SUPPLEMENTAL DATA

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No.	COMMUNITY	NAME/ LOCATION	SCALE	INFRASTRUCTURES	PROGRESS	SMART CITY DESCRIPTION	DIGITAL TWIN DESCRIPTION	APPLICABILITY TO DISASTER MANAGEMENT	REFERENCES
1	Gilleland Creek Watershed, Travis County, Texas	Real Time Control Retrofit of Stormwater Management Facilities (TMDL project), AUSTIN, TEXAS	Sub-Systems	Storm-Water Management System	In Development	The Pon court basin was retrofitted with an automated valve that could be remotely accessed during a storm event, Middleton and Barrett (2008) showed that retrofitting stormwater basins with smart controls that increased detention times improved the basins' removal of a range of common stormwater pollutants. This project provides the decision makers the ability to control the detention times, it was hypothesized that increasing stormwater's detention time in a basin could encourage the removal of bacteria through sedimentation and exposure to sunlight. The retrofit allowed the basin to begin releasing stormwater after a specified detention interval, rather than beginning to release water immediately following a storm event. (Klenzendorf et al. 2015)	None found	No existing articles pertaining to Disaster Management because this model is still in development.	1. Klenzendorf, B.; Barrett, M.; Christman, M.; Quigley, M. *Water Quality and Conservation Benefits Achieved viaReal Time Control Retrofit of Stormwater Management Facilities near Austin, Texas* ; Technical Report; OptiRTC:Boston, MA, USA, 2015 2. Chen, Y. and Han, D. (2018). *Water quality monitoring in smart city: A pilot project* . Automation in Construction, 89, pp.307-316.
2	Hamburg, Germany	Large-Scale IoT Deployments in a Smart City (MONICA PROJECT),Hamburg,Germany	Systems	Facilities Management	In Development	The MONICA IoT platform will be demonstrated by IoT applications addressing environmental and safety issues associated with large open-air events held in inner cities (e.g., concerts, funfairs or sports matches). Two main ecosystems will be implemented at large-scale: (a) a Security Ecosystem and (b) an Acoustic Ecosystem. The first will show how a multitude of innovative applications for managing public security and safety can be seamlessly integrated with numerous IoT sensors and actuators. The MONICA IoT platform will collect and analyze sensor data to enable decision support systems (DSS) and a common operational picture (COP). The Acoustic Ecosystem will demonstrate smart applications for managing open-air music performances in urban spaces by seamlessly integrating IoT devices using the MONICA platform. (Sebastian et al. 2018)	None found	No existing articles pertaining to Disaster Management because this model is still in development.	1. Sebastian, M.; Dorothea P., Julia-Ann, S.; Michael, F; Thomas, S. *MONICA in Hamburg: Towards Large-Scale IoT Deployments in a Smart City* ; The IoT European LSP Projects.
3	Austin, Texas	Flood Early Warning System (FEWS Project)	Sub-Systems	Flood Management System	In Operation	Data is compiled by the system through an assortment of sources, including a privately hosted gauge-adjusted radar rainfall system, which pulls in rainfall data from the National Weather Service Doppler radar and then adjusts the radar and data based on what a network of 4,883 virtual ground rainfall gauges in the Austin area are recording. A vendor-hosted hydrologic and hydraulic model runs every 15 minutes using the gauge data that shows peak stage and flow of flood waters at various locations throughout Austin. The models are then calibrated against sensors operated by the U.S. Geological Survey (USGS). (Heaton 2012)	The project uses 3rd party vendor-based software for forecasting and predicting flood alerts and warning, but no information on how the information is forecasted was found.	No details pertaining to Disaster Management are available.	1. "Flood Early Warning System | Watershed Protection | AustinTexas.gov - The Official Website of the City of Austin." (2018). Austintexas.gov, <http://www.austintexas.gov/department/flood-early-warning-system> (Nov. 4, 2018). 2. Heaton, B. (2012). "*Flood Early Warning System Keeps Austin, Texas, Prepared*", <http://www.govtech.com/public-safety/Flood-Early-Warning-System-Austin-Texas-Prepared.html> (Nov. 4, 2018).
4	Philadelphia	Smart Grid Outrage Management	Sub-Systems	Electricity Distribution System	In Operation	The PECO project combines and co-optimizes second generation demand response (DR), renewable generation resources, and energy storage. The project will enable participation through virtual generation and dispatchable load reductions based upon dynamic forecasts of load, generation, and prices. (Electric Power Research Institute, 2010)	Smart meters, integrated into the larger smart-grid system, allow the distribution system to automatically detect faults and to reroute power to minimize disruptions. The project includes software for next day schedules for the distributed resources and enables the combined resources to participate in wholesale markets. The PECO project identifies next day optimization of DER (Distributed Energy Resources), DER participation in wholesale markets as virtual generation, and dispatch load based on dynamic forecasts of load, generation, and prices. The PECO project will also specifically identify the day-ahead energy requirements into the RTO market as a virtual power plant and will be included in the operation studies for generation and transmission operations. (Electric Power Research Institute 2010)	None found	1. Electric Power Research Institute. (2010). Smartgrid.gov, https://www.smartgrid.gov/files/Exelon_ComEd_PECO_Smart_Grid_Demonstration_Overview_20101 2.pdf> (Nov. 4, 2018). 2. Hamidi, V., Smith, K., Wilson, R., "*Smart grid technology review within the transmission and distribution sector*", Innovative Smart Grid Technologies Conference Europe (ISGT Europe) 2010 IEEE PES, pp. 1-8, Oct 2010. 3. Maykuth, A. (2015). "Peco smart-meter installation close to done"., <http://www.philly.com/philly/business/20151206_Peco_smart-meter_installation_close_to_done.html> (Nov. 4, 2018).
5	Vicenza, Italy	Water and Flood management using effective Citizen Observations	Systems	Water & Flooding System; Infrastructure System	In Operation	In a citizens' observatory, all parties are active participants: creating knowledge about the situation in a participatory manner and contributing to dealing with the situation. In the observatory, citizens will be encouraged to provide information to authorities and to other citizens; this in turn requires that authorities and organizations can comprehend the information which is provided by citizens and provide information in a form which is best suited for citizen consumption. The objective of Italian Smart Cities is to encourage the building of a network that can promote innovation in the territories and offer cities of all sizes ideas and experiences to replicate. Through browsing by subject, city and project, the platform allows companies, researchers, associations, and citizens to get an overview of the main "smart" interventions going on in the various cities, fostering virtuous partnerships among municipalities.	None found	None found	1. Alfonso, L., Chacón, J. C. and Peña, G. (2015) Allowing citizens to effortlessly be-come rainfall sensors, in A. Mynett (ed.) E-proceedings of the 36th IAHR World Congress, Madrid, IAHR, pp. 1-5. 2. "Ciravegna, F. (2016). 'Periodic Report Summary 2 - WESENSEIT (WeSenseIT: Citizen Observatory of Water)' <https://cordis.europa.eu/project/rcn/106532/reporting/en?rcn=182487>, (Sept. 30, 2016) 3. Mazumdar, S., Wrigley, S. N., Ireson, N., Ciravegna, F. (2015)." Harnessing location-based services for effective Citizen Observatories". International Journal of Spatial Data Infrastructures Research, 13. pp. 101-108.
6	Shanghai City Centre. Shanghai, China	Modeling Transportation road network for Pluvial Flash Flood	Systems	Transportation; Water distribution systems	In Planning	A Spatio-temporal pattern between traffic analysis and integrated flood modelling is proposed as a solution for this study. This pattern focuses on development of a simplified simulation tool, which can build a road network model, assigning trip paths with the effect of road closures, and evaluating travel delay and vehicle volume redistribution in a given flash flood scenario in Shanghai. Shanghai being the largest city and global financial hub in China is growing as a smart city exponentially, currently China has initiated an IoT Center in Shanghai to study technologies and industry standards, a group of 60 telecom operators have initiated "Sensing China" to advance capabilities towards IOT.	None found	None found	1. Kontokosta, C. (2015). "The Quantified Community and Neighborhood Labs: A Framework for Computational Urban Planning and Civic Technology Innovation". SSRN Electronic Journal. 2. Li, M., Huang, Q., Wang, L., Yin, J. and Wang, J. (2018). Modeling the traffic disruption caused by pluvial flash flood on intra-urban road network. Transactions in GIS, 22(1), pp.311-322. 3. Yan, J., Liu, J., and Tseng, F. (2018). "An evaluation system based on the self-organizing system framework of smart cities: A case study of smart transportation systems in China". Technological Forecasting and Social Change.
