interact with every aspect of their surroundings. Formulating such holistic solutions will stretch the way business, IT and real estate align to address work-life ambience.

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Sample Vendors: Eutech Cybernetic; GE; Honeywell; Intel; Johnson Controls; Signify; Schneider Electric; Siemens; Spacewell; Terminus

Recommended Reading: "Evolve Your Smart Building Solutions in the IoT Era"

"Technology CEOs Should Differentiate Smart Building Solutions Based on Buildings' Purpose"

"Exploit Indoor Location Services to Differentiate IoT Solution Value"

"3 Areas to Drive IoT Differentiation Beyond Functions and Features"

"Crafting Workspaces That Enhance the Employee Experience"

"Top 10 Strategic Technology Trends for 2019: Smart Spaces"

Data Exchange

Analysis By: Bettina Tratz-Ryan

Definition: Data exchanges in intelligent urban ecosystem have been developed from the data marketplace concept that will drive the flow and interaction of data between the smart city stakeholders. The value of data will be determined through the context and significance that data is representing to develop and execute on valuable data streams for various public and private users. Value of data exchanges are measured by the impact and usefulness of data collaboration between industry data brokers and marketplaces.

Position and Adoption Speed Justification: In an urban ecosystem and smart city, data access and its exchange are key, leading to orchestrating data streams from multiple sources and interconnecting them with external stakeholders. The acceleration of data marketplaces into data exchanges is based on cities collaborating for find a "system of systems" approach that even offers data exchange as a service. Therefore, the speed of adoption has been changed toward to 5 years, given that many cities are building out data orchestration around:

- Data generated by government agencies, citizens, assets and businesses.
- Operations management data resulting from urban infrastructure and operations.

By associating big data with people or situations, city managers can provide responsive services that apply predictive and prescriptive capabilities to anticipate unfolding events in real time. The

ability to contextualize data with data orchestration requires data collection and dissemination based on a city's understanding and skill of industrial data governance.

Value and market price of enriched data are determined by the business opportunity represented and on the certifiable quality of the data itself to cities and the wider industrial ecosystem.

Its adoption rate will vary based on:

- The ability to convince the owners of the data of the value of data orchestration and sharing.
- The technical interoperability of data layers and analytics systems.

User Advice: Data exchanges will unlock the data economy within smart cities and across urban regions. CIOs in government as well as in the stakeholder business community may consider standardization or adaptive governance models to feed open source application and delivery models as they plan to integrate their application operation systems and platforms. The ability to interface with middleware underlying a proposed ecosystem will be critical. If unable to drive scale and usability across all ecosystem partners, CIOs may look to engage with third-party developers or other entities to enable solutions in automotive, environmental development and journey mapping (among others) to be built on their platform.

Existing systems employ various delivery and innovation models such as those now used by standards organizations like FIWARE (the platform for smart cities) and local government API development in Europe. CIOs will also want to pursue discussions with the business and knowledge communities in their cities, and collaborate with them on digital rights management, data attributes required and privacy issues. In the long term, they will want to develop a roadmap for connecting a "system of data marts" that embed open data portals and warehouses in an algorithmic business environment.

They may also want to consider chatbots and smart machines to create automatic and machine learning insights. Data exchange architects need to thoroughly understand the user profiles (or personas) or use cases to determine how context is achieved. Read-only access can be offered as an information or report tool without individualized access but with low-level customization on the part of users. Data exchanges such as the National Technical Information Service (NTIS) in the U.S. or Guiyang Global Big Data Exchange (GBEx) in China take a different approach. They provide a business process around aggregation, management and enrichment, cleansing and analysis of data sources for the sake of licensing data to external customers. Many CIOs who are working on the vision and execution plan of smart cities will look to monetize their sites by migrating their existing open data portals into the transaction environment of data marketplaces.

Business Impact: Local government business models and sourcing strategies will be empowered through transparency and access to government tenders and requests for proposals for all business partners. This will minimize financial and operational risk when engaging in joint government and private-sector partnerships as well as service hubs due to transparent disclosure of financial and transactional records and valuation information. Data marketplaces create an innovation thrust for new digital business models by:

- Understanding the city as a contextualized marketplace with demographics in real time or near real time.
- Cross-referencing the environment and the context in which the data and the insights were gathered.

Zillow (Trulia) and Waze are examples that use open government data in different customer markets. With interactions between public and private sectors, cities and smart communities have opportunities to create service and market response agility by identifying market data for digital knowledge sharing and management that include crowdsourcing insights that could lead to civic entrepreneurship.

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Emerging

Sample Vendors: Cloudera; Hitachi; IBM; Indra (Minsait); Microsoft; NXN

Recommended Reading: "Turning Smart Cities Into Intelligent Urban Ecosystems"

"Establish an Urban Data Exchange for Smart Cities"

"The Urban Data Exchange Will Be an Engine of Community and Ecosystem Innovation"

"Top 10 Trends in Data and Analytics, 2020"

"Predicts 2020: Data and Analytics Strategies — Invest, Influence and Impact"

Smart City as a Service

Analysis By: Bill Finnerty

Definition: Smart cities as a service (SCaaS) is an approach in which ecosystem partners provide smart cities with technology and data leveraging a subscription model. Governments, nongovernment organizations and private companies are able to leverage these offerings without having to invest in the infrastructure to generate the related service or data. The provider is able to spread the risk and investment related to establishing and maintaining the capabilities across the broader market.

Position and Adoption Speed Justification: Government CIOs often recognize the challenges related to funding and prioritization that occur for both infrastructure and technology projects. This makes it difficult to establish a roadmap to keep smart city infrastructure current. This struggle for resources poses a significant challenge during times of austerity, such as many governments are facing in the recovery from the COVID-19 pandemic.

Many cities are considering the ascetics of Internet of Things (IoT) sensors and considering policies to ensure that sensors and enclosures do not become eyesores.

Providers, particularly those communications service providers deploying 5G, are seeking additional recurring revenue streams to offset costs and increase profits. Digital business models that support new revenue through the reuse of a multipurpose sensor pack or reselling the data to multiple parties provides such an opportunity.

As a merger of existing “as a service” (XaaS) models, IoT, network and data, the time to implement these solutions will be relatively short, and therefore SCaaS, will move through the Hype Cycle quickly.

User Advice: The implementation and proliferation of SCaaS will increase the collaboration and engagement between government jurisdictions and ecosystem players. CIOs must establish partnerships with service providers and third parties to leverage their infrastructure and platform expertise in expanding smart city capabilities.

Government CIOs:

- Engage planning and other architectural review boards in developing smart-city-friendly regulation to encourage private-sector investments.
- Ensure that data strategies include guidance on procuring reoccurring datasets and the related governance.
- Develop a data marketplace in conjunction with the ecosystem.
- Engage smart city and communications service providers about their roadmaps and potential SCaaS offerings. Use this information to adjust smart city plans.
- Consider public-private partnership opportunities for SCaaS offerings to accelerate your initiatives while sharing the risks and rewards with partners.
- Focus on delivering a consistent experience for constituents, regardless of the model used to acquire data or provide services.
- Evaluate the risks of consuming SCaaS datasets for which vendors do not achieve anticipated markets growth. These offerings may increase in price or be abandoned.

Nongovernment and private-sector organizations:

- Assess the value that smart city data sources and or sensors, if offered in a XaaS model, could provide in achieving business outcomes.

Providers:

- Establish a cross-industries team to identify use cases for common smart city datasets (for example. air quality or traffic).
- Develop business models that increase profit by extending SCaaS products to markets beyond city government.

- Test market interest in an XaaS model for smart city data and services. This requires a government and other partners that are actively engaging in an intelligent urban ecosystem.
- Evaluate both financial and reputational risks of PPPs where markets do not materialize.

Business Impact: Governments can accelerate their smart city initiatives by becoming a SCaaS consumer. Governments can focus the use of data to improve outcomes without investing in the related infrastructure, elevating concerns such as talent, security and budget for supporting large IoT deployments.

Focusing on procuring smart city data, rather than implementing infrastructure, requires a shift in governance and procurement. Engage city leaders in developing new business models that solve the problems they struggle with and that constituents care most about. Project roadmaps may need to be adjusted based on provider timelines. When making the case for SCaaS, considering infrastructure implementation costs versus those of delaying a new service until a provider solution is available.

Providers will need to rethink their approach to smart city implementations. Direct investment in smart city infrastructure presents new business models and opportunities. Maximizing the types of data collected and services offered as part of a single network connection and procurement of real estate will be essential.

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Adolescent

Sample Vendors: AT&T; Hitachi; NTT; NXN; Verizon

At the Peak

City Operations Center

Analysis By: Bettina Tratz-Ryan; Bill Finnerty

Definition: A city operations center refers to a platform that helps government officials manage smart city environments with a city solution encompassing a comprehensive and holistic viewpoint. The solution delivers operational insights to optimize the city operations' efficiency and quality of citizen life through visualization. It is also referred to as command and control.

Position and Adoption Speed Justification: In smart city environments, speedy and seamless data exchange and information for city issues — such as traffic congestion, air pollution, energy and water consumption, safety and security conditions, and natural disasters — are required between different sectors and processes. The city operations center connects different data sources and orchestrates user- or citizen-facing engagements and the ideal view of situational awareness. It enables smart city officials and leaders to:

- Integrate data from various sectors and agencies
- Manage resources
- Connect with citizens and address their concerns
- Realize transparency and accountability for city operations
- Optimize city growth and operations

A city operations center also practices open government principles of transparency and accountability by sharing data about city operations with the public. The level of adoption varies by the technical and data requirements of local governments to consolidate multiple management platforms. Very often, operations centers work together in system approaches to align processes for emergency response, resilience, mobility management and many other objectives. To enable scale and integration, the operations center is cloud-based and linked to other platforms that may feed and exchange data and insights to it.

User Advice: City government CIOs and urban planners need to define the operations center as a platform for management decisions for specific environments that include multiple business units and data streams. Traffic control, public safety and policing, as well as critical infrastructure, have their own departmental operating platforms. In a smart city strategy, different datasets are now joined from various operating management platforms and systems across government entities, districts and neighborhoods. CIOs must consider the orchestration of IoT implementations and in-use data to extract value for operations control and city management. This way, they can deliver KPIs for optimization of maintenance routes, asset wear and tear, and real-time decision making. The analytics in the operating platform also involve event and situational data. So, CIOs will support decisions in operations centers and urban platforms that offer the ability to manage and orchestrate infrastructure alignment and user experiences in real time to apply KPIs such as ISO 37120 and SLAs.

CIOs should provide solid data fusion and visualization for benefits resulting from smart operations and urban management, as they have direct impacts on fiscal control of city government and provide transparency (with contextualized information) to citizens. Data exchanges may be on mass data or contextualized data, depending on the data governance and collection models.

CIOs of local governments should leverage a city operations center to both address current issues and craft a medium-city strategy. It should include development of the local economy and disaster countermeasures, as well as emergency responses due to natural catastrophes or terror attacks. The data in a city operations center is consolidated to understand such city trends as traffic volume and flow and demographic changes.

Business Impact: The purpose of a smart city is to optimize city operations — not to build infrastructure. Domain technology and knowledge will play important roles in the city operations center, because they help city governments make quality judgments based on data.

The primary functions (business impact areas) of a city operations center are:

- Routine operations management, resource monitoring and optimization, automated decision making, dashboard reporting, and data sharing
- Emergency response hub, situation awareness and escalated decision making by humans
- Data resources for future smart city planning

In this regard, operations centers will morph from a decision-making perspective into urban platforms that create an interactive engine for application development and data visualization. In addition to control and command centers, for instance, FIWARE standards provide a framework environment that allows an urban open-source migration path for standardized service, data and process management.

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Sample Vendors: Cisco; Fluentgrid; Hitachi; Huawei; IBM; Microsoft; NEC; NXN; Oracle

Recommended Reading: "Predicts 2020: Resilient Smart City Development Requires Data-Driven Engagement of Citizens and Businesses"

"Establish an Urban Data Exchange for Smart Cities"

Digital Ethics

Analysis By: Jim Hare; Frank Buytendijk; Lydia Clougherty Jones

Definition: Digital ethics comprise the systems of values and moral principles for the conduct of electronic interactions among people, organizations and things.

Position and Adoption Speed Justification: Digital ethics remains at the Peak of Inflated Expectations. Digital ethics and privacy remain growing concerns for individuals, organizations and governments. Consumers are increasingly aware that their personal information is valuable, and they're frustrated by lack of transparency and continuing misuses and breaches. Organizations increasingly recognize the risks involved in securing and managing personal data, and governments are implementing strict legislation in this area.

The coronavirus outbreak has demonstrated the important role of digital ethics in how governments and healthcare organizations are using technology and personal data to address the pandemic. However, no matter how urgent the response to the crisis is, decisions about how technology and data are used could result in more harm than good if those decisions are not grounded in digital ethics. The pandemic has shown that regardless of the hype around digital ethics, many organizations are still not applying them. And, as a result, the innovation hasn't yet passed the Peak of Inflated Expectations.

