Inter-American Development Bank

International Case Studies of Smart Cities

Orlando, United States of America

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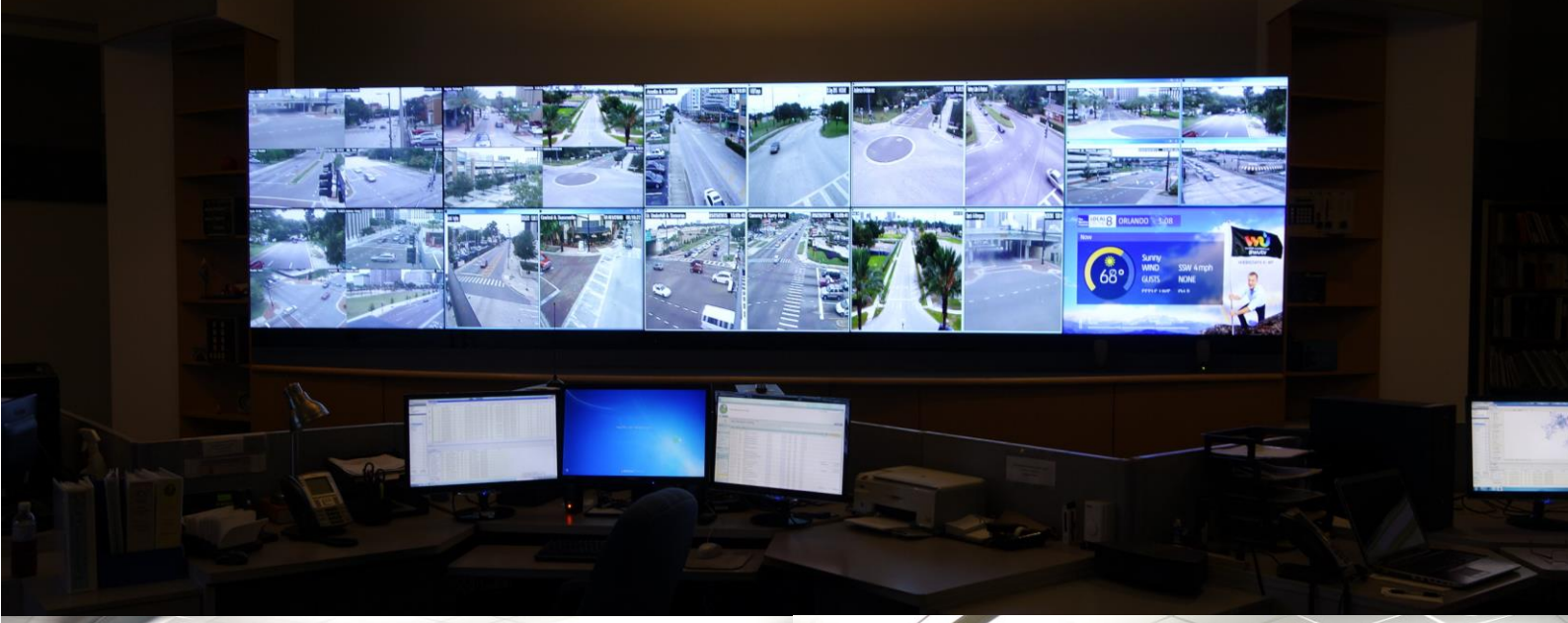

International Case Studies of Smart Cities

ORLANDO
UNITED STATES

IDB-KRIHS Joint Research

IDB

THE REPUBLIC OF KOREA

KRIHS Korea Research Institute for Human Settlements

GDPC Global Development Partnership Center

Abstract

This case study is one of ten international studies developed by the Korea Research Institute for Human Settlements (KRIHS), in association with the Inter-American Development Bank (IDB), for the cities of Anyang, Medellin, Namyangju, Orlando, Pangyo, Rio de Janeiro, Santander, Singapore, Songdo, and Tel Aviv. At the IDB, the Competitiveness and Innovation Division (CTI), the Fiscal and Municipal Management Division (FMM), and the Emerging and Sustainable Cities Initiative (ESCI) coordinated the study. This project was part of technical cooperation ME-T1254, financed by the Knowledge Partnership Korean Fund for Technology and Innovation of the Republic of Korea. At KRIHS, the National Infrastructure Research Division coordinated the project and the Global Development Partnership Center provided the funding.