7	Shihmen Reservoir, Taoyuan City, Taiwan	Modelling Intelligent water resources and allocation for Multi-Users	Systems	Water distribution systems	In Planning	The reliability of this approach is demonstrated through scenario assessment. Results indicate that the optimal water allocation strategies can be categorized as. 1. An increase in public water demand or decrease in agricultural water demand would bring more impacts of water supply on agricultural sectors, which could be because public sectors gains high priority of water supply; and 2. A larger decrease in inflow amount will bring more impacts on agricultural sectors than public sectors. Artificial Neural networks are one of the many Artificial Intelligence techniques used to develop optimal strategies for water allocation systems adapting to various water demands of competing users. By applying innovative ICT, Taiwan continues to promote various programs related to smart technology and plans to build a modernized smart city that is low-carbon, green, and harmonious and has sustainable development. In 2015, the Executive Yuan of Taiwan began drafting the "ide@ Taiwan 2020 Policy: White Paper" and proposed five dimensions and 18 measures for implementation to forge a new Taiwan that is high-quality, innovative, and sustainable. (Wu et al. 2018).	This Artificial Neural Network (ANN) model is constructed to estimate the optimal (minimum) water shortage for providing decision makers with comprehensive information presenting the impacts of the tradeoff allocation on water supply to public and agricultural sectors, respectively. Two ANN models, the Backpropagation Neural Network (BPNN) and the Adaptive Network Fuzzy Inference System (ANFIS) models, are built to estimate the seasonal water shortage rates of both sectors based on predicted monthly (seasonal) inflow, water demands and historical reservoir storage. In brief, the simulation method and the NSGA-II are used to calculate the seasonal water shortage rates of both public and agriculture sectors, and then the ANNs (BPNN and ANFIS) are used to estimate the seasonal water shortage rates under the optimal reservoir operation. This intelligent system is expected to serve as an assessment reference when facing water shortage situations, which shall help to reduce the economic	None found	1. Chang, F., Wang, Y. and Tsai, W. (2016). Modelling Intelligent Water Resources Allocation for Multi-users. Water Resources Management, 30(4), pp.1395-1413. 2. .Corzo, G., Solomatine, D., (2007) Baseflow separation techniques for modular artificial neural network modelling in flow forecasting, Hydrological Sciences Journal, 52:3, 491-507 3. Mohammed, S. K., Bagavathi, S. P. (2016). Framework for a Smart Water Management System in the Context of Smart City Initiatives in India. Procedia Computer Science, 92, pp.142-147. 3. Nikodem, J., Klempous, R.(2013). "Smart Water Distribution System". The 6th International Conference on Information Technology. 4. Nguyen, K., Stewart, R., Zhang, H., Sahin, O., Siriwardene, N. (2018). Re-engineering traditional urban water management practices with smart metering and informatics. Environmental Modelling & Software, 101, pp.256-267. 5.Wu, S., Chen, T., Wu, Y., and Lytras, M. (2018). "Smart Cities in Taiwan: A Perspective on Big Data Applications". Sustainability, 10(2), 106.
8	New York City	Adaptively Controlled Rain Water Harvesting System	Sub-Systems	Rainwater Harvesting System	In Planning	The Continuous Monitoring and Adaptive Control (CMAC) approach aggregates information from on-site sensors (e.g., water level measurements) and weather forecasts, then implements custom logic based on these data sources to make automated decisions about when and how to store or release water collected from sites incorporating storm water infrastructure. New York being the economic hub of the world is continuously engaged in digitizing the city with smart innovations. The city aims at setting up strategies and policies to successfully actualize the connected devices and internet of things (IoT).	The CMAC system was developed to pair moisture based irrigation with forecast-based logic and adaptive control of the cistern's discharge valve. The purpose of this simulation is to demonstrate the operation and benefits of a completely automated CMAC system. Logic rules were designed to minimize overflow from the cistern to the raingarden during periods of active rainfall ("wet weather") and to minimize irrigation use. This is a minimal example of a digital twin as it only focuses on a single point with limited imaging capacity.	None found	1. Roman, D., Braga, A., Shetty, N., and Culligan, P. (2017). "Design and Modeling of an Adaptively Controlled Rainwater Harvesting System". Water, 9(12), 974.
9	New York City	Active Traffic Management System	Sub-systems	Traffic Management Systems	In Operation	The first phase of Midtown in Motion has resulted in an overall 10% speeds improvement as suggested by the E-ZPass travel time data and verified by independent taxi GPS data. Currently it is being expanded to more areas, with a total of 210 microwave sensors, 56 traffic cameras and ETC tag readers at 59 intersections, covering the Midtown Manhattan area from 1st to 9th avenue and from 42nd to 57th street, more than 270 square blocks (more than 300 controlled intersections). New York City is exploring innovative approaches to building a smarter, more equitable and responsive city. The objective is to make New York City the most innovative and tech-friendly city in the world. Rather than expending too much effort on individual projects or use cases, such as a smart lighting corridor, the city is trying to shift its focus to ensure smart and connected infrastructure systems interoperate with each other to provide a fundamentally improved user experience. (Rosencrance, 2018)	None found	None found	1. Rosencrance, L. (2018). "NYC smart city projects focus on user experience, transportation". <https://internetofthingsagenda.techtarget.com/feature/NYC-smart-city-projects-focus-on-user-experience-transportation> (Oct. 21, 2018). 2. Schwartz, A. (2018). "Midtown In Motion Could Eliminate NYC Traffic Jams". <https://www.fastcompany.com/1768031/midtown-motion-could-eliminate-nyc-traffic-jams> (Oct. 21, 2018). 3. What Makes New York a Smart and Equitable City." (2018). Smart City, <https://www.smartcity.press/new-yorks-smart-city-initiatives/> (Oct. 14, 2018). 4. W. Xin, J. Chang, S. Muthuswamy, M. Talas, "Midtown in Motion: A new active traffic management methodology and its implementation in New York City", Transportation Research Board Annual Meeting, 2013.

10	Mallets Creek Watershed, Ann Arbor, Michigan	Real-Time Storm Water control network	Sub-systems	Storm Water Drain System	In Operation	Remote control of valves and sensors is implemented using a polling scheme, in which field-deployed nodes request commands from a remote server. To conserve power, nodes spend most of their time in a deep sleep state, consuming only 1/10 _A of current. Upon waking up, each node takes sensor readings and transmits the readings to a cloud-hosted time series database via authenticated (and optionally encrypted) HTTP requests. Before going back to sleep, the node polls a set of commands from a dedicated feed in the same database.	None found	In recent years, the city of Ann Arbor, Mich., has struggled to deal with increased floodwaters reaching the city. To funnel pooling waters after intense storms safely away, the city worked with the University of Michigan to develop Open Storm, a package of open-source sensors, hardware and algorithms to measure and control storm water. This system was used to control the storm water in real time during the storms in March 2018. Chief Deputy Water resources commissioner, Washtenaw County Government estimated that prior to installing Open Storm, it cost Ann Arbor $22 per gallon to drain storm water. That cost has dropped to $16 per gallon, roughly saving the city $1 million in infrastructure costs, primarily due to the water valve, which costs only a few thousand dollars. (MeCarter 2018).	1. Howell, S., Rezgui, Y. and Beach, T. (2017). Integrating building and urban semantics to empower smart water solutions. Automation in Construction, 81, pp.434-448. 2. McCarter. (2018). "Smart Cities Connect 2018: How Ann Arbor (Mich.) Drained Stormy Waters Smartly". Technology Solutions That Drive Government, https://statetechmagazine.com/article/2018/03/smart-cities-connect-2018-how-ann-arbor-mich-drained-stormy-waters-smartly> (Oct. 14, 2018). 3. Mullapudi, A., Bartos, M., Wong, B. and Kerkez, B. (2018). Shaping Streamflow Using a Real-Time Stormwater Control Network. Sensors, 18(7), p.2259. .