Board members and other executives are sharing their concerns about the unintended consequences that the innovative use of technology can have. There is frequent, high-profile press coverage of stories that concern the impact of data and technology on business and society more broadly. More universities across the globe are adding digital ethics courses including the University of Oxford and the University Melbourne that recently launched programs and centers to address ethical, policy and legal challenges posed by new technologies. Government commissions and industry consortiums are actively developing guidelines for ethical use of AI. See “How Forthcoming EU Legal Framework Will Affect Your AI Initiatives.”

User Advice: Business value and digital ethics need not be in conflict. Intention is key. If the only goal is business performance, and ethics is seen only as a way of achieving this goal, this may lead to window dressing. However, if the goal is to be an ethical company, and this leads to better business performance, then this serves all parties, and society more broadly. It will only strengthen the organization, helping you to have an even greater positive influence in the future.

Business and IT leaders responsible for digital transformation in their organizations should:

- Identify specific digital ethics issues, and opportunities to turn awareness into action throughout the various business domains.
- Discuss ethical dilemmas from different points of moral reasoning, such as outcome determinative versus empathy-focused. Ensure that the ethical consequences have been accounted for and that you are comfortable defending the use of that technology, including unintended negative outcomes.
- Elevate the conversation by focusing on digital ethics as a source of business value, rather than simply focusing on compliance and risk. Link digital ethics to concrete business performance metrics.

Business Impact: There are ethical consequences that arise through the use of digital technology in every business domain. Digital ethics should be treated as a tangible business practice discipline rather than an academic discussion. It does not have to be at odds with optimizing business performance. In fact, ethical behavior can have business value in itself.

Areas of business impact include influencing innovation ideas, product development, customer engagement, corporate strategy and go-to-market.

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Sample Vendors: Avanade; Hypergiant; IBM; Microsoft; Salesforce; SAP; SAS

Recommended Reading: “Data Ethics and COVID-19: Making the Right Decisions for Data Collection, Use and Sharing”

“Digital Ethics: What Every Executive Leader Should Know”

“Digital Ethics by Design: A Framework for Better Digital Business”

“Top 10 Strategic Technology Trends for 2020”

“The CIO’s Guide to Digital Ethics: Leading Your Enterprise in a Digital Society”

“Data Ethics Enables Business Value”

“Use Privacy to Build Trust and Personalize Customer Experiences”

Energy-Water Nexus

Analysis By: Bettina Tratz-Ryan

Definition: Energy production and water use are closely interdependent. The energy-water nexus is a term for the complex interplay of cause and effect between water and energy supply and consumption in smart cities, industries and homes.

Position and Adoption Speed Justification: According to the UN-Water directive, by 2020, half the world’s population will be living in countries with water supply shortages. Factors that contribute to the shortage include:

- Water is critical to energy supply, such as hydrothermal as well as nuclear power plants.
- 70% of freshwater available globally is used for agricultural purposes, 22% for industrial use and 8% for residential consumption.
- The biggest loss of water is in transport and distribution.
- Although there are new technologies on desalination (removing the saline from saltwater to turn it into freshwater), the process consumes high amounts of energy (approximately 15 kWh to 17.1 kWh per 1,000 gallons of water produced).
- Water is integral for shale gas production.

While sustainable management of water and energy seem battling the risk for many organizations, the lack of true water pricing relative to the cost of delivery distorts the value perception at large. Analytics and data generation through Internet of Things (IoT) opens the insights into which processes in generation and use of water and energy can be optimized for sustainable societal development. Regions and countries with increasing cases of droughts and the shifts in water allocation are challenged in their economic and industrial performances, especially with those highly dependent on oil and natural gas. The uncontrollable increase of population and rapid industrialization in developing countries are also major contributors.

User Advice: CIOs in different water-intensive industries need to build the capital expenditure (capex) of water management tools, the critical factor of price volatility of energy, and the cost related to channel and supply water into their IT procurement models. CIOs must work with city leaders to make the gap between holistic investments versus price of water delivery visible

IT leaders in the industry need to track volatility in real time by analyzing data through smart city, water- and energy-management platforms and boards. End users need to look to involve new energy sourcing that includes waste to energy, circular economy to generate energy and broader energy-generation models in microgrids and distributed grids.

CIOs in emerging economies should apply or evaluate technology solutions such as sensors, IoT and analytics together with modeling and simulation for energy use. They should also network with solutions that create water sustainability and quality of water harvesting and management as they are key concerns for developed markets as well. CIOs should also explore using sensors to prevent water leakages in pipelines and storage tanks.

Business Impact: Business is greatly affected by the availability and cost of energy and water as well as by the competing sources for other industries such as agriculture and food production in addition to water supply to cities. Cost of operations to produce water as well as energy based on competitive uses presents significant issues, and the potential stigma of using water for industrial uses instead of civic uses could prove a reputational risk. Transparency and public relations have to be shown to disperse the concerns for depletion or risk relative to operations. For example, the fracking industry in the southern U.S. is using water from urban centers to bring it to the fracking locations, causing discussions about droughts and water availability in the community. In different industries, the energy-water nexus has caused businesses to change their business processes. The textile industry is dyeing without water, saving the water and, in addition, also energy as the textiles do not need to be dried.

For organizations operating in countries in which the water prices are subsidized, the exploitation of water should be positioned more about responsible use versus scarcity that may lead to economic penalty.

Benefit Rating: Moderate

Market Penetration: Less than 1% of target audience

Maturity: Emerging

Sample Vendors: ABB; Accenture; Adasa; Black & Veatch; Deloitte; Fujitsu; GE Energy Connections; Hitachi

Recommended Reading: “Digitopia 2035 Scenario: A Sustainable Society — How to Increase Your Digital Ambition”

“How CSCOs Should Lead a Response to the Water Scarcity Challenge”

“Video: Kimberly-Clark’s Water Strategy — Risk Management to Value Creation”

Greenfield Smart City Framework

Analysis By: Bettina Tratz-Ryan

Definition: A greenfield smart city framework is a strategic plan that is used to build a new urban area or district with limited or no existing infrastructure, such as communications, electrification and resource supply. All government and industry sectors link to community, district and industry collaboration platforms through ICT and digitalization to build a sustainable ecosystem. Citizens receive smart city services not only through government but also through the ecosystem of partners.

Position and Adoption Speed Justification: Greenfield smart cities are increasingly gaining attention from conglomerates of city and real estate developers in emerging countries that want to create digital and intelligent smart city projects. Adoption becomes evident in examples such as India's announcementthat smart cities will be the core of urban, industrial and social development. Neom, Toyota's Woven City and Chicago's Lincoln Yards are examples of new housing districts or even entire cities being built from the ground up through public and private ecosystems. Those greenfield programs require a strong and holistic framework that connects national business and society development goals with urban or regional development. City leadership — together with nongovernmental agencies, urban planning committees, academia, real estate developers and industrial clusters — will define the vision of sustainable, efficient and citizen-centric city operations and services. The greenfield framework approach is often built on urban control centers sharing information and business models across the ecosystem looking to benchmark KPIs on performance and delivery. Handoff with government may occur, but should stay in a partnership approach. The speed of adoption varies greatly between changing governments and the bureaucracy associated with strategy and construction. Many investments will depend on reaching the goals of institutional investors like the World Bank Group, which will instill governance in these projects.

User Advice:

Government CIOs, chief digital officers and urban-planning leaders need to:

- Build digital business models for greenfield smart cities, leveraging learning from the industrial ecosystems that have built transaction or collaboration platforms. Focus on best practices of process and data exchange, including financial and risk-sharing models.
- Design citizen experiences around work-life balance, digital work, citizen entrepreneurship, culture/traditional lifestyle or sustainable living, because you need their buy-in for data exchanges across the variety of ecosystem participants delivering the experience outcome. Otherwise, you may get entangled in privacy discussions.

In a greenfield smart city project, urban ecosystem leaders must consider these points:

1. Expect the development of a greenfield framework to take a considerable effort. In this long span, conditions of the smart city project related to, for example, the city government's policy or finances, may change. Therefore, it is important to remain flexible when implementing the project to cope with changes. The ability to report financing and investment strategies to banks and investors is critical to validate the KPIs of the smart city solutions to be deployed.
2. The city government has neither the experience nor the knowledge on how to design, construct and operate the smart city. Therefore, city leaders must leverage the best use cases of other smart city projects and set up a consortium consisting of best-of-breed members from various

industries. Be sure to include ICT vendors that have experience in smart city project implementation.

3. The thrust of digitalization across industry, business and society can be channeled in greenfield districts as innovation districts or corridors. That can include sensors, autonomous assets and mobility, data-driven service models or new green tech development. This requires leaders to build holistic, secure and scalable infrastructure foundation to enable capacity-intensive use cases and applications.

4. Be leading edge, not bleeding edge. Since there is no restriction in terms of legacy networks, evaluate the maturity of the selected technology or products against the risk of investing early or too expensive. Use an innovation governance framework to avoid risk.

Business Impact: A well-governed engagement model can provide measurements of business impact and citizen inclusion. An ecosystem to configure a greenfield smart city framework is immense; interoperability is needed between use cases, technology and the Internet of Things (IoT). Real estate developers of greenfield smart cities are interested in developing self-sustainable (self-sufficient) and environmental knowledge centers, as they enact operations to curb inefficiencies not only in the infrastructure but also simultaneously through citizen communications and service platforms. Thus, business leaders should determine the ownership of implementing vision and methodology and develop easy-to-use profitable business services. These services will be available through smart city application stores or city marketplaces.

Governance will be required by institutions like the World Bank to create transparency in the investment process as well as in the sustainable development goals of the United Nations. In addition, many emerging cities are eligible to the COP 21 climate change funds when their infrastructure is delivered, due to climate change considerations.

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Emerging

Sample Vendors: Accenture; Arup; Capgemini; Cisco; Fujitsu; Hitachi; IBM; LG CNS; NXN; Samsung

Recommended Reading: “Turning Smart Cities Into Intelligent Urban Ecosystems”

Sustainability and COP 21

Analysis By: Bettina Tratz-Ryan

Definition: During the 21st Conference of the Parties (COP 21) to the U.N. Framework Convention on Climate Change in 2015, around 450 cities and city states pledged to reduce carbon and GHG emissions to contribute to the 2% global warming limit. Since then, cities are becoming environmental and sustainability centers of excellence.

Position and Adoption Speed Justification: Cities face climate-change-related challenges in the form of rising sea levels, rising heat levels and droughts, and challenges to food systems. A large and growing number of city governments around the world are addressing these challenges with "resilience strategies" that also create opportunities to build new collaboration and infrastructure, sustainable industries, and more holistic citizen engagement. With the aftermath of the COVID-19 pandemic, cities are linking resource resilience, sustainable development goals (SDG) and climate change together to create a sustainable social and business model moving forward. For example, the European Green Deal is putting carbon emission reductions as well as circular economy as key enablers for a sustainable living. The diversity of political and demographic environments will, however, change the momentum on local government due to funding and economic discourse, which leaves this innovation profile at the current location from 2019.

The momentum and adoption rate are being driven by citizen and business concerns about climate change. Interest groups such as C40 for cities and European Green Capital share insights on carbon reduction and sustainability initiatives and KPIs to measure impact. Based on some local impacts and the social cohesion and contextualization of the urban service environment generated through projects that solve cities' distinctive needs, cities will outpace countries and regions in sustainability and environmental momentum and execution.

User Advice: CIOs in cities like Copenhagen, New York City, Dubai, Singapore and Santiago de Chile have all started to support or develop a sustainable smart city strategy. They are using Internet of Things (IoT) and a range of operational efficiency, data sharing and business process alignment elements to condense the urban asset footprint, while visualizing this impact in various channels. CIOs can support the development of collaboration and dashboarding of like-minded citizens who will engage based on the visibility of environmental activities such as restricting high-emission vehicles in city centers and energy conservation and green energy options for streetlights and buildings.

CIOs have the opportunity to define the key performance measurements of smart city initiatives, while mapping those to sustainability goals, including COP 21 commitments. CIOs need to create advisories on the use of IoT by citizen advisory boards for measuring not only emissions and air pollution, but also waste and recycling rates. This includes starting to cooperate with public-private partnerships with utilities, waste management companies and consumer goods providers to create business awareness and end-to-end life cycle applications in microgrids, recycling, and smart building and home ecosystems.

CIOs can build their city operations centers to orchestrate differing datasets that can link public safety to air quality and critical infrastructure resilience and mobility changes impacting reduction of emissions from combustion engines and uptake of electric vehicles. The centers can even enable citizen and social crowdsourcing of green ideas with citizen engagement and feedback. Using the available data, citizens will gain a perspective on data privacy, as they will see that their data is instrumental in contributing to more-efficient management of the overall environment. When CIOs have good ethical and privacy governance on data usage, citizens will engage with governments.