As an international destination for theme parks, sporting events and conventions, Orlando approaches the smart city operation through Orlando Operations Center (OOC), an integrated facility established in 2001 by the Mayor after the 1977 hurricane. The major features of the integrated operation include the sharing of fiber optic networks and CCTV cameras, and close cooperation between transport, police and fire departments for road, criminal and disaster incident, and the emergency operation center within the OOC taking the lead in case of special event management and large-scale natural disasters. Along with the OOC, the city hall also utilizes smart city functions such as red light violation enforcement through detectors, bus management through AVL technology, GPS garbage truck tracking, and GIS water management. Orlando has experienced significant benefits in terms of shortened decision-making and response time, reduced operation cost, improved environmental impacts as well as enhanced service quality and communication with citizen.

JEL Codes: L86, L91, L96, O18, Q55, R41

Keywords: Smart city, intelligent transport system, crime and disaster prevention, emergency operation, environmental management, incremental system implementation, urban management, real-time information

With the collaboration of:

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Table of Contents

Executive Summary

In this report, we describe how the City of Orlando in Florida, the United States has applied information communication technology (ICT) and smart city approach to provide civic services to citizens and perform city operation in an integrated and efficient manner.

As an international destination for theme parks, sporting events and conventions, Orlando approaches the smart operation of transportation, security and emergency management through Orlando Operations Center (OOC), an integrated facility established in 2001 by the Mayor after the 1997 Atlantic hurricane season. The major features of the integrated operation include the sharing of fiber optic networks and CCTV cameras and close cooperation between transport, police and fire departments for road, criminal and disaster incident, and the emergency operation center within the OOC taking the lead in the case of special event management and large-scale natural disasters etc. The OOC operates as a smart city center through functions such as adaptive traffic signal control, remote CCTV management and city monitoring through display screen walls within OOC, 911 communications center system that harnesses CAD, EMD software and AVL technology, and incident information management and distribution through live camera feeds, VMS, SMS and smartphone alert services. Also, on top of advanced video conferencing system that enables effective communication between other city department headquarters and county operation center, the OOC focuses on citizen interaction through broadcasting system and SNS communication station.

Along with the OOC, several departments within the city hall utilizes smart city functions such as red light violation enforcement through detectors and software, bus management through AVL technology, GPS garbage truck tracking, GIS water management through sensors and meters, as well as smart metering and analytics through advanced metering infrastructure.

The OOC and city hall departments also provide wide range of smart services to citizens. This includes bus information service, parking information service, traffic information service, online reporting to police, emergency alert applications, smart waste information, automated waste trucks, pre-paid power pass program for utilities payment, GIS infomap for citizen, online education programs etc.

Such smart city approaches and use of ICT in city management and civic service provision, the OOC and the city hall have experienced significant benefits in terms of shortened decision-making and response time, reduced operation cost through remote controlling of devices and the sharing of information, fiber optic network, facility and devices as well as increased service quality to citizen. Also, the smart approach harnessing technology led to better management of city traffic and criminal and disaster incidents, reduction of traffic accidents, improved environmental impacts through effective waste, water and energy management along with enhanced communication with the citizen. Moreover, the variety of information collected through cameras, meters and sensors enabled the city to perform data analytics, understand the usage pattern and improve the systems and services accordingly. The City of Orlando regards one of the main purposes of effective city management as to keep the economic engines of the city undisrupted and further encourage tourism, investment and business through enhancing the perception of public safety.

Orlando, United States (Source: City of Orlando, 2014a)

ORLANDO, U.S.

A bustling downtown Orlando is known for drawing businesses of all types and strong ability to attract corporate headquarters. The city is also well known for its significant inflow and outflow of population, being a popular city for tourism. Orlando is the home of world-famous attractions including the Disney World and hosts international conventions at the Orange County Convention Center, the second largest convention center in the United States. Therefore, city operations and management on sectors such as transportation, security, and disaster (especially against hurricane) are of great deal to the city of Orlando.