11	Barcelona, Spain	Citizen Sensing to collective monitoring: Working through the Perceptive and Affective Problematics of Environmental Pollution	Systems	Environment Improvement	In Operation	As a result of Citi - Sense the largest real time urban air quality sensor network was made operational, with 324 air quality sensor units installed in the nine participating cities (Barcelona, Belgrade, Edinburg, Haifa, Ljubljana, Oslo, Ostrava, Vienna and Vitoria-Gasteiz). Several additional sensor devices were also tested and improved. (CORDIS, European commission, 2018). CITI-SENSE developed and implemented information flows from sensors to users, and designed new methods for visualization of air quality information using data from several sources at the same time. The project developed among other, a method to provide a real-time air quality map that can be done for almost any city where sufficient number of sensor devices are in place. ("Barcelona Outdoor Air Quality - CITI-SENSE", 2018). Barcelona is rethinking its smart city projects. The Spanish metropolis has long had a reputation for being at the forefront of urban technological innovation. With a municipal network of 500km of optical fiber, free Wi-Fi routed via street lighting, and sensors to monitor air quality, parking spaces and even waste bins, Barcelona has been at the cutting edge of testing the internet of things (IoT). (Tieman 2018). Barcelona has also used this extensive fiber network to build out individual IoT systems across urban services. To improve energy efficiency, the city installed 19,500 smart meters that monitor and optimize energy consumption in targeted areas of the	None found	None found	1.Adler, L. (2018). "How Smart City Barcelona Brought the Internet of Things to Life". Data-Smart City Solutions, <https://datasmart.ash.harvard.edu/news/article/how-smart-city-barcelona-brought-the-internet-of-things-to-life-789> (Oct. 21, 2018). 2. "Barcelona: smart city revolution in progress | Financial Times." (2018)., <https://www.ft.com/content/6d2fe2a8-722c-11e7-93ff-99f383b09ff9> (Oct. 21, 2018). 3. Pritchard, H., and Gabrys, J. (2016). "From Citizen Sensing to Collective Monitoring: Working through the Perceptive and Affective Problematics of Environmental Pollution". GeoHumanities, 2(2), 354-371.
12	Coastal towns of Cannes, Brest and Le Havre in France	SCDT for Coastal Development in France	Sub-Systems	Port; Harbor	In development	The data for prediction of the city infrastructure projects (primarily the port re-development) is obtained through images, photos, GIS along with the usage of Building Information Modelling Software. These are to be linked to human interactions in the future. ("Why cities all want a digital double - L'Atelier BNP Paribas" 2018). The data are mainly used for the re-development of port installations.	None found	None found	1. "Why cities all want a digital double - L'Atelier BNP Paribas." (2018). <https://atelier.bnpparibas/en/smart-city/article/cities-digital-double> (Oct. 6, 2018).
13	City of Paris & Greater Paris	Paris Community Planning SCDT	Systems	• Streets • Roadways • Buildings • Sewerage networks – sanitary and storm drainage	In Development	Smart City Data is collected through satellite photos, aerial photography and the deployment of drones make it somewhat easier to build up a three-dimensional model of a city. These data are used for city's infrastructure development.	Algorithms are able to generate 3D models automatically from a series of photos. There still a colossal amount of processing and checking to be done. Moreover, once the model has been set up, it has to be updated on a regular basis. This means that the city authorities have to run fresh data-capture campaigns on a regular basis, every two years in some cases. This means that the city authorities have to run fresh data-capture campaigns on a regular basis, every two years in some cases. ("Why cities all want a digital double - L'Atelier BNP Paribas" 2018)	None found	1. "Why cities all want a digital double - L'Atelier BNP Paribas." (2018). <https://atelier.bnpparibas/en/smart-city/article/cities-digital-double> (Oct. 6, 2018).
14	Cebu, Bohol, and major cities of Philippines	Post disaster tourism recovery in Phillipines	Systems	• buildings, • roadways • underground sewerage systems	In Operation	Spatiotemporal knowledge about the post-disaster tourism recovery, including the recovery statuses and trends, and the photos visually showing unfixed damages were found out. A tool based on a PHP script was developed to collect Flickr photos and their metadata. The tool retrieves Flickr data by scanning the study area using a 0.5 degree by 0.5 degree moving window, starting from the upper left corner. Since the Flickr API allows for accessing a maximum of 4000 photos in a single API query execution, a window is subdivided into four equal-sized sub-windows in case more than 4000 photos are contained within that window. This subdivision is recursively performed until no API query returns more than 4000 photos. For the case study, using the tool, 71,329 geo-tagged & time-stamped (ranging from 1 April 2004 to 6 July 2016) Flickr photos were collected from 3790 users.	The photos were classified into tourist photos and non-tourist photos. A user was classified as a tourist if most of the photos contributed by this user could be visually recognized related to tourism (e.g., sightseeing), and then all the photos from the user were classified as tourist photos. Finally, quantitative and qualitative analysis of the photos were conducted. Here, the similarity between the photos after the disaster was clearly analyzed and interpreted for monitoring and assessing post-disaster tourism recovery. Fig 5 displays the method followed in the data analysis in a clear way.	The findings/results contributed to a better tourism rehabilitation of the study area. It was found that the more famous tourist areas in Philippines like Cebu and Bohol recovered faster after the disaster compared to other areas. This was probably because of more attention given to them as those tourist rich places generate more revenue. (Yan et al. 2017)	1. Yan, Y., Eckle, M., Kuo, C., Herfort, B., and Fan, H. (2017). "Monitoring and Assessing Post-Disaster Tourism Recovery Using Geotagged Social Media Data". ISPRS International Journal of Geo-Information, 6(5), 144.
15	Pisco, Peru	Post disaster recovery in Peru	Community Level	Buildings	In operation	The researchers/authors carried out field surveys in the city in 2012 and 2013 and also examined previous surveys to determine that building reconstruction peaked between 2008 and 2009.	After analyzing the five-year recovery process using satellite data and field survey, the authors compared its reconstruction conditions by visual interpretation with those by image analysis using satellite image.	An accuracy of 71.2% was achieved for the visual interpretation results in congested urban areas, and that for developed districts was about 60%. The result shows that satellite imagery can be a useful tool for monitoring and understanding post-disaster urban recovery processes in the areas in which conducting long-term field survey is difficult. (Hoshi et al. 2014) Therefore, this method of data collection can be integrated with the generation/creation of digital twins for disaster recovery of cities to a certain extent of accuracy. (Therefore, we can conclude that Satellite images and spatial-temporal data can be used in disaster recovery, thereby, giving a way of incorporating the data in the creation of digital twins. A digital twin can simulate and tell the various possible outcomes and alternatives. Based on that information, a decision could be made.	1. Hoshi, T., Murao, O., Yoshino, K., Yamazaki, F., and Estrada, M. (2014). "Post-Disaster Urban Recovery Monitoring in Pisco after the 2007 Peru Earthquake Using Satellite Image". Journal of Disaster Research, 9(6), 1059-1068.
16	City of Chicago	Underground Infrastructure Mapping	Sub-Systems	Underground Utilities, Water, Sanitation & sewerage systems	In Development	• Underground Infrastructure Mapping – More than 500 sensors are to be installed in the city to track/monitor air quality, temperature, moisture levels, traffic movements, and noise. The resulting data will be open to researchers and the public for analysis and planning, as well as to corporate vendors developing tech-based solutions. ("Current Products | City Tech" 2018)	• Holes and drills are made in streets or sidewalks, workers simply take a simple digital snapshot of the tangle of pipes and wires underneath. The image is then scanned into the mapping platform, which extracts key data points from it: namely, the depth, height, and width of the pipes in the photo. That 3-D data is layered onto a digital map of Chicago's streets. Over time, as more holes are punched open and more images get translated, the platform can extrapolate the layout of other underground areas that haven't been ripped open. And with continuous refinement and reconfiguration, the accuracy of this process can be increased. ("How Do You Map What's Underneath a City?" 2018)	None found	1. Bryne, M., <https://www.americaninno.com/chicago/city-digital-announces-development-of-tech-for-underground-map-of-chicago/> (Oct. 21, 2018). 2. Bliss, L., and CityLab. (2016). "How Do You Map What's Underneath a City?" CityLab, <https://www.citylab.com/design/2016/10/the-underground-movement-to-map-subterranean-chicago/503624/> (Oct. 21, 2018). 3. "City Digital Network – Converge Media." (n.d.). Converge Media, <http://convergemedia.com/city-digital-network/> (Oct. 21, 2018).