Business Impact: The impact to the local government CIO is profound: Smart cities demand more user-focused services and experiences, as identifying business impacts that influence environmental impacts has become more transparent. COP 21 declarations of city leaders and

other nonstate parties such as R20, ICLEI and C40 create opportunities for CIOs to connect to industry and cross-jurisdictional governments to build innovation projects that support cities as incubators for green initiatives and new technologies.

In addition, as data becomes an instrumental conduit for transparency and decision making for policy and user experiences, CIOs will be able to build data and shared infrastructure services to connect urban layers to spatial development. CIOs can also share valuable GIS data to insurance, real estate development and banking, as well as to logistics and supply chain organizations to indicate climate change impact on cities and regions, which is posing a business risk.

Reaching sustainability goals needs to become more transparent, which provides CIOs with options to look for frameworks such as STAR Communities and World Bank Group's CityStrength diagnostic to orchestrate data and create traction.

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Sample Vendors: Deloitte; Esri; Sphera

Recommended Reading: "Digitopia 2035 Scenario: A Sustainable Society — How to Increase Your Digital Ambition"

"Predicts 2019: Smart Cities Will Mitigate Social and Resilience Risks and Reward Digital Opportunities"

"How to Build a Business Case for Sustainability and Social Responsibility in Supply Chain"

"How Can CIOs Keep the COVID-19 Pandemic From Overshadowing Their Sustainability Efforts?"

"Predicts 2020: Resilient Smart City Development Requires Data-Driven Engagement of Citizens and Businesses"

5G

Analysis By: Sylvain Fabre

Definition: 5G is the next-generation cellular standard by the 3rd Generation Partnership Project (3GPP). The standard targets maximum downlink and uplink throughputs of 20 Gbps and 10 Gbps respectively, latency below 5 milliseconds and massive scalability. New system architecture includes core slicing as well as wireless edge.

Position and Adoption Speed Justification: Seventy-three operators have announced 5G rollouts (Source: Global mobile Suppliers Association [GSA], April 2020), just under 9% (up from 5% one year ago) of mobile networks.

3GPP Release 16 freeze date has been postponed due to the COVID-19 pandemic, with a freeze target date of mid-2020.

5G encompasses a range of 3GPP standards focused on different functionality:

- R15: Extreme broadband (5G NSA and then 5G SA)
- R16: Augmentations for Industrial IoT (massive IoT, slicing and security improvements)
- R17: Augmentations for wider ecosystem expansion (freeze target date end of 2021)
- R18: Additional augmentations (e.g., extra territorial 5G systems, railway smart station services)

Due to this phased introduction, and the time required from the vendors' ecosystem to build standard compliant networks and grow silicon and device availability, Gartner expects the full potential for 5G use cases to materialize first in 2022.

Use of higher frequencies and massive capacity, will require very dense deployments with higher frequency reuse. Here we see regional differences, whereby mmWave will be leveraged in the U.S. and South Korea, but may not see initial adoption elsewhere.

Gartner expects many 5G deployments to initially focus on islands of deployment, without continuous national coverage.

Less than 45% of CSPs globally will have launched a commercial 5G network by 2025. Uncertainty about the nature of the use cases and business models that may drive 5G is currently a source of uncertainty for many CSPs, enterprises, and technology and service providers (TSPs). Gartner estimates that 5G capable handset penetration will reach 50% in 2023 in Western Europe, and could be a little faster in North America.

We are seeing different dynamics by regions, where in many parts of Africa for example, 5G would not be the next step to lower bandwidth services, and handset cost may be an inhibitor for lower income subscribers. Adoption is more aggressive in APAC and NAR, with Europe cautiously enthusiastic — and the developing world lagging.

User Advice:

TSP product managers should:

- Focus mobile infrastructure planning on LTE, LTE-A, LTE-A Pro, small cells and heterogeneous networks (HetNets), as part of a planned transition toward 5G.
- Ensure backward compatibility to preceding generation (LTE) devices and networks. This is necessary because 5G coverage may be limited, so new 5G devices need to be able to seamlessly transition to 4G fallback infrastructure for uninterrupted service.
- Focus on related architecture initiatives — such as software-defined network (SDN), network function virtualization (NFV), CSP edge computing, distributed cloud architectures and cloud native containerization, as well as end-to-end security in preparation for 5G.

- Provide solutions where new frequency allocations (preferably) should be used for the latest technology — 5G — to benefit from lower cost per byte, higher bandwidth and more capacity.
- Help CSPs refine generic services to vertical-focused solutions (B2B) for 5G.
- Have a clear understanding of specific verticals and their use cases for more effective consultative selling of their 5G solutions.
- Build their ecosystem of partners to target verticals more effectively with 5G.

Enterprise business leaders should:

- Identify use cases that definitely require the high-end performance of 5G; these may be few or even nonexistent for many verticals.
- Evaluate the multiple IoT alternatives available that may prove adequate, more available and more cost-effective than 5G for many use cases (e.g., low-power wide-area [LPWA] such as NarrowBand Internet of Things [NB-IoT], long-range [LoRa], Wireless Smart Ubiquitous Networks [Wi-SUN]).
- Clarify the level of complexity involved in operating a private 5G network.
- Evaluate options for CSPs or other providers to be involved in running the 5G network.

Business Impact: Gartner Enterprise 5G Surveys indicate that vertical use cases with 5G would be first motivated by operational cost savings. Another driver is agility — in particular, in oil and gas and manufacturing.

In addition, the vertical users for 5G appear to value lower latency from ultrareliable and low-latency communications (URLLC) and expect 5G to outperform rivals in this area.

With massive machine-type communications (mMTC), scenarios of very dense deployments can occur, supported by the 5G target of 1 million connected sensors per square kilometer.

5G enables, principally, three technology deployment and business scenarios, which each support distinct new services, and possibly new business models (such as latency as a service):

- Enhanced mobile broadband (eMBB) supports high-definition video.
- mMTC supports large sensor and IoT deployments.
- URLLC covers high availability and very low latency use cases, such as remote vehicle/drone operations.

URLLC and mMTC will be implemented after eMBB. Only eMBB addresses the traditional mobile handset requirement of ever higher throughput. URLLC addresses time critical industrial applications such as automation, with latency around 1 ms over a limited range for a limited number of connections — where reliability and latency requirements surpass bandwidth needs. Finally, mMTC addresses the scale requirements of IoT. Apart from some smart city scenarios, mMTC may not be required in most locations for some years, with NB-IoT and other LPWA such as LoRa being sufficient for a while.

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Early mainstream

Sample Vendors: Cisco; Ericsson; Huawei; NEC; Nokia; Samsung; ZTE

Recommended Reading: "Market Guide for 5G New Radio Infrastructure"

"Assessing 5G Mobile Technology for Organizations"

"How to Select 5G NSA/SA Migration Paths"

"Forecast: Communications Service Provider Operational Technology, 1Q20 Update"

"Market Trends: Strategies Communications Service Providers Can Use to Address Key 5G Security Challenges"

"Reduce Privacy Risks When Using 5G Products and Services"

Civic and Community Development

Analysis By: Bettina Tratz-Ryan

Definition: Civic and community engagement is a social cohesion strategy in smart cities to build community engagement through platforms and applications developing trust, open data and open dialogue between societal and demographic parties. Civic development is purpose-driven to develop empowerment toward quality of life for a future-ready community, including efforts in healthcare, wellness, and social care and services.

Position and Adoption Speed Justification: Available open data from community and government enables stakeholders to provide transparency by connecting the dots to understand community issues and sentiments, as well as how to motivate and engage users. Citizens, businesses, nonprofits and technologists can all benefit from open data, whether by creating and utilizing neighborhood maps during pandemic times, providing support through social engagement, or analyzing user journeys to generate demographically based applications.

The speed of adoption has increased due to the civic needs related to postpandemic social requirements. The acceleration of civic and community engagement frameworks, platforms and applications depends on citizens and communities trusting governments and their communities feeling empowered to advance not only on various issues but also on personal perseverance. Strengthening community participation through civic and community development creates new opportunities for open data and citizen science initiatives. The level of adoption varies based on regional or communal trust regarding access to safe data, data privacy and security. This includes GPS and user-centric data collected through IoT, as well as more-formalized citizen ID, or e-ID engagements, with GDPR.

User Advice: CIOs of local governments should facilitate as moderators between constituents and public and private entities on the use of data and technology. To harness sentiments through crowdsourcing and social media engagement (and with orchestrated data analytics, especially on open data), hackathons and civic technology groups could get involved in innovation projects. Issues arise from an increasing information-driven knowledge web, which is vulnerable to fake news or bias.

CIOs in cities, knowing how significant information verification is, could provide a clearinghouse or information hub or platform for citizen developers and community NGOs. City collaboration in departments, social services and different multiple stakeholder communities should be available online and offline, as well as through ad hoc and more planned processes. For instance, CIOs can apply augmented reality, AI and chatbots to understand native language suggestions and digitize them toward problem inventories, citizen top trends and user perspectives.

Civic and community engagement becomes increasingly significant, as demographics shift. With pandemics and other direct life-changing events, disadvantages through the digital divide can appear. Including older generations, migrants and millennials in community participatory research reveals different use patterns of communications and engagement technologies and their impact on the city environment. It not only extends to usage (and, therefore, different dashboards and access points), but also poses to CIOs important questions about data quality and the identification of false data and fake news.

CIOs also need to be aware of increasing data privacy and identity management concerns, focusing not only on data generation but also on data governance and citizen IDs for data-sharing permissions and access requirements.

Business Impact: The business implications of the ability to connect to social and civic like-minded people and demographics are more dedicated communications and applications of user-focused services. Many of the industrial engagement platforms, including communities on consumer applications such as Facebook and Google, show that community identification significantly increases the satisfaction rate with surroundings — that is, city or urban management. For many departments and their ecosystem partners, this also means that they must create differing, inclusive, user-specific aspects in their service delivery. However, city officials are often used to following due process, because their authority and lack of resources prohibit them from getting closer to the communities. Utilizing civic outreach through dedicated mechanisms not only provides some data that may enrich a process or action, but also trains city officials to get closer to specific segments in their communities.

NGOs have been working as conduits in many cities to facilitate connections between city police and teenagers, for instance — something that can be also supported through a broad civic environment. Inclusion in community, labor markets, environment, education and health can be provided with single identity management that will create trust in data sharing and will improve quality of life in obtaining more comprehensive services. With their ability to be close to sentiments and citizen issues, NGOs have a major impact during a crisis to drive “social cohesion,” which is defined as the ability of a community to create an equal, safe and prosperous community.

Improvements in social platforms, smartphones, e-commerce and analytics have lowered the barriers for citizens to interact and transact with one another. Increasingly, these networks are developing from the bottom up, with lines blurring about engagement, development and community participatory research by, for instance, linking citizen science to environmental health.

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Sample Vendors: CitizenLab; Esri; Minsait; an Indra company; Tableau Software

Recommended Reading: "Postpandemic Scenarios: The Future of Digital Government Transformation"

"Government APIs Are About Delivering Outcomes, Not Technology"

Digital Security

Analysis By: Barika Pace

Definition: Digital security is the practice of governing, managing and operating the security systems of IoT, OT, physical and/or cyber-physical security systems. Digital security creates a state of trust, protection and safety for business assets: cyber assets (such as software and information) and physical assets managed by cyber assets (such as machines, buildings, etc.). As such, it plays a critical role in business focus to manage risks to the organization.

Position and Adoption Speed Justification: Digital security markets have evolved as digital transformation has evolved digital business. While other terms such as cybersecurity, cyber-physical system security, IoT security and others have been used in technology contexts for design and implementation purposes, digital security is the business view of those efforts. Unfortunately, precision of language remains a challenge in markets and with end users, and "digital security" as a term has grown increasingly synonymous with cybersecurity. The term has been clouded by the convergence of IT, IoT, OT, and cyber-physical systems, as more technology providers gravitate toward converged solutions and security and risk leaders look for high levels of integration. It remains relevant to distinguish the physical context in security and its impact on business decisions. The convergence of IT, OT, IoT, and CPS into hyperconverged security platforms for ease of integration continues to emerge over the last year, take with it the concept of digital security. The marketplace has seen signs of increased consolidation over the last year. As such, it has its own adoption by business and technology users. The position of digital security on the Hype Cycle reflects a peak period of recognition with the term and its impact on markets. A continuing evolution of next-generation capabilities (e.g., artificial intelligence, advanced cloud security services, robotic process automation) enhance capabilities for digital security. Risks across digital transformation initiatives increase due to the complexity of supported systems and functional requirements. Products claiming to offer digital security solutions are predominantly vertical-specific and have evolving capabilities. Movement on the Hype Cycle for 2019 reflects these changes and responses.