1. Introduction

1.1 General city overview

Orlando is a city located in Central Florida, USA, in the seat of Orange County. Orlando city is the 26th largest metropolitan area in the States, and the third largest metropolitan area in the state of Florida. As of 2014, Orlando had a population of 255,636 in its total area of 287 km^2. The GDP per capita of Orlando is US$**24**,822 and the median household income is US$41,345 according to U.S Census Bureau, 2013 American Community Survey.

The City of Orlando saw a dramatic change since 1971 with the major theme park Walt Disney Resort settling approximately 21 miles (34 km) southwest of Downtown Orlando in Lake Buena Vista, forming the backbone of Orlando's tourism industry. Orlando is nicknamed 'The City Beautiful' and its symbol is the fountain at Lake Eola. The city is also currently known as 'The Theme Park Capital of the World' featuring 7 of the 10 most visited theme parks in North America (5 of the top 10 in the world), and the figures from the destination's official tourism association showed that more than 62 million people visited Orlando in 2014 alone. This announcement marked a new all-time record for the U.S. travel industry, solidifying Orlando's position as the most visited city in the nation. Not surprisingly, passenger traffic for Orlando International Airport has been increasing over the years and on a recent 12-month-moving average basis, total traffic is nearing 3.1 million.

Aside of being one of the most visited city in the U.S. as a leading tourism destinations in the world, Orlando is a major industrial and hi-tech centre. The metro area has a US$ 13.4 billion technology industry employing approximately 53,000 people, as well as nationally recognized as cluster of innovation in digital media, agricultural technology, aviation, aerospace, and software design. As many as more than 150 international companies have facilities in metro Orlando.

1.2 Smart city overview

1.2.1 Development background and history

Orlando has been experiencing rapid population growth since the 1970s. Between 1972 and 2001, the percentage increase in population was as high as 75%. Tourism also continued to grow. One of the effects of the growth was an increase in the size of the traffic control infrastructure that requires support and maintenance. This included the devices such as traffic signals, pedestrian signals, warning beacons and dynamic message displays for safe and efficient movement of vehicles and pedestrians throughout the city. Matching with the demands, the city saw a sharp rise in the number of traffic signals in the city and along with this increase, a dramatic rise in the number of complaints regarding traffic signal operation and calls for maintenance of these traffic control devices were seen.

Traffic control is only one of many examples of demands that followed city growth. Businesses expanded, demographics diversified and in turn, Orlando Police Department and Orlando Fire Department Response received more calls for service.

The final push came when Orlando was closely affected by the natural disaster, a severe hurricane in 1997. Since each department and agency had to request data from each other, operation inefficiency was clearly observed at the time. The Mayor realized a need for one-stop information platform, an integrated city operations facility that enables efficient data share and collaborative decision-making. The city's duty to protect its population and visitors from any kind of incidents became heavier.

In response, it was decided to integrate the Orlando Police Department, the Orlando Fire Department, Orlando Traffic Management, the Network Operations Support, and the Emergency Operations Centre into a combined facility in order to create smart and efficient emergency response system. The Mayor initiated the OOC project in 1998, the business plan of Orlando Operations Center was released in 2001 and in the same year the OOC opened as an integrated center with four sub-centers.

1.2.2 Vision, current and future projects

Orlando Operations Center's mission is to "provide citizens, visitors, and businesses with a reliable, efficient Public Safety communications and emergency operations system by:

- Managing communications, traffic, and event coordination in a central secured facility
- Creating a new permanent joint EOC and Orlando Operations Center in the same facility
- Providing space for present and future needs
- Integrating new technologies
- Coordinating the responses of fire/rescue, police, traffic engineering and other City departments in their day to day operations
- Coordinating through the EOC the response of all the City's departments during times of disasters
- Providing cost saving through shared communication and information management infrastructure
- Providing staff with the necessary technical advances available in the marketplace