17	Atlanta, Georgia	Smart Cities and Inclusive Innovation	Systems	Buildings, Transportation Systems, Water Utility, Water leakage & water shed management, Crime	In Development	Here, two types of data are mainly used and collected through sensors. The first one is the infrastructure data, which includes data from transportation systems, drainage systems, buildings, etc. Next is the human-infrastructure interaction/performance data. This includes energy consumption, social network data, etc.	This project uses virtual reality (VR)-based platform mainly built on the Unity cross-platform game engine. The platform includes an analytics plugin, which is used to process data between the platform and the server system. This plugin consists of multiple layers such as data acquisition and data compression modules, which are linked to a spatiotemporal analytics and simulation server system, coupled with the city database. The analytics server system is planned to conduct city networks analyses across both infrastructure (e.g., transport, power, water supply and drainage, etc.), and human/social networks to monitor city network dynamics and performance such as operation, allocation of resources, and consumption. Cumulative spatiotemporal information captured in this way enables the server system to progressively learn and generate richer analytics insights that are fed into a living digital simulation server system for examining a variety of possible future scenarios, facilitating decision-making.	The main strategy is to leverage data to make better informed decisions that impact the residents, visitors, and businesses in Atlanta. Data-centric model is utilized for descriptive, prescriptive, and predictive capabilities to radically improve city operational efficiency, service delivery, and transparency. The five most important reasons of this project are to improve mobility, public safety, environment, city operations efficiency and public & business engagement. The flowing areas are the most concentrated on: Crime: Georgia Tech and the Atlanta Police Department are working together to test an algorithm that finds connections between crime incidents. It dissects incident reports, learns the similarities between words, and common patterns in how crimes occurred. Traffic: Georgia Tech and the City of Atlanta are leveraging technology and data from the North Avenue Smart Corridor Project to improve traffic operations along the corridor. Researchers are using data collected from various sources to improve traffic signal timing, energy use, and	1. "City of Atlanta | Smart Cities and Inclusive Innovation." (2018). Smartcities.gatech.edu, <http://smartcities.gatech.edu/city-atlanta> (Oct. 28, 2018). 2. "SmartATL." (2018). Smartatl.atlantaga.gov, <https://smartatl.atlantaga.gov/> (Oct. 28, 2018).
18	South Bend, Indiana	Smart Water Monitoring and Treatment System in South Bend	Sub-Systems	Sewerage, Waste water treatment	In Operation	EmNet has installed more than 150 sensors that gather information about water flow and rainfall. Data is captured from wireless sensors and level indicators in the sewer system as well as from SCADA devices placed throughout the system. The network of depth sensors, flow sensors and smart valves measures water levels and redirects wastewater from trunk lines approaching maximum capacity to less stressed lines. The data is integrated and aggregated into three types–geographic, asset, and environmental data. They are then fed it into the data collection and interpretation system (IBM's Intelligent Operations Center software and EmNet sensor network), thereby, providing an overall view of the water treatment systems. Lastly, information is delivered to a central dashboard that can issue alerts to worker PDAs if any problem comes up. ("Has your drinking water been digitized? Connected technology has hit water management" 2018) The city and EmNet instrumented the wastewater collection/sewer system and later partnered with IBM to apply a Smarter Water solution. The solution, based on IBM's Intelligent Operations Center (IOC) software, collects city water and wastewater supervisory control and data acquisition (SCADA) system data in near real time. This data includes water levels in the sewer system, rain gauge data, and pump station data to monitor what's happening at any point in time in the wastewater system. ("CSO cloud control - Civil +	The data from the sensors, combined with predictive weather data, is crunched and analyzed in order to provide real-time decisions about water flow. The decision-making process of wastewater management has been automated by installing sensors and gathering data that can help a city determine where to direct water through their underground system in order to prevent overflows. 12 million hours of data were collected from the sewer sensors. This is an intelligent digital twin system. In addition to collecting and aggregating data to deliver a unified view of the city's water and wastewater infrastructure, a sophisticated analytics and monitoring capabilities is employed that helps the city predict where wastewater overflows are likely to occur. Sensors and level indicators monitor, measure, and communicate the depth and flow of wastewater throughout the 500-mile collection system. If flows rise to dangerous levels or if a blockage occurs or if the level of pollutants in high, authorities are	a. South Bend has reduced wastewater overflow by a billion gallons per year b. South Bend dramatically reduced the volume of untreated sewage and pollutants (lead) entering the St. Joseph River, the drinking water sources in the area and the number of basement backups in low-lying areas. ("CSO cloud control - Civil + Structural Engineer magazine" 2018)	1. Booker, T. (2017). "Now what? South Bend needs new answers for lead problem after money dries up." South Bend Tribune, <https://www.southbendtribune.com/news/local/now-what-south-bend-needs-new-answers-for-lead-problem/article_3161fae6-6a06-11e7-85ed-afeb26b25a68.html> (Oct. 21, 2018). 2. "Case Study: South Bend, Indiana Targeting Iron And Manganese In Drinking Water." (n.d.). www.wateronline.com, <https://www.wateronline.com/doc/south-bend-indiana-targeting-iron-and-mangane-0001> (Oct. 21, 2018). 3. "Quick Tips." (n.d.). South Bend Indiana, <https://southbendin.gov/department/public-works/division/water-works/> (Oct. 21, 2018). 4. "South Bend, Indiana Uses Smart Technology to Monitor and Regulate Wastewater Levels." (n.d.). Environmental Resilience Institute Part of the Prepared for Environmental Change Grand Challenge, <https://eri.iu.edu/erit/case-studies/south-bend-indiana-uses-smart-technology-to-monitor-and-regulate-wastewater-levels.html> (Oct. 21, 2018). 5. "CSO cloud control."

19	City of Chicago	Smart Green Infrastructure Monitoring	Sub-Systems	Buildings, Energy Management	In Development	• Smart Green Infrastructure monitoring – Real-time sensing capabilities by collecting Data using sensors and cloud-based analytics are used to evaluate the performance of storm water management techniques and green buildings' efficiency. ("Current Products | City Tech" 2018)	• The Smart Green project will develop a cloud-based solution to accurately monitor and analyze and predict the impact of green infrastructure installations on urban drainage foundations. ("Current Products | City Tech" 2018) • Sensors have been installed at four green infrastructure sites across Chicago measuring the performance of permeable pavement, bioswale, infiltration planters, and tree pit filters. These first of the kind data on green infrastructure performance is being used to improve green infrastructure design, enable performance-based cost analyses, and are publicly available through the Chicago Open Data Portal. Finally, the pilot resulted in a commercial ready technology suite for real-time green infrastructure monitoring. ("City Digital & Smart Chicago Collaborative Join Forces | UI LABS" 2018) • Sensors measure water runoff from streets and sidewalks. Apart from that, sensors also	• Resulting technology and analyses can be used to inform refinements in future designs and measurement tools, and assist Chicago, other cities, and developers in green versus gray infrastructure investment and operations decisions. ("Current Products | City Tech" 2018) ("City Digital & Smart Chicago Collaborative Join Forces | UI LABS" 2018)	1. Levy, J. "Smart Green Infrastructure Monitoring Sensors." (2018). <https://data.cityofchicago.org/Environment-Sustainable-Development/Smart-Green-Infrastructure-Monitoring-Sensors-Hist/ggws-77ih> (Oct. 28, 2018).