User Advice:

Security and risk management leaders should:

- Assess digital transformation impacts occurring in the organization and harness digital security capabilities where needed.
- Establish proofs of concept to discover, classify and manage all connected devices to ascertain risk landscape, raise organizational awareness and create business value by onboarding visibility tools that can have dual purpose for operational teams.
- Plan your IT and functional alignment in the areas of architecture, governance, security, software management, infrastructure, support and software acquisition by teaming up cross-functional resources.
- Deploy skills training to incorporate unique digital security controls into mainstream security and risk management plans.
- Develop the same skills training for development and awareness to incorporate specific digital security controls into existing cybersecurity practice.
- Establish a list of new competencies required to support digital business initiatives and establish new roles as needed.
- Assign enterprise ownership for digital security capabilities that are not already claimed by a business unit and develop more effective techniques for selecting unique tools.
- Record all digital assets, from sensors to large industrial equipment, and create visibility into the organization's digital networks and think about digital security as part of a holistic ecosystem.
- Leverage cloud-based security programs to supplement scale and diversity of digital security requirements.
- Brace for increasing privacy regulations that impact digital security requirements and incorporate steps in privacy management to accommodate them.
- Drive alignment with environmental, health, safety, business and IT to address the cyber-physical realities over digital security only.

Business Impact: Business initiatives using advanced technologies continue to experiment with better methods of protecting assets in digital transformation initiatives (see "Managing the Digital Risks of Blockchain Initiatives"). Security and risk managers apply controls on behalf of the business as a single-system approach to effectively manage digital risks to the organization. Digital security has moved from providing transformational benefits to mainstream benefits. This move is due to digital security components' ability to provide more practical advantages to organizations in deploying digital business technologies and services with mainstream providers, and with better testing, certification and technical standards for implementation.

Benefit Rating: Moderate

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Sample Vendors: 802 Secure; Cisco; Darktrace; Dragos; Forescout Technologies; Radiflow; Tenable; Thales; Xage Security

Recommended Reading: "Develop a Pragmatic Vision and Strategy for Digital Business Security"

"Market Guide for Operational Technology Security"

"2020 Strategic Roadmap for IT/OT Alignment"

"Market Insight: Tech CEOs Must Act Before Convergence Kills Your Stand-Alone OT/IoT Product Solution"

"Emerging Technology Analysis: Cyber-Physical Systems Security Is an Opportunity for Security Product Managers"

Intelligent Street Pole

Analysis By: Bettina Tratz-Ryan

Definition: An intelligent street pole is an asset that hosts a variety of different IoT and networking devices, cameras, monitors and displays. It is controlled and monitored from a single operator, and enables EV-charging, interactive lighting, parking management and crowd control. It can provide the backbone for a citywide Wi-Fi or 5G network that can enable computing and communications for intelligent street and district services.

Position and Adoption Speed Justification: Intelligent street poles are an evolution of smart streetlighting, which moved rapidly into mainstream adoption for being a lighting pole. In comparison to light posts, street poles host a variety of different city- and ecosystem-relevant sensors and technologies, and allow a concerted aggregation of location-based data. The maturity of context-based analytics around parking options, asset management in vicinity of smart buildings and real estate, retail locations in downtown areas will be accelerating. Reason is that for instance tourism and public safety concerns are highly benefiting from situational awareness mapped to location- and user-centric data. Street poles are owned by public works, utilities or private sector stakeholders, and therefore serve a variety of different business purposes. Many urban planning decisions on spatial development and the services on micromobility, climate change and green spaces, last-mile logistics and development of new business districts can evaluate smart street poles as a valuable urban real estate for:

- A 5G base station
- EV parking and concierge
- Private-sector curb pricing for insurance or retail

Issues around management of assets mounted on poles, together with maintenance, data orchestration and cybersecurity, need to be solved to enable scalability and drive adoption. Utilities, CSP and real estate developers emerge as deployment stakeholders. As the postpandemic activities in locations in cities, especially in heavily frequented spaces, increase, intelligent street poles will become the center of monitoring and communications platforms.

User Advice: Intelligent street poles gain in value with the number of different solutions and applications provided to citizens and the urban ecosystems. From panic buttons to complex video analytics, CIOs and their teams in urban ecosystems have to determine location, connectivity and compute power to gain ROI and value streams. Google Sidewalk Labs is measuring the location value of a curb by square feet, with all the assets that belong to this quadrant. Data and insights through analytics gained from the street pole will become the value of smart city, smart street or district deployment. Therefore, ecosystems CIOs and their teams need to:

- Develop scenarios in the planning process of infrastructure deployments for smart city initiatives to calculate the connectivity, computing and powering requirements for multiple IoT sensors and other products on the pole. This is critical, as cyber-physical systems and mesh technologies may define and execute on the linked data analytics or data graphing off the post.
- Enforce digital security at the individual asset level of the pole as well as at the edge gateway and the transmission to the core of the street pole ecosystem. With the increasing mesh of interactions and value generation, the access to potential digital intrusions as well as privacy violation is rising.
- Architect a data exchange mechanism in a “system of systems” approach to connect different data lakes from various systems together, and make interactions autonomous to accelerate speed. Pool data from government’s open data portal to allow for validation as well as transparency.
- Analyze electricity generation options to power sensors on the pole, developing a microgrid.

Business Impact: Intelligent street poles are expected to become valuable real estate, as their location as well as the ability to connect a multitude of sensors together avoid mostly costly truck rolls and installations. New designs of street poles and light posts turning into real estate platforms will include charging stations, parking meters and other consolidated road management system. Therefore, understanding the complexity of ecosystems on a street-by-street and/or campus level and providing the gains from managing the complexity will drive ROI and future-proof implementation in greenfield locations and districts. Privacy concerns should be managed upfront, with the understanding that intelligent street poles will initially be available as light posts. However, they will also be deployed in parking garages or as part of smart real estate development of the private sector. Urban leaderships could apply them to revitalize locations or create innovation hubs by offering data from street poles to ecosystem partners, with new AI and video analytics technology.

Obstacles to ecosystem development are the complexity of ownership and the financial benefits.

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Sample Vendors: Acuity Brands; Cisco; CIMCON Lighting; Fluentgrid; GE; Signify

Recommended Reading: "Turning Smart Cities Into Intelligent Urban Ecosystems"

Sliding Into the Trough

Water Management

Analysis By: Bettina Tratz-Ryan; Aanchal Mair

Definition: Water management describes a solutions approach using information to holistically monitor water throughout the hydrological cycle. Water management solutions include water sourcing and rainfall forecasting, groundwater monitoring, water analysis for water supply, water treatment plants and wastewater treatment facilities as well as water-loss analysis throughout the transportation cycle.

Position and Adoption Speed Justification:

Water management requires a differentiated set of technology and service skills to cater effectively to:

- Distribution for residential and commercial customers
- Water pollution, water treatment and recycling
- Natural disasters (such as flooding and drought)

These skill sets include reporting and management tools for infrastructure and sensors, database and information aggregation and assessment tools. Water management is still in the emerging phase of grid discussion. With priorities shifting by regional or national basis, the topic has captured the attention of industry players due to government initiatives as well as the developments in pricing of water — once meters that monitor true consumption are installed. The position of the profile has not moved again in 2020 in the Hype Cycle because water management has developed more-complex use cases. While local utility and freshwater supply is experiencing more water intelligence, the imbalance of climate-related resource shortage and natural disruption is still not priced in the supply, therefore artificially keeping the delivery cost low. Water management is also growing for applications with industry and business uses including touristic sites like beaches and lakes. In reverse, it also offers insights into disaster recovery for water-related issues in manufacturing operations. In the future, residential water needs will be computing with the business needs and analytics will be needed to bring balance together. South Africa and the state of California are examples for this competition.

But there is also an infrastructure resilience issue which solutions are addressing now with artificial intelligence (AI). Adoption is accelerating as emergency response around water crises in drought

and flooding relative to shifts in weather patterns has captured businesses from a risk perspective. Water quality issues through agriculture fertilization are driving water prices in cities up by up to 50% year over year in countries like Germany. That is accelerating the deployment of new water management solutions as well as the time to deliver water to customers.

User Advice: Users (industries) and suppliers (municipalities) need to evaluate the implementation of data management and analytics for their water infrastructure and water quality. This is particularly true when they must report or comply with increasing wastewater regulations, while improving efficiency and reducing loss and waste-disposal costs. Especially in emerging smart city planning scenarios, the build-out of smart grid and meter data management, together with water management data analytics, can provide a real-time view of natural or managed hydrological resource consumption. Intelligent water meters on consumers' premises enable water suppliers and municipalities to monitor consumption and create incentives for more efficient water usage as well as identify potential customer service problems due to poor water pressure or quality. Remember to implement security standards in the water management process, the physical infrastructure and the privacy policy on consumer data. For municipal water utilities or sewage plants, water management dashboards will assist in providing real-time data on water quality. In addition, sensor-based water management systems can detect water leakages in dams and pipes, especially important in projecting flooding or contamination situations for heavy rainfalls or during monsoon seasons. In addition, assess processes that are triggered through emergency response events in terms of not only viability of infrastructure but also quality and contamination issues. IT professionals in utility and municipal contexts need to include the opportunity to develop an adaptive and flexible water management strategy, cognizant of the legacy of IT and operational technology (OT) integration. The strategy should be based on intelligent information received and analyzed from environmental sensor and satellite networks, smart water meters and deep computing and analytics engines.

Business Impact: Consolidating previously fragmented data points and tools to manage and control water issues, from supply to reuse and recycling, provides water suppliers and municipalities with the ability to reduce costs. It also improves both the interface between asset tools for pumping stations, meters and monitors, as well as customer service with fewer water supply failures and better water quality. Partnerships with IT and water operations have to be built to connect the different data and information sources for a consistent analytics framework. As data will be the driving source for business models, it will be important to build financial models with asset management and new service models, especially in smart ecosystems — including cities. Leveraging geospatial and hydrological models will assist not only with the right workforce allocation but also with water rationing and quality control. It also supports scenario planning for communities that need to manage competing interest groups and disaster preparedness.

The complexity of water management data will also require more solutions capabilities related to an entire management cycle that includes operations, user billing and monitoring, and forecasting of demand and quality.

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Sample Vendors: ABB; Adasa; AquamatiX; Arcadis (SEAMS); Atos; Ecology Examination; GE; IBM; KISTERS; Schneider Electric

Recommended Reading: "Predicts 2019: Smart Cities Will Mitigate Social and Resilience Risks and Reward Digital Opportunities"

"10 Critical Actions Water Utility CIOs Should Take to Move Digital Initiatives Forward"

Smart City Framework

Analysis By: Bettina Tratz-Ryan

Definition: Smart city framework guides the development of a service experience by connecting into an intelligent urban ecosystem to improve its citizens' lives, stimulate its economy and protect its environment. The ecosystem of actors is facilitated with algorithmic business, legal frameworks and policies and data marketplaces. They define and measure the impact of technology through data and analytics to create a user-focused and contextualized experience.

Position and Adoption Speed Justification: The speed of smart city adoption will require city stakeholders — including local government, citizen organizations and businesses — to build a vision and governance toward a design, implementation and operations roadmap, and to measure them for accountability. In the past year, we have seen many cities accelerate the development of a smart city framework based on traffic, social and safety issues, rather than on technology availability. The smart city framework determines the data exchange and information required to build user-focused services and experiences. Especially in the new postpandemic world and during recovery of COVID-19, cities will have to bring a resilience factor into their smart city strategy. Data resources will be used through open data portals, visualization and application interfaces, as well as via unified user IDs to interface with citizen and businesses. User-driven experiences by information analysis and data mining are creating the city and, therefore, citizen-specific (residential and business) context. Smart city governance will drive all the projects that will contribute to smart and integrated city and urban environments.

User Advice: City CIOs and IT leadership have to operate and manage the city perception of residential and business citizens. For example, this can be accomplished by linking citizens' personalized context of safety, air quality and standard of living to metrics on pollution through commuter traffic, highway congestion and fossil fuel plants.

Local public-sector IT leaders should not only focus on the measurements of smart city infrastructure performance (such as traffic velocity, revenue per parking vehicle and cost savings through mobile applications). They should also focus on determining the citizen satisfaction quotient and providing a satisfactory communications and feedback cycle to citizens.

CIOs in local government and private-sector ecosystems may choose to share their insights and data orchestration with other smaller cities or regional partners. This is done to create a synchronized network of best practices for cities, avoiding the duplication of infrastructure, Internet

of Things (IoT) platforms or data analytics. This could become a system of systems approach or smart city as a service.

CIOs should apply a technology inventory that will support the set of objectives as well as the information and data exchange requirements for the city, along with public-private initiatives.

Business leaders should harness the opportunity of the data that will be made available to optimize their business model. This could lead, for example, to financial or insurance sectors establishing risk factors to help assess premiums for property insurance and traffic accidents. It could also help in analyzing user behavior data gathered through different sensors.

Business Impact: The digital business impact can be transformational for city leadership and both residential and business groups. Residential and business citizens collect and socialize information that can complement — or in some cases — be even more valuable than information collected through infrastructure owned and managed by the city government or other enterprises in city service delivery and operations. The blending of smart data will add to the privacy and safety discussions in specific use cases all the way up to local government. Technology approaches, such as cloud and big data management, will challenge the perception of security in storage and management of data, so a data vault and trust factors must be conveyed through active communication. The business impact of smart city frameworks is driven by the ability to automate and deliver better service experiences, and by how well citizens feel recognized in their desire to innovate their city and how safe their data will be. Open data portals and data marketplaces will provide transformational access to urban context that will be used to drive more use-case and user-specific ambient services, including demographic changes, digital skills, knowledge exchange and sustainability-related ambience.