2. Service Spectrum

2.1 Overview of the smart services and high level functions

In the same year that the business plan was released (2001), 28,000 sq ft (2601m²) Orlando Operations Centre (OOC) was established to provide joint facility that provides public safety support and the continuity of government during major disaster. As planned, it was comprised of four major operations for the city of Orlando:

- Traffic Management Centre
- 911 Communications Centre (both Orlando Fire Department and Orlando Police Department)
- Network Operations Support
- Emergency Operations Centre

Although OOC was not built directly under the smart city initiative, integrated city management may be considered to be heading towards similar direction; providing benefits through smooth communications between agencies for efficient decision-making process, and allowing better quality service to citizens. Through an interview, OOC also revealed that their facility is opened to incorporating other sectors of city management such as waste, water and energy management in the future if there exist clear benefits.

2.2 Transportation and urban mobility

2.2.1 Bus information service

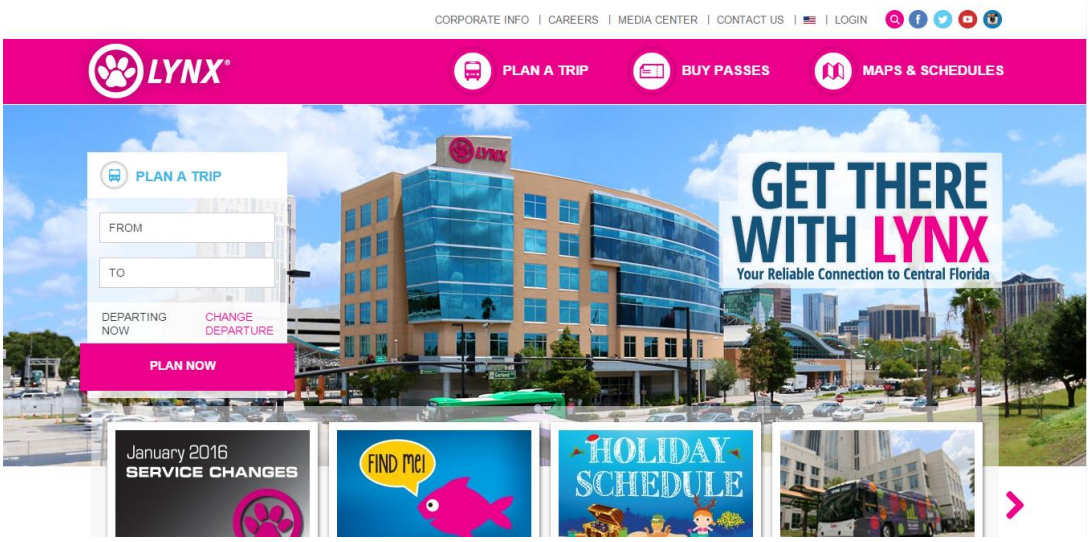


Figure 1 LYNX webpage (source: golynx.com)

City of Orlando has a public bus system called LYNX that connects Orange County with the surrounding Seminole, Osceola and Lake Counties. This Lynx system is run by the Central Florida Regional Transportation Authority. There are total 4,406 LYNX bus stops of which 1,096 are sheltered bus stops. Of this, the Orange County has 3,341 stops and 773 stops with shelters. LYNX provides schedules bus services to 61 routes by 235 buses and vanpool services by 70 vans.

LYNX also runs a free-of-charge buses called Lymmo (Links 31 and 62) in Downtown Orlando. Lymmo buses connect downtown destinations to the Lynx Central Station as well as to car parks. For the Orange Line, service runs every 7 minutes during peak and 15 minutes off peak; and the Grapefruit Line runs every 10 minutes during preak and 15 minutes off peak. The

Traffic Management Center within the Orlando Operations Center controls traffic signals on a three-mile route along a independent right-of-way.

The LYNX website offers functions such as “plan a trip”, “buy passes”, and “maps & schedule”, “service alerts”, “sunrail connections (railway network)” etc. The website also provides information on the “LYNX Vanpool Program” which allows a group of people to commute to work using a van prodied by LYNX, and the “LYNX Park N Ride” that provides free car park lot and direct connection to LYNX buses or vans.