20	Indianapolis	Global Water Technologies, Inc.	Sub-Systems	Water, People, Policy	In Planning	The plan engages the people who are the consumers of water, upgrades the pipes and infrastructure that make up the delivery system and improves the policies that encourage water efficiency at the local, state and national levels. Global Water Technologies has partnered with GreenSuite to connect "people" with a web-based consumer portal that provides information on water usage analytics, methods to improve efficiency and ways to reward such behavior. GreenSuite helps provide with the following information and functions: • Monitoring the usage behaviors of utility customers, • Measuring utility customers' energy usage versus other community members, • Reporting energy usage to customers online, through their mobile devices and email and • Rewarding customers that alter their usage behaviors by offering incentive reward ("Global Water Technologies, Inc. | Reducing Water Loss" 2018) One of the major steps involves installation of good measurement tools that show where the underground problems are located and how conditions are changing.	A sensor + software solution is to be used to measure pressure, flow and noise conditions in underground pipes and find the problems before water mains break. Getting real-time data would be the first step in creating a "smart water grid" that reduces water loss and collateral damage. New tools and solutions can be developed around that flow of data to better manage the critical water infrastructure and protect the vital water it carries to every home and business. ("Global Water Technologies, Inc. | Reducing Water Loss" 2018)	None found	1. "Global Water Technologies, Inc. | Reducing Water Loss." (2018). Gwtr.com, <http://www.gwtr.com/waterloss.php> (Nov. 4, 2018).
21	Miami-Dade County, Florida	Sea-level measurement to do flood mitigation	Sub-Systems	Flood Mitigation	In Planning	The sea level rise can be predicted/calculated by using one of the following simulation tools: • Eyes on the Rise • Surging Seas • NOAA Sea Level Rise Viewer A Sea Level Rise Task Force has been created which collects and reviews the following data: Potential impact of sea level rise on public services, facilities, real estate, water, ecological resources, property and infrastructure. Moreover, the sea water level rise, leading to floods in low lying areas are also being determined. These are accomplished by using sensors, GIS and LiDAR (light Detection and Ranging) and the data collected includes geographical, topographical, climatic and rainfall data. Sea Level Rise Task Force convened several meetings and offered recommendations to address sea level rise. One such recommendation was adopted by the County Commission for studying the feasibility of designating climate change Adaptation Action Areas. As a result, the administration conducted a study and concluded that the best approach was to begin with a pilot program to identify the most vulnerable areas. ("Miami-Dade County - District 6 - News Release" 2018)	The program will use the best available science to designate Adaptation Action Areas on the basis of their vulnerability to climate change. The aim of this designation is to provide a more holistic view of the challenges present in these areas, and then use this information to produce comprehensive solutions that can account for multiple issues at once. The experience gained through this pilot process will be used to support the designation of subsequent rounds of Adaptation Action Areas, which will include a more detailed vulnerability assessment. ("Miami-Dade County - District 6 - News Release" 2018)	Helps with the mitigation measures for sea-level rise, causing flood mitigation	1. "Miami-Dade County - District 6 - News Release." (2018). Miamidade.gov, <http://www.miamidade.gov/district06/releases/2016-01-20-sea-level-rise-pilot-program.asp> (Nov. 4, 2018). 2. "Miami-Dade County Memorandum." (2018). Miamidade.gov, <http://www.miamidade.gov/mayor/library/memos-and-reports/2015/10/10.23.15-Second-Quarter-Status-Report-In-Response-to-Multiple-Resolutions-Pertaining-to-Recommendations-by-the-Sea-Level-Rise-Task-Force-May-1-2015-to-July-3-2015.pdf> (Nov. 4, 2018).
22	Singapore	Land Transportation Authority, Singapore	Sub-Systems	Transportation	In Development	LTA is trying through the collection and analysis of data to help with transport challenges in Singapore based upon existing data.	FASTER system will analyze collected data to predict the impact of traffic accidents in order to implement better mitigation strategies.	None	Smart Nation Singapore.' Open Data and Analytics for Urban Transportation. https://www.smartnation.sg/initiatives/Mobility/open-data-and-analytics-for-urban-transportation
23	East Orlando, FL	Smart Community Program	Community Level	Resident System	In Development	Smart Community is an integrated program that connects people to the places they need to go and the services they need to receive. Through a Mobility on Demand (MoD) framework, Smart Community leverages existing ridesharing and car-sharing products to offer residents access to cars when required. Smart Community's trip planning application, Transit AVL, and Transit Kiosks will provide real-time multimodal travel information to integrate trip planning with modal choice options. Smart Community will allow travelers in the same area to share information and coordinate trips to destinations such as employment centers, education facilities, the grocery store, and medical treatment centers. Smart Community will have a benefit for low income and underserved populations in the area and help to connect the community to the region. (FDOT 2017)	None found	None found	1. FDOT. (2017). "Connecting the East Orlando Communities, Vol 1 - Technical Applications" <http://www.cflsmartroads.com/projects/design/future/FDOT-2017-ATCMTD-Vol-1.pdf> 2. FDOT. (2017). "Orlando Smart Community 2017 ATCMTD." <https://www.fdot.gov/traffic/its/projects-deploy/cv/maplocations/atcmtd-orlando.shtm>
24	Singapore	Singapore's Housing & Development Board, Smart HDB Town	Systems	Residential Infrastructure	In Development	Computer simulation and data analytics are helping to improve the planning/designing methods in each residential community.	None found	None found	1. Singapore HDB. "Smart HDB Town Framework". <https://www.hdb.gov.sg/cs/infoweb/about-us/our-role/smart-and-sustainable-living/smart-hdb-town-page>
25	Orlando, FL	GreenWay Project	Community Level	Transportation	In Development	GreenWay is a FDOT project to connect Advance Sensor Technology, Conditional Transit Signal Priority (TSP), Adaptive Deployment Traffic Signal Interface with Track Positive Train Control (SunRail), Smart Parking technology with Signal Performance Metrics (SPM), Expand Integrated Corridor Management (ICM), and Signal Control Analytics and Visualization. GreenWay is designed to better utilize the multimodal transportation system by actively managing over 1,000 traffic signals within the region. Data managed in the proposed SunStore will be connected with GreenWay to support Real Time Operation through a regional Decision Support System (DSS). This connection will allow strategic planning for special events to include consideration of all modes and users and will provide a unified approach to system operations and management. (FDOT 2017)	None found	None found	1. FDOT. (2018). "City of Orlando Greenway/Pedestrian Safety." <http://www.fdot.gov/traffic/its/projects_deploy/cv/MapLocations/CoO_Greenway.shtm> 2. FDOT. (2017). "Orlando Smart Community 2017 ATCMTD." <http://www.fdot.gov/traffic/its/projects_deploy/cv/MapLocations/ATCMTD_Orlando.shtm>
26	Singapore	Singapore - A Smart Nation	Sub-Systems	Transportation	In Development	Location-tracking sensors on vehicles and the data mining of anonymized bus fare are leading another transportation revolution in Singapore.	This solution is able to predict commuter behaviors and forecast crowding to avoid traffic jams to shorten commuting time.	None found	1. Benner, T.,(2016) "SINGAPORE: A SMART NATION" SMART AMERICAN. 6-7 <https://www.anfei.mx/public/files/articulos/Scientific_American_Singapore.pdf> (May 10, 2016)
27	Orlando, FL	Pedestrian Safety Guide and Countermeasure Selection System (PedSafe)	Sub-Systems	Transportation	In Operation	PedSafe is an innovative pedestrian and bicycle collision avoidance system currently being designed by FDOT. PedSafe will connect advanced signal controller capability, use of Connected Vehicle (CV) technologies, and existing communication capabilities to reduce the occurrence of pedestrian and bicycle crashes. As a region and a state that annually tops the dangerous by design list of most dangerous areas for walking, development and implementation of PedSafe is an immediate priority with multiple benefits. The application will be easily transferable throughout the country. (FDOT 2017)	None found	None found	1. FDOT. (2017). "Orlando Smart Community 2017 ATCMTD." http://www.fdot.gov/traffic/its/projects_deploy/cv/MapLocations/ATCMTD_Orlando.shtm 2. Zeeger, C. V., Nabors, D., Lagerwey, P. (2013). "Pedestrian Safety Guide and Countermeasure Selection System." <http://www.pedbikesafe.org/pedsafe/guide_background.cfm> (Aug. 2013)
28	Singapore	Intelligent Energy Systems	Community Level	Electrical	In Operation	Singapore's IES Pilot implemented in two phases. The phase 1 that began in 2010 focused on developing the enabling infrastructure and the testing of smart meters that are equipped with communication capabilities. This initial phase established two-way data communication. Phase 2 began in 2012 and this evaluated customer application which based on advance metering infrastructure. The main focus of phase 2 was to engage the customers through applications tests. Smart meters that are equipped with communication capabilities play an especially vital role in allowing the system to be two-way channel. They provide both consumers and the grid operator with information on how much electricity they are using. Other measures to be energy efficient include smart streetlight, which is designed to detect motion and adjust automatically, as well as sending signal to city officials when faulty is anticipated to be fully implemented. Smart technologies are expected to work together to reduce energy wastage while promoting a sustainable and greener urban environment.	None found	None found	Lee, S. K., Kwon, H. R., Cho, H., Kim, J., Lee, D. (2016)IDB.' International Case Studies of Smart Cities: Singapore, Republic of Singapore'. 32.