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Emerging

Sample Vendors: Accenture; Arup; Cisco; Fujitsu; IBM; Microsoft; NXN; SAP; Schneider Electric; Siemens

Recommended Reading: “Turning Smart Cities Into Intelligent Urban Ecosystems”

“Predicts 2020: Resilient Smart City Development Requires Data-Driven Engagement of Citizens and Businesses”

Smart City Transportation Strategy

Analysis By: Pedro Pacheco; Bill Finnerty

Definition: A smart city transportation strategy defines the way that a government implements policy that will leverage technology and data to address transportation-related needs of residents, visitors and businesses. The strategy should address topics such as smart parking, ride sharing,

bike and scooter shares, multimode ticketing, mobility-as-a-service apps, smart logistics, wayfinding and other related solutions.

Position and Adoption Speed Justification: Transportation needs are a common starting point for smart city initiatives as many urban areas struggle with congestion, transit, parking and last mile transportation. Cities that develop a comprehensive strategy and related policies position themselves to manage smart city transportation in conjunction with economic development and planning rather than react to community and vendor initiatives.

The smart city transportation ecosystem consisting of public, private and citizen mobility concepts and solutions is regularly outpacing government strategy and policy. Rather than being reactive as vendors test and unregulated market.

The smart city transportation strategy is past the Peak of Inflated Expectations because cities have realized the need for a comprehensive approach and have started to address regulation related to permitting, data sharing, and management of solutions. For instance, several cities starting taking steps toward the creation of their own MaaS (mobility as a service) ecosystem and platform. This is a decisive step toward the deployment of a fully integrated mobility strategy under a user platform. One good example is Berlin's MaaS app, Jelbi. The city's transport authority called it the largest MaaS app in the world due the vast diversity of mobility services covered.

User Advice: Data exchange is key for CIOs developing or supporting a smart city transportation strategy. IoT sensors on smart transportation devices, whether owned by a government or private sector entity, and transportation mobile apps and systems provide a wealth of valuable data for the ecosystem.

CIOs need to establish data governance, management and orchestration, through data marketplaces as part of their support for smart city transportation strategies. They must identify the datasets most valuable to ecosystem partners and manage the development and approval of data policy that facilitates sharing these. Direct engagement with industrial hubs, supply chain organizations, last mile logistics and real estate development are key to drive the value they provide in contributing to smart transportation strategies. For example, a CIO working for a warehouse company could contribute fleet CO2 emissions data to be leveraged by government agencies to meet goals related to environmental policy and obtain relative grant funding.

CIOs working on efforts in support of a smart city transportation strategy need to develop capabilities for IoT. Ecosystem participation relies on government agencies being able to bring value to the ecosystem; data from IoT sensors on government-owned transportation assets and other vehicles to contribute is one such value item.

CIOs supporting public transport and traffic agencies need to establish an operations platform for many different functions of public transport and traffic management to enable control and management processes. They will also need to develop capabilities in geospatial and business intelligence systems to consume and utilize the data being shared by the ecosystem.

Finally, city transport authorities need to provide a centralized mobility platform that offers users an easy access to all mobility solutions, covering all types of A-to-B travelling in a seamless way. The

number of users to this platform will be detrimental to ensure the future success of a smart city transportation strategy.

Business Impact: Particularly in a time of economic distress, a smart city transportation strategy supports government creating a stable market, with known operating parameters, which enables the ecosystem to thrive.

Ride, bike and scooter share companies benefit from having a clear regulator environment in which to operate. It establishes the rules of engagement to align community expectations with micromobility operating procedures.

Transportation and urban planners utilizing data from the transportation ecosystem to inform decision making can guide both improved scenario planning and community engagement, but must beware of the data security and privacy issues.

Health and human service agencies benefit from having greater options to support clients' door-to-door transportation needs.

Residents benefit from greater and more reliable transportation options to get them to school, work and social events.

Local businesses benefit from access to transportation data that can inform them about the demographics and quantities of people that are traveling within reach of their location, allowing them to better target offerings and advertisements.

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Sample Vendors: MaaS Global

Recommended Reading: "COVID-19 Scenarios for Automotive and Transportation CIOs"

"3 Ways Transportation CIOs Can Shape a Mobility-as-a-Service Ecosystem Effectively"

"Use Scenarios to Plan for the Future of Mobility 2025: The Scenarios"

Micromobility

Analysis By: Michael Ramsey

Definition: Micromobility is the use of single-person vehicles or transportation modes, primarily within urban and suburban areas. Although the term is not specific to any technology, the use of the term became common with the proliferation of dockless bike-sharing services and electric scooters.

Position and Adoption Speed Justification: Scooters, bikes, Segways and other single-person transportation modes that are accessible for short-term rental exploded in popularity in 2019, but have retracted somewhat as the challenging economics of the business models associated with them have collided with the COVID-19 pandemic. Micromobility startups rocketed around the globe in the past few years as the use of smartphone-enabled activation and mobile payments in a dockless environment led to a fast-paced spread of bikes, e-bikes and, particularly, e-scooters. For example, Bird, one of the leading e-scooter companies, has spread to more than 100 cities. However, the same company laid off 30% of its workers in April 2020 as a result of economic conditions.

These services have been very popular and provide quick and inexpensive transportation offerings inside cities, though they have also been somewhat controversial. Dockless vehicles have been left in spots that sometimes clutter sidewalks or other rights of way. Users of e-scooters sometimes ride on the sidewalks, creating a dangerous situation for pedestrians. Still, the new options have created a way to travel very quickly in the city and not get in any other vehicle. As cities contemplate closing off sections of city centers to vehicle traffic, rental options like these could be attractive.

The micromobility trend is so fast paced that it has the chance of burning out before it changes the city environment. In many places, cities are opting for restricted usage or issuing special deployment licenses. Many of these services are deeply unprofitable and, in light of the global economic conditions, could cease to operate. However, fears of virus exposure associated with public transportation could push some users into biking and e-scooters, creating a small refuge for the businesses.

User Advice: Look for ways to connect these services into a holistic transportation strategy, enabling payment or scheduling options that complement public and private transportation options. Be wary of investing in, or connecting with, services that skirt or avoid city regulation, because the services could quickly be frozen out for an individual town. Create transportation plans for a region with a consideration of micromobility as a means to solve some traffic congestion, to address pollution concerns and to even provide low-cost transit.

CIOs in local governments should assess the impact of single-user mobility given urban street and walkability aspects, as well as within the strategies for healthier and greener communities. Align routing and geospatial data to user journeys and map it through accidents and capacity data for street designs. As the steep increase of usage will challenge existing patterns on traffic velocity, decisions on use of micromobility on streets versus pedestrian walkways versus bike lanes will change the algorithms on speed of movement in cities.

Ensure that micromobility providers are now implementing some kind of sanitation regimen to prevent vehicle contamination.

Look for ways to use micromobility to provide transportation options for people who feel uncomfortable in public transportation as a result of the COVID-19 pandemic.

For CIOs working for industrial and commercial clusters and real estate development, set up data exchanges for mobility and related ecosystem datasets that can be combined to use for new

services on last-mile logistics, as well as adjacent service potentials in touristic, health and insurance business sectors.

Business Impact: Micromobility could have a significant impact inside large cities where traffic is challenging and where pollution and congestion are concerns. Micromobility businesses could be damaged or made irrelevant by strict regulation that would render implementation expensive or cumbersome. Today, the business is mixed in nature, being both positive and negative, absent a cohesive strategy to integrate this type of mobility into a city. In the long term, micromobility could help reduce pollution and provide low-cost transportation within cities. But there are risks to safety and of added congestion if cities and service providers fail to coordinate.

Benefit Rating: Moderate

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Sample Vendors: Bird; JUMP; Lime; Skip

Recommended Reading: "Smart City Funding Models: It's Time to Be Creative"

"Turning Smart Cities Into Intelligent Urban Ecosystems"

"What CIOs Need to Know About Micromobility"

"3 Ways Transportation CIOs Can Shape a Mobility-as-a-Service Ecosystem Effectively"

Chatbots

Analysis By: Magnus Revang

Definition: A chatbot is a domain-specific conversational interface that uses an app, messaging platform, social network or chat solution for its conversations. Chatbots range in sophistication from simple, decision-tree-based, to implementations built on feature-rich platforms. They are always narrow in scope. A chatbot can be text- or voice-based, or a combination of both.

Position and Adoption Speed Justification: Chatbots represent the No. 1 use of artificial intelligence (AI) in enterprises. Primary use cases are in customer service, human resources, IT help desk, self-service, scheduling, enterprise software front ends, employee productivity and advisory. There are also a variety of offerings in the market, such as developer self-service platforms, managed products, middleware offerings, integrated offerings and best-of-breed approaches.

Chatbots in social media, service desk, HR or commerce, as enterprise software front ends and for self-service, are all growing rapidly. Still, the vast majority of chatbots are simple, relying on scripted responses in a decision tree and relatively few intents. Similar to chatbots are virtual agents, which are broader in scope and sophistication, require more infrastructure and staffing to maintain, and are designed for an extended relationship with their users outside of single interactions. Users will interact with hundreds of chatbots, but few virtual agents.

The majority of implemented chatbots are unsophisticated and rule-based — failing to live up to expectations of stakeholders. The number of proofs of concept (POCs) is high, as is the failure rate to bring even unsophisticated chatbots into production. Gartner is seeing a backlash against chatbots, primarily focused on unsophisticated implementations.

User Advice:

- Start POCs for chatbots today, because most enterprises experience trouble scaling from the initial POC to production. The focus should be on uncovering the hindrances that will stand in your way.
- Treat vendors as tactical, not strategic — acknowledge that you'll most likely want to switch vendors in the future.
- Focus on vendors offering platforms that can support multiple chatbots.

Business Impact: Chatbots are the face of artificial intelligence and will impact all areas where there is communication between humans today. Customer service is a huge area where chatbots are already influential. Indeed, this will have a great impact on the number of service agents employed by an enterprise and how customer service itself is conducted. For chatbots as application interfaces, the change from "the user learns the interface" to "the chatbot is learning what the user wants" has significant implications for onboarding, training, productivity and efficiency inside the workplace. To summarize, chatbots will have a transformational impact on how we interact with technology.

Chatbots have played a strategic role in several companies' response to COVID-19. This might have an acceleration effect on the technology.

Benefit Rating: Transformational

Market Penetration: 20% to 50% of target audience

Maturity: Adolescent

Sample Vendors: Amazon; Cognigy; Google; IBM; Microsoft; NTT DOCOMO; Oracle; Rasa; Rulai

Recommended Reading: "Architecture of Conversational Platforms"

"Market Guide for Conversational Platforms"

"Market Guide for Virtual Customer Assistants"

Connected Home

Analysis By: Jessica Ekholm

Definition: A connected home is networked to enable the connection and interoperability of multiple devices, services and apps, ranging from communications and entertainment to healthcare, security and home automation. Solutions are delivered over many interlinked and integrated

devices, sensors, tools and platforms that learn from patterns and behaviors in the home. Contextual, real-time smart home experiences at the local or cloud level enable individuals and other connected services in the household to control and monitor the home remotely or within.

Position and Adoption Speed Justification: The connected home is a concept that overarches several technologies, devices, applications, services and industries.

The concept has evolved to include, without being exhaustive:

- Media entertainment
- Home security and monitoring
- Home automation
- Energy management products and services
- Health and fitness

The connected home is evolving from being designed to follow simple rule-based programming to rendering increasingly intelligent systems. Truly intelligent solutions that learn from the consumer behavior and habits within — and even outside — the home to deliver contextualized and personal experiences are starting to appear. Despite advancements in orchestrating and integrating discrete connected home solutions through smart home hubs and cloud integration, this is achieved only in tightly closed implementations. Use cases that extend beyond consumer solutions and bring the consumer experience to extensions of the home, such as the hospitality industry and the connected car, are starting to be defined.

Overall, connected home has moved closer toward the trough since last year's iteration as the market is maturing. The adoption of connected home solutions continues growing, albeit at a slow place, differing by regions and countries within regions. Yet, the drive created by the introduction of virtual private assistant (VPA) speakers, such as Amazon Echo and Google Home, continue on and is expected to increase as such products are introduced in more countries. Apart from strong growth in VPA-enabled smart speakers, Gartner's 2019 connected home survey, for U.K. and U.S. customers, showed that home security is one of the strongest drivers for consumers to purchase connected home device in the next three years. It also suggests that consumers' top concerns about connected home devices and services are around privacy and security — an issue that is unlikely to ease over the coming years and one that will hamper the market as a whole. As such, since the 2019 update we have seen an increased amount of providers pushing devices and services aimed at improving connected home security.