LYNX Tracker powered by Clever Devices provides estimated bus arrival times and bus location map as a pilot project for Orange Bus Rapid Transit (BRT), Grapefruit BRT and Lime BRT routes. The bus location map (as shown in Figure 2) allows the user to find bus routes and bus stops on the map, see the buses moving on the map real-time (updated approximately every minute), and get informed the estimated arrival times at selected bus stops. The user can also use the Route Progress view to receive a pop-up notification when a bus has reached a selected stop.

LYNX website also provides interactive maps powered by Esri’s GIS mapping software (Figure 3) that allow users to find the closest routes and bus stops, find if a stop has a shelter of bench and pull the bus schedule information for a given time point. It also allows users to see transit service areas, crashes, construction sites, and road blocks.

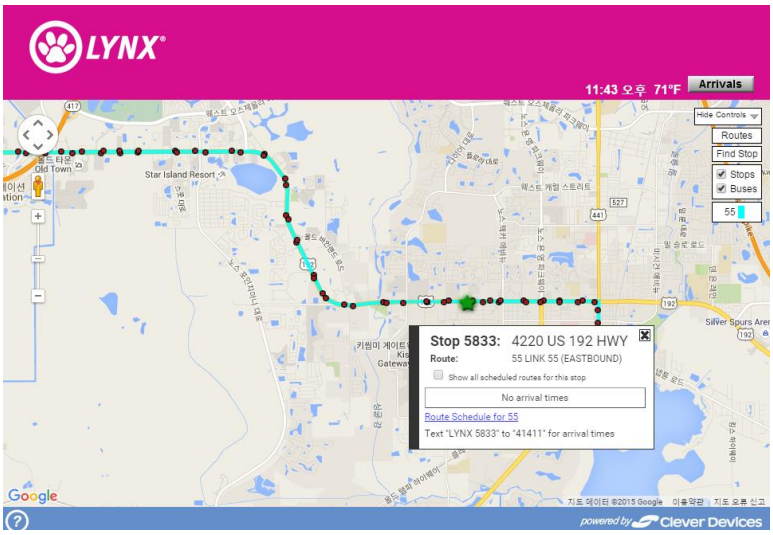


Figure 2 LYNX bus location map with estimated arrival times (source: lynxbustracker.com)

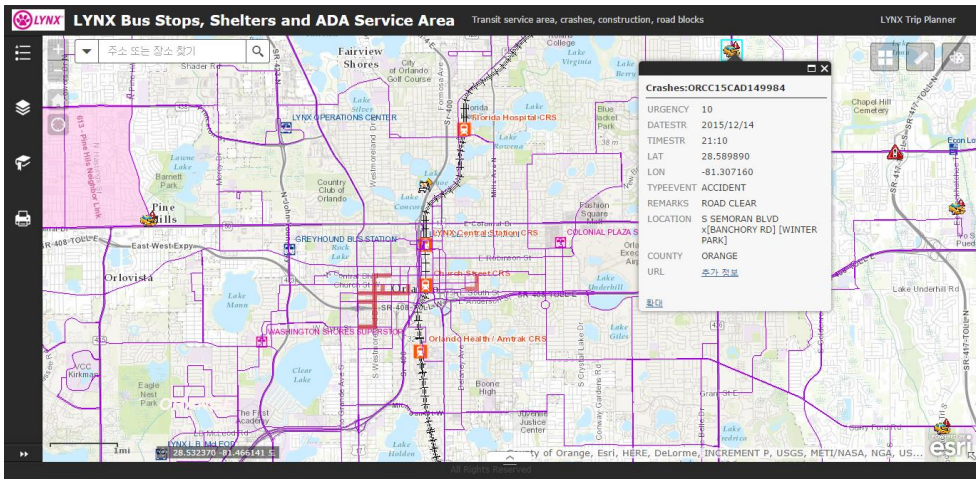


Figure 3 LYNX interactive maps (source: lynxbustracker.com)