29	Orlando, FL	Smart Freight	Systems	Truck Freight System	In Development	The Smart City initiative provides Orlando with a platform to advance integrated real time data management and information system to drivers advising which route to take, locations of available loading areas, introduces incentive-based programs such as off-hours freight deliveries, and support of efficient urban delivery and logistics program. Leveraging partnerships with Metroplan Orlando and FDOT, the City has initiated a freight plan to implement strategies to promote the increased operations of freight throughout the region (freight priority corridors, institutional organizations, operational improvements, and air quality measures).	None found	None found	City of Orlando. (2016). "BEYOND TRAFFIC: THE SMART CITY CHALLENGE - VISION NARRATIVE FOR ORLANDO, FLORIDA." <https://www.singtel.com/about-Us/news-releases/singtel-and-edmi-to-develop-iot-driven-smart-meters-in-singapore>
30	Singapore	e-TrafficScan	Sub-Systems	Transportation	In Operation	LTA works in cooperation with city taxi companies. All taxi vehicles in the city are equipped with the GPS that tracks their locations and speed as they probe on the road network. Taxies act as a form of moving sensor and data collected are returned to drivers to provide travel information on both expressways and arterial roads, improving the time-efficiency of their journey route. The information can be found on the One Motoring Portal, along with other ITS such as EMAS and GLIDE.	None found	None found	Lee, S. K., Kwon, H. R., Cho, H., Kim, J., Lee, D. (2016)IDB.' International Case Studies of Smart Cities: Singapore, Republic of Singapore'. 29.

31	Orlando, FL	Urban Analytics	Community Level	Transportation	In Development	Traffic detection cameras and loop sensors in approach lanes to intersections provide information regarding volumes and lane occupancy. Information such as travel time along corridors and arterials as well as dwell times and delay at intersections are captured through the use of Bluetooth reading devices, and backend data analysis to match unique device identifiers known as MAC addresses. Traffic congestion and travel speeds at intersections are also calculated using Inrix/HERE traffic data. These types of analytics allow Orlando to calculate its network efficiency and identify areas that may need operational improvements. The Orlando autonomous vehicle / connected vehicle (AV/CV) program will extract data from connected vehicles to the roadside devices that will be leveraged into the dynamic signal systems that control signal timings and optimize the coordination of traffic along arterials. Information from these systems will also be put into the ITS infrastructure to display travel information on dynamic message signs to alert motorists of congestion, detours or accidents ahead. The Orlando AV/CV program would allow for full integration of these systems across the City, to produce an increase in network efficiency and a decrease in fuel consumption and emissions.	None found	None found	City of Orlando. (2016). "BEYOND TRAFFIC: THE SMART CITY CHALLENGE - VISION NARRATIVE FOR ORLANDO, FLORIDA." <https://www.singtel.com/about-Us/news-releases/singtel-and-edmi-to-develop-iot-driven-smart-meters-in-singapore>
32	Singapore	Green Link Determining (GLIDE) System	Sub-Systems	Transportation, Traffic Management	In Operation	Within the Intelligent Transportation System (ITS), all traffic signals are controlled by the Green Link Determining (GLIDE) system. Under the system, the green light is allocated based on real-time traffic demands and traffic signals at neighboring junctions along major avenues are linked, minimizing the drivers' stops while they travel from one intersection to another (this is known as a green wave). Presence of pedestrians are detected through push button that they press at crossings. GLIDE automatically detects the traffic flow, traffic light faults and pedestrians and for such system thin metal wire detector loops are installed below the road surface and before signal junctions.	None found	None found	1. Lee, S. K., Kwon, H. R., Cho, H., Kim, J., Lee, D. (2016)IDB.' International Case Studies of Smart Cities: Singapore, Republic of Singapore'. 28. 2. Singapore LTA. "GREEN LINK DETERMINING (GLIDE) SYSTEM". <https://www.lta.gov.sg/content/ltaweb/en/roads-and-motoring/managing-traffic-and-congestion/intelligent-transport-systems/green-link-determining--glide--system- .html> 3. Gibson, D., Milton, K., Klein, L. A. (2007), 'A New Look at Sensors'. <https://www.fhwa.dot.gov/publications/publicroads/07nov/04.cfm> (Dec. 2007) 4. U.S. Dept of Transportation FHWA (2006). "Traffic Detector Handbook" Vol 3-1. (Oct, 2006)
33	Orlando, FL	Intelligent, Sensor-Based Infrastructure	Systems	Parking, Transportation	In Development	By leveraging the data from partners, Orlando has integrated smart meter technology to provide usage data for residential and commercial utility use. This usage provides the City with metrics used to estimate peak demands based on historical information and to know when resources can be conserved, eliminating the need for overuse of power plants and water reservoirs. (BEYOND TRAFFIC: THE SMART CITY CHALLENGE - VISION NARRATIVE FOR ORLANDO, FLORIDA 2016) Also, the city has replaced all parking meters with smart meters that are used to track parking trends and provide information to the public on available parking spots. Orlando's vision for the future incorporates a broad use of various "smart" sensors that will allow for a highly advanced, safe and efficient infrastructure. Sensors such as air quality monitors and noise monitors will be added on LED street lights to measure ambient aesthetics. Utilizing and testing new sensor technology will allow the City to detect major issues not only in the transportation network, but its entire infrastructure before a major malfunction or accident occurs.	None found	None found	1. City of Orlando. (2016). "BEYOND TRAFFIC: THE SMART CITY CHALLENGE - VISION NARRATIVE FOR ORLANDO, FLORIDA." <https://www.transportation.gov/sites/dot.gov/files/docs/FL%20Orlando.pdf> (Feb 4, 2016)
34	Singapore	One Motoring	Systems	Transportation	In Operation	ONE.MOTORING is the comprehensive portal serving all drivers and vehicle owners in Singapore. On this web portal, citizens can access traffic information collected from surveillance cameras installed on roads and taxi vehicles with GPS. Through Traffic Smart, drivers are able to see snapshots of roadways that is taken at every 5-minute interval. Due to security and technical restriction reasons, real-time moving video or close-up shots are not provided online. It also provides information on current ERP rates (Electrical Road Pricing), sections where road works are in progress, traffic images of major expressways, traffic news, travel time calculator, road maps and street directions, and parking information. This useful portal can also be accessed on mobile devices. One motoring, not only provides traffic information but also offers information and guidance for citizens regarding buying, selling and maintaining their vehicles.	None found	None found	Lee, S. K., Kwon, H. R., Cho, H., Kim, J., Lee, D. (2016)IDB.' International Case Studies of Smart Cities: Singapore, Republic of Singapore'. 16.