User Advice: The market is consolidating quickly around open ecosystems through cloud integration and open API adoption, where voice recognition solutions dominate the user interface. The differentiating factor in the next 12 months will be the faster adoption of machine learning techniques to deliver learning solutions and faster integration into open ecosystems. With such horizon, vendors must:

- Go beyond the programmable home and add intelligence by using analytics engines and machine learning techniques to create and shape a “learning” home that will deliver the intelligent home.
- Develop partnership strategies to build your existing expertise in devices, services and customer relationships. Provide a unified user experience and compelling integrated connected home solutions across products, brands and platforms.
- Partner with software providers for a unified platform. Base your solutions on standardized protocols to speed up market adoption.
- Open up APIs and make products work with market-leading connected home ecosystems.
- If you are a single-solution vendor, don’t lose focus on your own brand recognition while partnering with home ecosystems.
- Offer ease of use and reasonable hardware costs, differentiating the quality of experience on the services you have on offer by providing efficient support.
- As adoption extends beyond tech savvy early adopters, simple and quick installation and use are becoming increasingly important. Consider easy and quick installation and set up as key customer experience differentiators.
- Deliver high levels of trust and data transparency to consumers.

Business Impact: Connected home solutions affect a wide spectrum of manufacturers of white goods, entertainment electronics and home automation, security, and fitness and health products. These solutions also impact network infrastructure and service providers in areas ranging from energy utilities to surveillance, healthcare, assisted living, insurance, communications and digital entertainment.

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Early mainstream

Sample Vendors: ADT; Amazon; Apple; Belkin International; Deutsche Telekom; F-Secure; Google; Insteon; Samsung; Vivint

Recommended Reading: “Market Trends: Connected Home Adoption in the U.S. and the U.K.”

“Market Insight: The Move From the Connected Home to the Intelligent Home”

“Market Insight: How Sensors Drive New Interactions in the Future Connected Home”

“How to Plan a Connected Home Product Experience Roadmap”

IoT Platform

Analysis By: Alfonso Velosa; Eric Goodness; Scot Kim

Definition: An Internet of Things (IoT) platform is a software that enables development, deployment and management of business solutions that connect to and capture data from IoT endpoints to improve operations such as monitoring remote assets or optimizing maintenance. Capabilities include:

- Device management
- Integration
- Data management
- Analytics
- Application enablement and management
- Security

It may be delivered as edge or on-premises software, or cloud IoT platform as a service, or a hybrid combination.

Position and Adoption Speed Justification: Enterprises continue adding IoT capabilities to assets and products, seeking benefits such as cost optimization, process optimization, better interactions with customers, and new opportunities such as product as a service. The sophistication, scale and business value of these interactions call for specialized technology resources, most often implemented as an IoT platform. While enterprises across all verticals are deploying IoT, the strongest impetus comes from asset intensive industries such as manufacturing or oil and gas.

Continued integration, culture, and security challenges, and schedule delays for IoT projects, as well as excess vendor hype has moved IoT platforms closer to the Trough of Disillusionment. 2020 sees many vendors struggling to maintain business and technology viability as end users delay deployments due to economic uncertainty and employee safety concerns. Further, most large vendors have yet to develop a clear IoT platform strategy that will drive scale. Yet there is increased vendor and enterprise focus on application enablement and solutions that deliver clear business results and shorter project payback. These trends lead us to shorten the time to plateau down to two to five years. Note that the speed of adoption continues to across the consumer, commercial and industrial verticals.

User Advice:

CIOs should factor in the following issues:

- Deployments: Start with smaller IoT projects, identify IoT platform technology strengths and weaknesses, acquire implementation lessons, and verify alignment to business KPIs and project payback requirements.
- Architecture: IoT platform strategies should be aligned to either external business foci, such as for an OEM's connected product, or internal foci, such as for an owner/operator of assets. Identify the range of IoT projects for your enterprise, and segment them by their focus, complexity and business objectives. Use these insights to establish a distributed deployment

and a platform of platforms architecture for using multiple IoT platforms for different enterprise needs. Be aware that while this drives scalability and mitigates your vendor risk it increases your complexity and cost risk.

- Skills: IoT projects using IoT platforms require new skills. Improve team's capabilities such as integration, based on a skills gap analysis. Develop a plan for how IT personnel can complement the IoT platform skills within the business units, and drive IT-OT alignment. Plan to leverage a service partner to support critical initiatives.
- Customization: While no IoT platform will work straight out of the box, push your technology vendors to deliver vertical market modules and solutions optimized for your vertical.
- Vendor selection: Prioritize vendors you already work with, for their IoT platform. Evaluate candidate vendors on their fit-to-your-business objectives and technology. Expect roadmaps to continue to evolve quickly in the fast-changing IoT market. Key criteria center on the vendor's ability to scale from proofs of concept to operational-scale deployments, vertical market expertise, partner ecosystem, long term support capabilities, and references that show business results.

Business Impact: There is a significant opportunity for enterprise stakeholders to leverage IoT-enabled assets and business processes to achieve greater value. This includes making better decisions from the data and information generated by connected products, people and equipment. This improves decision making and provides better decisions about assets distributed across the enterprise and its external stakeholders. Unfortunately, this data has been largely locked in the assets — mostly due to lack of connectivity, but also because of lack of systems and governance processes to obtain and share this data systematically.

IoT platforms act as the intermediary between the "thing" and the business processes and applications. Therefore, they facilitate the introduction of a new potentially transformative wave of digital business innovation and digital transformation to enterprises. IoT platforms provide the middleware foundation to implement asset centered business solutions — and are part of a broader business process transformation.

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Sample Vendors: Alibaba Cloud; AWS; Eurotech; Flutura; Kaa; Litmus Automation; Microsoft Azure; PTC (ThingWorx); ROOTCLOUD; Samsung SDS

Recommended Reading: "Magic Quadrant for Industrial IoT Platforms"

"Critical Capabilities for Industrial IoT Platforms"

"Survey Analysis: As More Companies Deploy IoT, They Increasingly Focus on Best Practices and Payback"

"Competitive Landscape: IoT Platform Vendors"

Microgrids

Analysis By: Ethan Cohen

Definition: Microgrids are groups of interconnected controllable loads, distributed energy resources and storage that act as single, controllable entities within a grid. They have two operation modes — connected to the main power network or "islanded." The operation of microgrids offers advantages to customers and utilities by improving energy efficiency, reducing transmission and distribution losses, improving reliability, reducing environmental impact and providing a more cost-efficient electricity infrastructure replacement.

Position and Adoption Speed Justification: Microgrids are small-scale versions of the centralized power system that generate, distribute, store and regulate the flow of electricity to consumers and in which sources are colocated with loads. This includes remote rural electrification and residential or community power networks, in addition to commercial, industrial, municipal, hospital, campus and military base power grids. Microgrids offer a compelling alternative to traditional energy generation and distribution, using connected intelligence and IoT technologies to enable integrated control of distributed power-generation assets, either in parallel to, or islanded from, the main power grid.

Microgrids also provide local options regarding the choice of electricity-generation source and supply, such as distributed renewable energy sources. They operate in coordination with the utility, but the infrastructure is controlled either in part (as with a community) or in whole (as with a university) by the local entity. Universities frequently own and operate their own microgrids, as do communities, airport operators and military bases. Third-party and mixed-ownership microgrids are also appearing in the marketplace along with new variations of microgrid financing, operating and services models.

With the increased focus on renewable energy, efficiency and the need to make the business case for the digital grid, a growing number of stakeholders are focusing on microgrids as a viable approach to local grid modernization. Microgrids incorporate local distributed energy supplies and storage technologies to meet the specific needs of the constituents being served while networking with the main grid. Although microgrids offer several benefits, such as improved reliability and distribution efficiency, they do not leverage the same economies of scale and coincident load factor of central-grid-provided energy. Consequently, microgrid-based energy tends to be more expensive than central-grid-provided energy — though some technology and operating costs are decreasing.

User Advice: Microgrids' technical requirements are the same as those of traditional power generation and delivery systems. However, the common use of renewable energy sources will require broad use of electronic power systems. To supply reliable quality power, the microgrid must have mechanisms to regulate voltage and frequency in response to changes in customer loads and system disturbances. All power in microgrids comes from distributed generation resources and controllable loads within the microgrid, which generally require significant investment in operational technology to perform distributed control.

Utility CIOs should monitor market developments in the microgrid use case space, and evaluate what kinds of offerings might be advanced to develop new revenue, enhance resilience and improve energy provisioning. Despite the significant promise and industry excitement over the concept, relatively few fully commercialized state-of-the-art microgrids have been deployed by utilities in North America. Promoters of the microgrid concept struggle to identify the best business models and regulatory structures — though there are increasing signs of change to decentralize the power-distribution infrastructure while adding greater reliability, security and self-healing capabilities to electricity distribution. The answers to these open questions around microgrids will profoundly influence the evolution of the electric power industry worldwide.

Business Impact: Microgrids will impact generation and distribution domains, and will have implications on energy retailing. Their role could become more important as utilities create new energy ecosystems and expand their business models and offerings. Microgrids can also be "aggregated" demonstrations of energy-technology consumerization, challenging the traditional utility business model, where the utility mainly provides energy as a cloud service. By facilitating consumer (or a group of consumers') integration into the energy market, microgrids are also contributing to the "geodesic" transformation of the energy-delivery infrastructure. The commercial integration of microgrids in the energy market will require a platform for the sharing energy economy and other emerging ecosystems, while network impact should be addressed via integration with distributed energy resource management systems (DERMS) and advanced distribution management systems (ADMS).

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Sample Vendors: Eaton; GE Power; Ormat Technologies (Viridity Energy); Saft; Schneider Electric; Siemens; Spirae

Recommended Reading: "Top 10 Trends Driving the Utility Industry in 2020"

"Predicts 2020: The Future of Energy Is Here — It's Just Not Evenly Distributed"

"Market Guide for Distributed Energy Resource Management Systems"

"The Energy Transition Question: Do We Need the Grid?"

Blockchain

Analysis By: David Furlonger; Rajesh Kandaswamy; Christophe Uzureau

Definition: A blockchain is an expanding list of cryptographically signed, irrevocable blocks of records shared by all participants in a peer-to-peer (P2P) network. Each block of records is time stamped and references links to previous data blocks. Anyone with access rights can historically trace a state change in data or an event belonging to any participant. Distributed ledgers are design limited and lack decentralized and tokenized elements.

Position and Adoption Speed Justification: A blockchain is an expanding list of cryptographically signed, irrevocable blocks of records shared by all participants in a peer-to-peer (P2P) network. Each block of records is time stamped and references links to previous data blocks. Anyone with access rights can historically trace a state change in data or an event belonging to any participant. Distributed ledgers are design limited and lack decentralized and tokenized elements.

User Advice:

- Educate senior leaders about the opportunities and threats that blockchain capabilities introduce. Use clear language and definitions in internal discussions about how distributed ledgers may or may not improve existing systems and processes.
- Continue to develop proof of concepts (POC) — especially in the context of market ecosystems. Identify integration points with existing infrastructures (for example, digital wallets, core systems of record, customer service applications and security systems). Analyze the role, maturity and interdependence of synergistic technologies such as artificial intelligence (AI) and the Internet of Things (IoT) as key levers in the evolution of blockchain complete and enhanced solutions.

Executives planning on deploying blockchain solutions must:

- Ensure sufficient innovation capacity is applied to the evolution of distributed ledgers and blockchains outside of your immediate industry.
- Identify integration points with existing legacy infrastructures. Evaluate the total cost of ownership against existing systems. Be very cautious about vendor lock-in and merely replatforming the enterprise without any additional value.

Business Impact: Blockchain provides an opportunity for enterprise leaders to imagine new kinds of business models and revenue flows. In particular, leaders decentralize commercial exchange, thereby reducing friction and cost, by monetizing multiple forms of assets. Enterprise leaders also face a threat from startups and businesses that can use the five core elements of the blockchain concept to disrupt and disintermediate markets and industries. This is done by offering capabilities like identity portability, trustless interactions, smart contracts and new forms of value exchange. These opportunities and threats will evolve over the next 10 years in varying degrees, affording strategic planners an opportunity to proactively address opportunities and threats. Regulation will play a significant role in the speed of evolution. Recent developments around the framing of compliance for token use and initial coin offerings (ICOs) are to be watched, as well as general consumer behavior toward, and acceptance of, multiple forms of assets. Progression with identity management will change the power structure in many industries and should be viewed through both a business and technology lens.

For distributed ledger concepts to really transform industry operating models via automation, and for economies of scale to improve efficiency, there needs to be a wholesale reimagination of digital transformation. COVID-19 may provide that catalyst. However, rather than encourage collaboration, it may increase fragmentation, making it harder for cross-industry and cross-jurisdiction consortia to be successful. Multiple business use cases have yet to be proven, and accurate value outcomes

have yet to be calculated. It is unclear whether current approaches for using distributed ledgers provide sufficient differentiation compared with existing, proven messaging and data technologies. Clearly, interoperability of both technologies and processes is a significant requirement.

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Adolescent

Sample Vendors: Algorand; Block.one; Cardano; Ethereum; Hyperledger; Neo; R3; Zilliqa

Recommended Reading: "Understanding the Gartner Blockchain Spectrum and the Evolution of Technology Solutions"

"Guidance for Blockchain Solution Adoption"

Vehicle-to-Vehicle Communications

Analysis By: Jonathan Davenport

Definition: Vehicle-to-vehicle (V2V) communication is the wireless transmission of data via dedicated short-range communications (DSRC) or cellular vehicle-to-everything (C-V2X) between vehicles.

Position and Adoption Speed Justification: V2V communications is slipping into the Trough of Disillusionment. Automakers continue to lack direction from a regulatory standpoint. For example, in 2019 the European Commission (EC) and the transport committee of the European Parliament both backed competing solutions. In the U.S. market, at the end of 2019, the Federal Communications Commission (FCC) lost its patience with the auto industry's low utilization of the 5.9GHz spectrum, which had been reserved for DSRC-based V2X for approximately 20 years. The FCC is now proposing to take >50% of this spectrum and repurpose it for other Wi-Fi-based use cases. Some of the spectrum will still be held back for vehicle safety use cases, but opens the possibility that it could be enabled for cellular-based V2X (C-V2X).

The DSRC and C-V2X technologies aren't compatible; thus, the lack of consensus may lead to a hybrid, dual-mode approach in some markets to ensure maximum interoperability among vehicles and infrastructure, with DSRC or C-V2X being sold in parallel, depending on OEM decisions. China will likely establish C-V2X as its technology for V2V, creating an important global shift that may well tip the scale in favor of C-V2X over the long term. In support of this, Geely Auto Group announced its plans to launch the first mass-produced C-V2X-enabled vehicles in China together with Qualcomm in 2021.

More broadly, there appears to be a move toward C-V2X. Toyota, which has already deployed DSRC technology in Japan, announced in April 2019 its decision to halt plans to install the technology to its cars in the U.S. (making a U-turn on a previous decision). Ford Motor Company said in January 2019 that it planned to deploy C-V2X in all new U.S. vehicle models beginning in 2022. The future technological evolution of V2V has yet to gain global consensus, as proponents of

C-V2X (Ford Motor Company and Audi) have gained favor among several OEMs and are actively conducting trials of LTE-based C-V2X solutions. However, Volkswagen announced in October 2019 that its Golf model will have DCRC-based technology, making it the first mass market vehicle to be equipped with such technology adding further confusion to which technology will "win."

User Advice: V2V communications can play a crucial role in not only improving traffic safety and flow by allowing vehicles in transit to send data about vehicle position, road conditions and traffic conditions to one another over an ad hoc mesh network. Drivers may simply receive a warning, or the vehicle itself may take preemptive actions, such as braking to slow down in an automated way. Regulatory mandates will help drive adoption in most markets, but a number of OEMs have already deployed V2V as part of an effort to differentiate their products and enhance driver safety (notably, Toyota, Cadillac and now VW). Direct willingness of consumers to pay for the technology is extremely limited, so penetration of V2V technology will be increasingly accepted as standard functionality across and within vehicle types.

Until global or regional consensus can be reached about DSRC or C-V2X, OEMs and automotive Tier 1 suppliers must prepare to deploy different technologies in different markets — depending on regulatory mandates and local market adoption trends. Regardless of technology implementation, OEMs must look to develop stronger relationships with governments at national and local levels to ensure the integration of V2V technologies is quickly established. They must determine the cost implications, and then design alternative deployment use-case models that can offset initial investments since the technology may become mandatory. OEMs should also engage with a clearly defined set of national government agencies (such as the U.S. Department of Transportation [DOT]) and engage in city trials to explore the technology's potential.

Communications service providers (CSPs) should lobby governments and automakers to push for the cellular standard. Revenue from the low-latency-based use case may help pay back investments in 5G and provide an angle to elicit government funding for rural rollout of 5G technology. CSPs also need to ensure that they can monetize their spectrum asset for V2V communications, even when messages do not travel across the cellular network.

Business Impact: V2V use cases enable safer driving performance with low latency (in the range of less than 10 ms) communications would have tremendous business and public safety impacts if implemented on a large scale and in an interoperable way. V2V technology is a key ingredient to realize the safety benefits of connected vehicles and future automated vehicles. The V2V functionality can supplement vehicle sensor capabilities with information from other vehicles on the road, thus warning of hazardous road conditions, collisions and changes in traffic patterns. The V2V communications technology represents crucial safety inputs that cannot be captured by conventional vehicle sensors, allowing drivers and vehicle systems to adjust driving strategies and initiate emergency maneuvers to ensure safety of passengers and other traffic participants. Furthermore, the ability of vehicles to communicate with one another could be used for innovative traffic management systems and help improve traffic flow.

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Sample Vendors: Autotalks; Bosch Group; Continental; DENSO; Ericsson; Huawei; Nokia; NXP Semiconductors; Qualcomm; Siemens

Recommended Reading: "Market Insight: Roadmap for V2X Technologies for Autonomous Driving — When to Invest"

"Toolkit: Top 10 Trends in Automotive and Smart Mobility for 2020"

"Market Trends: 5G Opportunities in IoT for Communications Service Providers"

"5G Will Overtake Alternatives to Provide V2X Connectivity"

"The Top 10 Wireless Technologies and Trends That Will Drive Innovation"

"Market Insight: How Mobile Operators Should Accelerate 5G Impact on Autonomous Vehicle Design"

Distributed Generation

Analysis By: Zarko Sumic

Definition: Distributed generation (DG) is an energy supply method that situates generation resources at or near load. These may include a minihydro, diesel, biofuel, wind, solar or fuel cell and may be consumer-owned. DG is a subset of distributed energy resources (DER), which also includes on-site storage. Wider adoption of DG transforms centrally managed, radial delivery networks into geodesic, requiring advanced hybrid engineering control and an economic-incentive-based distribution network operating model such as transactive management.

Position and Adoption Speed Justification: According to the Bloomberg New Energy Outlook Report 2019, the cost of solar declined 85% from 2010 to 2018 — close to low-triple-digit price performance improvement in less than a decade. That price performance improvement is the main driver behind rapid DG adoption by consumers. Exponential technology advances at the grid edge are making it simpler, easier and cheaper for businesses and consumers to begin self-generating. They are also making it easier for consumers to actively manage their interaction with energy markets by controlling when to buy, store or sell energy back to the grid. In addition, consumer desire to mitigate high-supply costs and volatility, in addition to increasing reliability and service quality expectations, lead to greater DG adoption. Innovation in consumer renewable sources, resulting in grid parity in many markets, has contributed to a decentralized supply trend. Larger and more sophisticated commercial consumers, or in some cases, groups of adjacent residential consumers (such as community solar customers) are the most likely adopters.

DG interconnection standards are maturing; however, regulatory oversight is still a patchwork of interconnection rules. Issues with siting and permit costs still limit penetration. Locales where renewable portfolio standards apply, and where feed-in tariffs and net metering arrangements are available, are more conducive to DG deployment. For example, California expects that one-fourth of new-generation resources will come on the customer's side of the meter (mostly rooftop solar). The

IEA World Energy Outlook forecasts that incremental solar PV deployments will account for more than 70 GW of the combined future capacity additions through to 2040 — the largest share of total additional capacity by type.

User Advice: Most utilities have had little incentive from their regulators to pursue DG, even when, on occasion, it can provide business value. Few utilities have an organizational structure ready to coordinate and facilitate a vast array of third parties with interests in DG expansion. This slow response has created opportunity for new entrants such as community solar providers or entities offering power purchase agreement contracts to large commercial and residential customers. There are now signs that utilities are taking a more proactive approach to address decentralization as a consequence of the energy technology consumerization trend. Utilities should look for transmission and distribution (T&D) asset deferral benefits, but have backup plans if the DG technology has an unplanned outage (just as with line design). As with demand response (DR), utilities must propose incentives to regulators that would help them support cost-effective alternatives to traditional utility wire infrastructure, but still adhere to their service mandate.

Utilities' CIOs must also consider the information management and communication effects of DG growth, such as the need to expand communications networks and historian systems. Because a significant percentage of DG will be deployed by customers in the form of renewable generation, it will also enable consumer participation in carbon dioxide abatement. Treating DG as a part of overall DER strategy will require investment in distributed energy resources management systems (DERMS) or modification of advanced distribution management systems (ADMSs). This will address needs for resource DG orchestration or address impact of DG on distribution network operation, respectively.

Business Impact: Integrating DG into electric distribution networks is a significant challenge for the industry and will require deep power engineering, electric delivery operations knowledge, and expertise in software and hardware design. Integrating DG into utility business operations will be equally challenging as the industry learns how to serve a more dynamic, decentralized grid and respond to diverse prosumer and business partner ecosystems.

Benefits and logistical challenges span utility organizational business units — generation, transmission, distribution and customer service. Retail energy, distribution operations and the supply domain will experience the greatest effects from DG. Rising DG deployment has positive and negative implications for utilities. Its impact on the energy provisioning model is transformational. DER gives energy consumers more choices and increases the installed base of environmentally and economically sustainable generation — reducing greenhouse gases and encouraging or directly supporting improved energy efficiency. However, DER creates significant challenges to grid operations while improving grid resiliency. DER in general, and DG in particular, are main drivers for energy transition and are creating structural change in energy systems. Consequently, DG adoption is challenging current business and operating models for utilities, raising questions about how the grid will be operated and monetized.

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Sample Vendors: Ballard; Bloom Energy; Capstone Turbine; Caterpillar; ITM Power; Plug Power; Tesla

Recommended Reading: "The Energy Transition Question: Do We Need the Grid?"

"Top 10 Trends Driving the Utility Industry in 2020"

"Industry Vision: Utilities as Platform Providers for the Energy-Sharing Economy"

"Market Guide for Distributed Energy Resource Management Systems"

Robotic Process Automation (RPA)

Analysis By: Frances Karamouzis; Saikat Ray; Melanie Alexander

Definition: Robotic process automation (RPA) is a licensed software tool for building scripts to integrate any application via the user interface and a control dashboard/orchestrator which automates routine, repetitive, rules based, predictable tasks using structured digital data.

Position and Adoption Speed Justification: In their initial form (over five years ago), RPA tools predominantly focused on task-centric use cases. End-user adoption has been consistently growing, and tools are expanding to automate more extensive process workflows. Vendors have grown and made extensive R&D investments. There are also new entrants, such as SAP and Microsoft. Gartner estimates the software market has reached over $1.3 billion and the services market is over $5 billion (with continued growth expected). Many buyers have expressed remorse as organizations have not architected their approach in a strategic manner and nor applied the right tools. As such, there has been movement through the Peak of Inflated Expectations, and we foresee a renaissance by morphing offerings and end-user zeal for operational excellence in a digital mode. This will now be heightened with the sharp increase in a work-from-home environment, which requires the default to be digital.

User Advice: Awareness and targeted usage within specific functional areas and industries is high (i.e., shared services, BPO deals, finance and accounting). However, there is still a large addressable market for a truly "industrialized" (repeatable, consistent, highly scaled) adoption as part of digitalized operations initiatives.

To maximize the benefits of RPA offerings:

- Understand that the starting point for your investment and overall choices needs to begin at the strategic design level; more specifically, with the overall architecture of the hyperautomation strategy, which includes a portfolio rather than one targeted technology. The overall approach and architecture for the automation of business and IT processes form the foundation that underpins workflow, efficiency, efficacy and business agility. Missteps are unforgiving, as processes are fossilized with far-reaching operational impacts.

- Ensure the use of multidisciplinary governance and coordination across business units, IT, security, sourcing and assurance functions.
- Stratify the overall portfolio of business stakeholder demand and build your hyperautomation roadmap. Determine the targeted role for RPA offerings within that strategic roadmap. The stratification of the portfolio will need to cut across several key variables: risk, reward, data profile (volume, velocity and viscosity of data) and business process profile (ranging from simple, well-defined rote examples to complex, SME-intensive, exception-heavy areas).

Business Impact: Experienced users of RPA have moved beyond simple, well-defined, highly repetitive use cases for their RPA software. Organizations are actively seeking to automate complex, subject matter expert (SME)-intensive, exception-heavy business processes. Thus, a majority of clients will demand that RPA vendors showcase functionality or partnerships across multiple automation technologies. These include process mining (also referred to as "process discovery" or "e-process mining"), ingestion engines (optical character recognition [OCR], computer vision and many other technologies), analytics, user experience and machine learning. The ability to integrate multiple automation technologies will be table stakes for RPA vendors to effectively compete and address the user demand.