35	Orlando, FL	Red Light Violation Enforcement	Sub-Systems	Transportation, Traffic Management	In Operation	The camera reads the license plate number and the software generates the driver's information. The light has to be red for the speed violation camera to turn on in order to reduce the conflict when drivers claim of video reading error.	None found	None found	City of Orlando. (2016). "BEYOND TRAFFIC: THE SMART CITY CHALLENGE - VISION NARRATIVE FOR ORLANDO, FLORIDA." <https://www.transportation.gov/sites/dot.gov/files/docs/FL%20Orlando.pdf> (Feb 4, 2016)
36	Singapore	Expressway Monitoring & Advisory System (EMAS)	Community Level	Transportation, Traffic Management	In Operation	When a traffic incident is detected, the LTA Operations Control Centre (OCC) will dispatch an EMAS Vehicle Recovery tow truck and LTA Traffic Marshal to the incident site, as part of the incident management process. The EMAS Vehicle Recovery crew and LTA Traffic Marshals will arrive quickly and work together to expedite the process of clearing incidents on expressways so as to bring traffic flow back to normal as fast as possible. Motorists are informed of the traffic condition so that they can drive more carefully as they approach the incident site or choose another route. Electronic signboards along the expressways and neighbor major roads display messages on the traffic situation ahead. Traffic information is also sent to local radio station for broadcast, and disseminated on relevant social media platform.	A simple digital twin. One of the functions is providing real-time information of travelling time from the entry point of expressway to selected exits.	None found	1. Singapore LTA. "Expressway Monitoring & Advisory System (EMAS)". <https://www.lta.gov.sg/content/ltaweb/en/roads-and-motoring/managing-traffic-and-congestion/intelligent-transport-systems/expressway-monitoring-advisory-system--emas--.html> 2. Revolvy."Expressway Monitoring and Advisory System" <https://www.revolvy.com/page/Expressway-Monitoring-and-Advisory-System> 3. Yew, C. C., Kim, G. H. (2015). "Expressway Monitoring and Advisory System" <http://eresources.nlb.gov.sg/infopedia/articles/SIP_507_2005-01-05.html> (May 01, 2015)
37	Orange County, FL	GIS InfoMap, Orange County, FL	Community Level	Transportation, Traffic Management	In Operation	Basically, this is a multiple information presentation system for government planners and researchers to acquire better understanding of the resource allocation within the City of Orlando. This map integrated useful data range from intersections to flood plains, etc.	None found	None found	1. City of Orlando. (2016). "BEYOND TRAFFIC: THE SMART CITY CHALLENGE - VISION NARRATIVE FOR ORLANDO, FLORIDA." <https://www.transportation.gov/sites/dot.gov/files/docs/FL%20Orlando.pdf> (Feb 4, 2016) 2. Orange County InfoMap Public. (2018). <http://ocgis3.ocfl.net/Html5Viewer/Index.html?viewer=InfoMap_Public_HTML5.InfoMap_Public>
38	Singapore new district	Punggol Digital District	Community Level	Facilities, Waste Management, Transportation, Traffic Management	In Development	The Punggol Digital District, imagined as a 50-hectare campus for technological research and innovation, is being built from scratch as an integrated smart-city concept, created by extending the existing Punggol's town center towards the waterfront. Unlike most urban development work, the Punggol project will see the integration of digital infrastructure from the ground up. The new digital platform will integrate various smart city solutions, including for facilities management, district cooling, pneumatic waste conveyancing, autonomous goods delivery, access and security, carparks, traffic lights, and autonomous vehicles. Data from the platform – ranging from information about "utilization of facilities, electricity consumption to even equipment breakdown information from estate and building management systems" – will be made available to academics, enterprises and entrepreneurs to develop new urban solutions for the region. The project sounds terrific but challenges are markedly. The challenge of integrating civic functions and technologies in a single open digital platform is a feature of the developing smart city narrative. US tech giant Cisco has come up with a so-called 'platform of-platforms' as part of its work in Manchester in the UK, which is says solves all of the technological issues, but remains in beta as the public and private sectors lead out new commercial models for smart-city procurement.	As the article described, a digital twin of the entire district will be made available for contributors to do safe testing of solutions before deploying them. The 'open digital platform' will be rolled out to other districts subsequently. The follow-up progresses worthy of our expectations.	None found	1. Blackman, J. (2018) 'Singapore preps open digital platform for major greenfield smart city development'. <https://enterpriseiotinsights.com/20180711/channels/news/singapore-preps-open-digital-platform-tag40 > (July 11, 2018) 2. JTC Corp. (2018) "Punggol Digital District". <https://www.jtc.gov.sg/industrial-land-and-space/Documents/JTC0049_18%20PDD%20ebook%20R5.pdf> 3. JTC Corp. (2018, Jan 29) "Punggol Digital District" Retrieved from https://www.youtube.com/watch?v=3SBp95qxNU
39	Orlando, FL	Traffic Information Service	Sub-Systems	Traffic Management Systems	In Operation	Both Central Florida Expressway Authority and HERE map is providing traffic flow, accidents, delays and FM closures minutely. Such information presentation enables vehicle operators to make better choice and save travel time.	None found	None found	1. Lee, S. K., Kwon, H. R., Cho, H., Kim, J., Lee, D. (2016)IDB.' International Case Studies of Smart Cities: Orlando, United States of America'. 2. HERE. (2018). "here we go" <https://wego.here.com/united-states/orlando/city-town-village/orlando--840djn4k-61f203c0dab54b73bef4c55766d4b31a?map=28.53823,-81.37739,12,normal&msg=Orlando> 3. Central Florida Expressway Authority. (2018). "Central Florida Expressway Authority." <https://www.cfxway.com/for-travelers/>
40	Singapore	Yuhua Community in Singapore	Systems	Real Estate Management	In Operation	In Yuhua community, the sensors provide residents with feedback on their behavior, helping them to use less water, electricity and so on, driving down household costs. The government, in turn, is able to aggregate this data, using analytics and computer simulation to improve the planning, design and maintenance of public housing estates. (Engadget 2018) Two scopes of concept under Yuhua community, one is relatively narrow concept-Smart Home. Another is relatively broad concept-Smart Neighborhood. In this case, we focused on Smart Neighborhood. As the detail of smart neighborhood, 3 systems included in Yuhua Community: ① Smart Pneumatic Waste Conveyance System (Smart PWCS): • Monitor the PWCS' performance and operational status, as well as residents' waste disposal patterns and volume • Optimize deployment of resources needed for waste collection by varying the frequency of waste collection, based on the volume of waste disposed. • Automated alerts will be sent to the PWCS contractor for any checks or repairs required. ② Smart Electrical Sub-meters and Remote Water Meters: • Enables remote collection and monitoring of water and energy usage and consumption patterns in the common areas. • Helps the Town Council better manage their resources for greater	None found	None found	1. HDB. 'Yuhua the First Existing HDB Estate to Go Smart'. <https://www.hdb.gov.sg/cs/infoweb/press-release/yuhua-the-first-existing-hdb-estate-to-go-smart > (July 28, 2015) 2. Souppouris, A. (2016), Singapore is striving to be the world's first 'smart city' <https://www.engadget.com/2016/11/03/singapore-smart-nation-smart-city/ > (Nov. 3, 2016)

41	Singapore	Virtual Singapore	Community Level	Digital Mapping	In Operation	It will enable users from different sectors to develop sophisticated tools and applications for test-bedding concepts and services, planning and decision-making, and research on technologies to solve emerging and complex challenges for Singapore. This project is championed by the National Research Foundation (NRF), Prime Minister's Office, Singapore, the Singapore Land Authority (SLA) and the Government Technology Agency of Singapore (GovTech). (Virtual Singapore 2018) Virtual Singapore will be developed based on geometric and image data collected from various public agencies, and will integrate different data sources to describe the city with the necessary dynamic data. The 2D data and information coordinated through existing geospatial and non-geospatial platforms such as OneMap, People Hub, Business Hub etc., which will enrich the 3D Singapore City Model. Advanced information and modelling technology will allow Virtual Singapore to equip with different sources of static, dynamic and real-time city data and information e.g. demographics, movement, climate.	It has potential to be a digital twin's tool, the actual operation status is unknown since virtual Singapore deployed in 2018.	None found	1. National Research Foundation. 'Virtual Singapore'. <https://www.nrf.gov.sg/programmes/virtual-singapore> 2. Geddie, J., Aravindhan, A. (2018), 'Virtual Singapore project could be test bed for planners - and plotters' <https://www.reuters.com/article/us-singapore-technology/virtual-singapore-project-could-be-test-bed-for-planners-and-plotters-idUSKCN1M70U1> (Sept. 27, 2018) 3. National Research Foundation. "Video Gallery". <https://www.nrf.gov.sg/programmes/virtual-singapore/video-gallery>
42	Singapore	Smart Meters in Singapore	Community Level	Electric Utility	In Operation	Singtel and global smart metering solutions provider EDMI are collaborating to deploy a smart electric metering infrastructure in Singapore. The partners have successfully tested smart electric meters, powered by seamless connectivity on Singtel's nationwide Cat-M1 cellular Internet of Things (IoT) network. The combination of smart meters with the IoT network enables the secure wireless transmission of real-time meter readings at regular intervals to the power grid. It also allows electricity suppliers to monitor electricity consumption and forecast demand more accurately. (Singtel 2017) According to the Business Group Managing Director at Singtel's Group Enterprise, Andrew Lim, "Giving electricity suppliers real-time data on electricity consumption allows them to optimize the distribution of electricity to certain areas and times of the day especially when demand is peaking. The pairing of smart meters with our IoT network will give consumers more accurate meter readings and ultimately bring cost savings." (Singtel plans to deploy IoT-driven smart meters in Singapore 2017)	The meters allow electricity suppliers to monitor electricity consumption and forecast demand more accurately. The Energy Market Authority plans to roll out smart meters in the second half of 2018. (Singtel 2017) The ability of meter's prediction is concealed now. More information is needed to fully define if this is a digital twin.	None found	1. Singtel (2017). "Singtel and EDMI to develop IoT - driven smart meters in Singapore". <https://www.singtel.com/about-Us/news-releases/singtel-and-edmi-to-develop-iot-driven-smart-meters-in-singapore> (Dec. 20, 2017) 2. TELECOMS (2017). "Singtel plans to deploy IoT-driven smart meters in Singapore". <https://www.telecomstechnews.com/news/2017/dec/22/singtel-plans-deploy-iot-driven-smart-meters-singapore/> (Dec. 22, 2017)
43	City of San Francisco	Data SF	Community Level	TRANSPORTATION	In Operation	Data SF is official open data program published by the City and County of San Francisco. - Data SF portal contains hundreds of open data, ranging from city management report to city infrastructure grade map. - As an open data, individuals, developers, and private companies can access through these sources and use for their benefits. For a smart city, company like Google Waze was able to test and develop a better navigation system with integrated traffic report and travel time calculation technology.	None found	None found	1. City of San Francisco, DataSF. (n.d.). Retrieved from <https://datasf.org/opendata/>
44	City of San Francisco	San Francisco Automated Water Meter (AWMP)	Systems	Water Management System	In Operation	Meter Transmission Unit (MTU): This radio unit is factory connected to each automated water meter and collects your meter reading each hour. Every six hours, it sends its information to a Data Collection Unit (DCU). The meter readings are encrypted and sent through the automated network using a private radio frequency (RF) channel from the meter box to the data collectors, and using a cellular data network from the data collectors to the AWMP database. The signals used to transmit data from Automated Water Meters are much weaker than those from many everyday devices, such as cell phone and baby monitors. Data Collection Unit (DCU). A total of 81 Data Collectors are located throughout the city on its facilities and city-owned poles and rooftops to transmit the meter readings to the SF Water, Power and Sewer's AWMP database; and AWMP Database: The SFPUC billing system will use this information to calculate the amount of water used and create bills.	None found	None found	Berger, M. A., Hans, L., Piscopo, K., Sohn, M. D. (2016). "Exploring the Energy Benefits of Advanced Water Metering." Ernest Orlando Lawrence Berkeley National Laboratory. Nov 13. 2018
45	City of San Francisco	San Francisco Shipyard Development	Community Level	Community Management	In Development	Smart Community App (powered by Bosch's Software Innovation Solutions): - Residents can access localized, real-time information such as transportation/mobility information. They can see where the community shuttle is on its route between the city and the Shipyard communities, or get details about local bus and train connections. - In addition, the app connects residents with local businesses, giving them news or information on events and special offers. It also connects community members and residents with each other, providing access to the community website and the blog. Community members, residents, and visitors can customize the app according to their own needs and desires. - The community administration, too, can interact with community members and visitors. For instance, administrators use the app to notify residents about community events. Residents, in turn, will be able to contribute to the safety of the neighborhood by reporting images or videos to the security staff.	None found	None found	1. Dorsch, L. (2016). Building the next communities in San Francisco. < https://blog.bosch-si.com/smart-city/building-the-next-communities-in-san-francisco> (June 24, 2016) 2. Highfield, V. (n.d.). Sensors, scandal and sustainability: Inside the San Francisco smart city being built from scratch on an abandoned naval yard. <https://www.alphr.com/the-future/1009514/inside-san-francisco-smart-city>
46	City of San Francisco	TransBASE	Systems	Transportation, Traffic Management	In Operation	Based on a spatial data acquired from the San Francisco open data policy (Data SF), the system generates more than 200 referenced variable across a range of geographic scales, including infrastructure, transportation, zoning, sociodemographic, and collision data, all linked to an intersection or street segment. TransBASE develops multivariate models to identify environmental correlates of pedestrian injuries to support the City's prioritization of areas and countermeasures for safety improvements.	None found	Adapted in Walk First - an inter-agency collaboration to create San Francisco's Pedestrian Safety Capital Improvements Investment Strategy with crash data linked to street, transit, infrastructure, land use, and population factors for systematic, citywide analyses of crash patterns. No evidence that this is currently used for disaster management but the information, crash data in particular, could be valuable in a disaster management situation.	1. San Francisco Department of Public Health. (2013) <https://www.sfdph.org/dph/hc/HCAgen/HCAgen2014/May%206/TransBASE%20Dec2013%20FINAL-2.pdf> (Dec. 20, 2013) 2. Vision Zero SF. <https://visionzerosf.org/wp-content/uploads/2015/04/VZSF_What-You-Need-To-Know.pdf> 3. Tingvall, C., Haworth, N. (2000). Vision Zero: an ethical approach to safety and mobility. In 6th ITE Int. Conf. Road Saf. Traffic Enforc. Beyond 2000. (Melbourne, 1999)
47	City of San Francisco	SF Park	Sub-Systems	Parking, Transportation	In Operation	The program utilizes smart parking meters that change their prices according to location, time of day, and day of the week, with the goal of keeping about 15% of spaces vacant on any given block. Parking usage is monitored via sensors placed in the asphalt. The wireless parking sensors detect parking availability in real time. Availability and prices can be checked via SFpark.org, iPhone and Android apps, and cell phone.	Based on a real-time data collected, it charges the lowest possible hourly rate to achieve the right level of parking availability. In areas and at times where it is difficult to find a parking space, rates will increase incrementally until at least one space is available on each block most of the time. In areas where open parking spaces are plentiful, rates will decrease until some of the empty spaces fill. While an image is not expressly noted, a functional image is necessary for a system like this to work. It is also an example of an automated loop, albeit on a small scale (a portion of an infrastructure system).	None found	1. SF Park Pilot Project Evaluation Summary.(2014) <http://sfpark.org/wp-content/uploads/2014/06/SFpark_Eval_Summary_2014.pdf> (June, 2014) 2. Sensor Independent Rate Adjustments (SIRA) Methodology and Implementation Plan. (2014). <http://sfpark.org/wp-content/uploads/2014/05/SIRA-methodology-and-implementation-plan_2014_05-14.pdf> (May 14, 2014)

UTILITY	TRANSPORTATION	31	
	WATER	18	
	ELECTRICITY	5	
BUILT ENVIRONMENT	BUILDINGS/FACILITIES MGMT	13	
	ENVIRONMENT	3	
	WASTE MGMT	3	