Organizations will not want to invest in multiple RPA offerings, but rather select the one that has the most robust options for the largest array of use cases. Thus, the use of one or more of the complementary technologies — which Gartner refers to as the "hyperautomation technology portfolio" — will be considered a must-have ingredient for business process automation initiatives and will be the norm. The biggest user challenges will include how to architect the solution, vetting the maturity of the complementary technologies, determining how many vendors to utilize, sorting out the combinations of licensing and contracting options, and ongoing governance issues. Therefore, one of the critical variables that will determine the value of RPA-centric automation implementations will be the effective use and architecture of complementary technologies.

Clients focusing on RPA-centric initiatives rather than strategically analyzing the larger technology toolbox options — iBPMS, iPaaS platforms, LCAP and decision management systems — will find it challenging to deliver on the larger portfolio of business demands in the digital age.

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Mature mainstream

Sample Vendors: AntWorks; Automation Anywhere; Blue Prism; Kofax; Microsoft; NICE; Pegasystems; SAP; UiPath; WorkFusion

Recommended Reading: "Predicts 2020: RPA Renaissance Driven by Morphing Offerings and Zeal for Operational Excellence"

"Magic Quadrant for Robotic Process Automation Software"

Climbing the Slope

Building Information Modeling

Analysis By: Marc Halpern

Definition: Building information modeling (BIM) is the process of managing data and information about facilities and physical infrastructure using an agreed-upon digitally enabled shared knowledge resource. This shared data and knowledge resource supports decision making from earliest conception to demolition, and traceably captures the decisions and the outcomes of those decisions.

Position and Adoption Speed Justification: BIM today is climbing up the Slope of Enlightenment. BIM concepts originally evolved during the late 1970s (Innovation Trigger) from civil engineering and architectural engineering departments at universities. By 2002, BIM reached the Peak of Inflated Expectations as commercial software vendors started hyping BIM and we began to see some startups. However, engineering and construction firms were slow to adopt BIM and by the mid-to-late 2000s, BIM began sliding into the trough. As the internet became increasingly mainstream throughout the 2000s, exchange and interoperability building information in digital format became more realistic and more widely accepted. Also, acquisitions of BIM providers and startups began. Nemetschek Group acquired GRAPHISOFT in 2006 and Hexagon acquired Intergraph during 2010. BIM slid into the Trough of Disillusionment about 2012 and began its ascent of the Slope of Enlightenment about 2015 as BIM increasingly became a cloud platform with technologies from existing architecture, engineering and construction (AEC) applications.

Recent accelerated adoption is also being encouraged by European regulations such as the U.K.'s mandate requiring that all publicly funded construction work must comply to BIM maturity Level 2 as defined by the British Standards Institution (BSI). This is one measure to help in fulfilling its target of reducing waste in construction by 20%. As BIM adoption continues to increase, Gartner clients request more guidance on best IT planning for BIM. Increasingly, they express concern about availability of BIM technology based on standards to ensure the viability of their BIM investments over the life cycles of their facilities.

User Advice: Like digital twins and PLM, BIM is a big corporate initiative that extends beyond technology. To successfully adopt and deploy BIM, CIOs must:

- Reduce the risk of failed BIM implementations by phasing the implementations into smaller, focused projects that build upon each other.
- Use both the BSI Levels 0 through Level 4 maturity model, and successively incorporate 2D BIM to 7D BIM categories of data as the company moves from one level of BIM maturity to the next.
- Involve stakeholders such as engineers, designers, construction planners and facilities operators in facilities life cycles to define requirements, and gain their support to positively encourage broader potential BIM user communities about BIM.

- Encourage BIM adoption by convincing supportive senior executives to redefine job performance metrics that encourage potential users to adopt BIM as a repository for designing, accessing content of, and supporting construction projects and facility maintenance.
- Address BIM data architecture challenges by assigning IT architects responsible for BIM implementation to work with key BIM stakeholders in engineering, construction management and facility maintenance.
- Assign a BIM lead to run a project defining corporate standards for creating and modifying BIM models, and establish a training program to educate the user community.

BIM data is coming from multiple silos related to engineering, construction, maintenance, and finance — all with different management policies. CIOs need to work with the CFOs and the facilities leaders together to sort out the data and implementation blueprint, as well as the service modeling. That is specifically key in these COVID times as well as post pandemic when buildings need to enable physical distancing, information management about crowds, etc.

Business Impact: Requests to implement BIM will typically come from business operations. However, there are benefits for CIOs as well. Most notably, BIM enhances the positive impact that CIOs have on business operations, elevating the influence of the CIO in the senior executive ranks. BIM also extends the influence of the CIO to facilities support.

The impact on facilities support goes beyond design and construction of facilities used for operations and by customers to also include operation and maintenance of the facilities. The value of having a single organizing framework for structured content, unstructured content, documents and models eliminates the costs of managing multiple applications that are otherwise needed to maintain and reuse that data. These content management benefits mitigate the costs of implementing BIM, although maintaining it increases overall information and technology costs. The biggest business benefits come from supporting the life cycles of facilities. BIM information and technology now contribute to the business because of money and time saved in design, construction, operation and maintenance.

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Sample Vendors: Autodesk; Bentley Systems; Hexagon (Intergraph); Nemetschek Group

Recommended Reading: “Adopt a Data Governance Strategy for Long-Term Building Information Modeling Success”

“Technology Insight: BIM Addresses Digital Workplace and Asset Management Priorities”

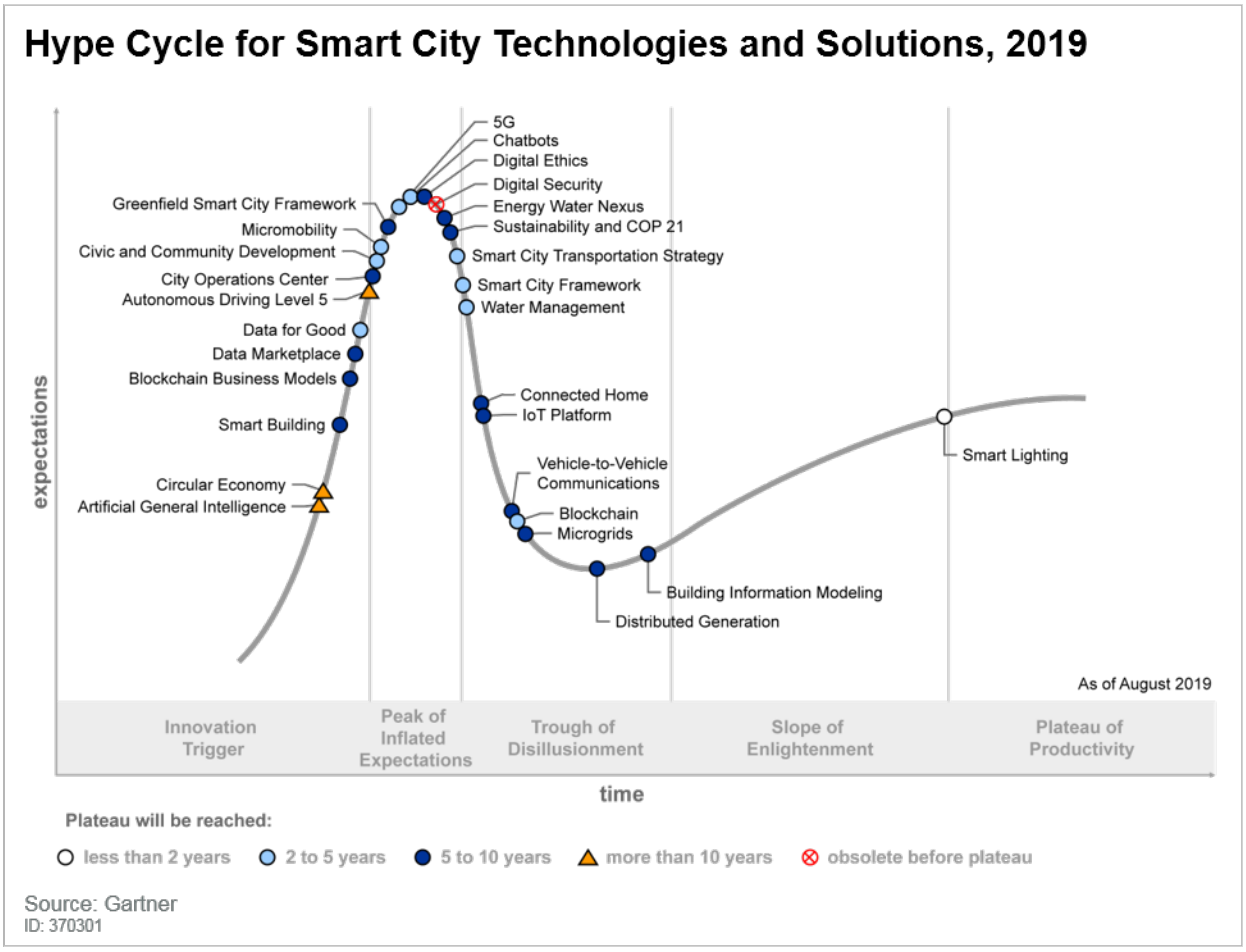
“Market Guide for Integrated Workplace Management Systems”

“Innovation Insight: How CIOs Can Leverage the IoT to Break Down Building Management Silos”

"COVID-19 Fast Response for Manufacturing CIOs"

Appendixes

Figure 3. Hype Cycle for Smart City Technologies and Solutions, 2019



Source: Gartner
ID: 370301

Hype Cycle Phases, Benefit Ratings and Maturity Levels

Table 1. Hype Cycle Phases

Phase	Definition
Innovation Trigger	A breakthrough, public demonstration, product launch or other event generates significant press and industry interest.
Peak of Inflated Expectations	During this phase of overenthusiasm and unrealistic projections, a flurry of well-publicized activity by technology leaders results in some successes, but more failures, as the technology is pushed to its limits. The only enterprises making money are conference organizers and magazine publishers.
Trough of Disillusionment	Because the technology does not live up to its overinflated expectations, it rapidly becomes unfashionable. Media interest wanes, except for a few cautionary tales.
Slope of Enlightenment	Focused experimentation and solid hard work by an increasingly diverse range of organizations lead to a true understanding of the technology's applicability, risks and benefits. Commercial off-the-shelf methodologies and tools ease the development process.
Plateau of Productivity	The real-world benefits of the technology are demonstrated and accepted. Tools and methodologies are increasingly stable as they enter their second and third generations. Growing numbers of organizations feel comfortable with the reduced level of risk; the rapid growth phase of adoption begins. Approximately 20% of the technology's target audience has adopted or is adopting the technology as it enters this phase.
Years to Mainstream Adoption	The time required for the technology to reach the Plateau of Productivity.

Source: Gartner (August 2020)

Table 2. Benefit Ratings

Benefit Rating	Definition
Transformational	Enables new ways of doing business across industries that will result in major shifts in industry dynamics
High	Enables new ways of performing horizontal or vertical processes that will result in significantly increased revenue or cost savings for an enterprise
Moderate	Provides incremental improvements to established processes that will result in increased revenue or cost savings for an enterprise
Low	Slightly improves processes (for example, improved user experience) that will be difficult to translate into increased revenue or cost savings

Source: Gartner (August 2020)

Table 3. Maturity Levels

Maturity Level	Status	Products/Vendors
Embryonic	■ In labs	■ None
Emerging	■ Commercialization by vendors ■ Pilots and deployments by industry leaders	■ First generation ■ High price ■ Much customization
Adolescent	■ Maturing technology capabilities and process understanding ■ Uptake beyond early adopters	■ Second generation ■ Less customization
Early mainstream	■ Proven technology ■ Vendors, technology and adoption rapidly evolving	■ Third generation ■ More out-of-box methodologies
Mature mainstream	■ Robust technology ■ Not much evolution in vendors or technology	■ Several dominant vendors
Legacy	■ Not appropriate for new developments ■ Cost of migration constrains replacement	■ Maintenance revenue focus
Obsolete	■ Rarely used	■ Used/resale market only

Source: Gartner (August 2020)

Gartner Recommended Reading

Some documents may not be available as part of your current Gartner subscription.

Understanding Gartner's Hype Cycles

Establish an Urban Data Exchange for Smart Cities

Market Trends: Smart City IoT Deployment Trends in Asia/Pacific

How to Plan the Role of 5G in Your Smart City Initiatives

Defining Urban Ecosystem Objectives and Measurements to Develop a Smart City Vision

Turning Smart Cities Into Intelligent Urban Ecosystems

Evidence

[1] "Turning Smart Cities Into Intelligent Urban Ecosystems." This report analyzes mobility options for congestion and determines opportunities for combined data analysis and conclusions on sustainability metrics.

[2] "COVID-19 and Beyond — A Challenge and an Opportunity for the Smart City CIO." The prediction of increasing requirements for data-driven decision making after recovery from COVID-19 concludes that mobility services need to be enriched with more data points to create citizen trust.

The "Great Reset" defines the onset of the rebuilding of society in a sustainable way.

The Global Covenant of Mayors for Climate & Energy defines the charters on sustainable development in cities.

More on This Topic

This is part of an in-depth collection of research. See the collection:

- 2020 Hype Cycle Special Report: Innovation as Strategy

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