2.2.2 Parking information service

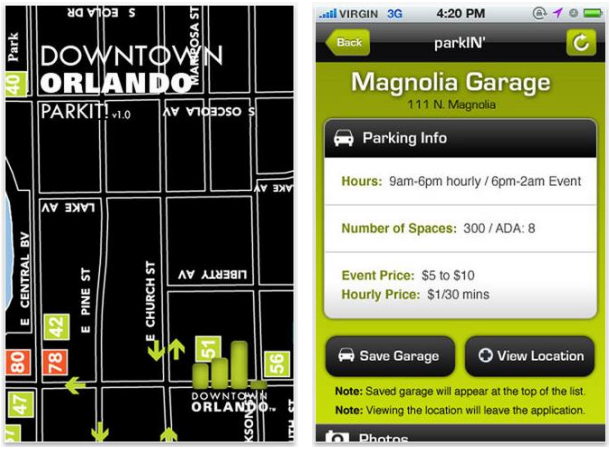


Figure 4 Orlando parkIN' mobile application (itunes.apple.com)

City of Orlando provides a parking information service through a mobile application called 'Orlando parkIN' (Figure 4) where downtown Orlando patrons can locate information about parking including pricing, locations, operating hours, number of spaces available etc. through interactive map.

2.2.2 Traffic information service

The traffic information of Orlando is available through "here" map (Figure 5) that displays color-coded up-to-the-minute current traffic flow updates (light, moderate, heavy, stopped), delay information as well as live reports of accidents, road works, road closures etc.

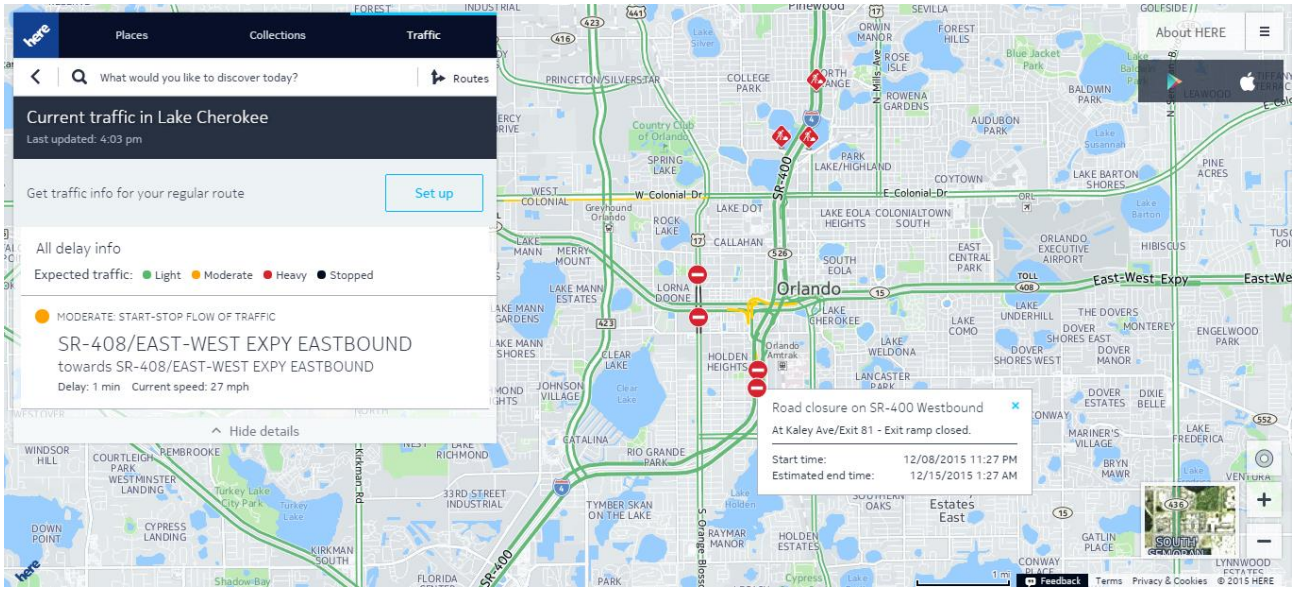
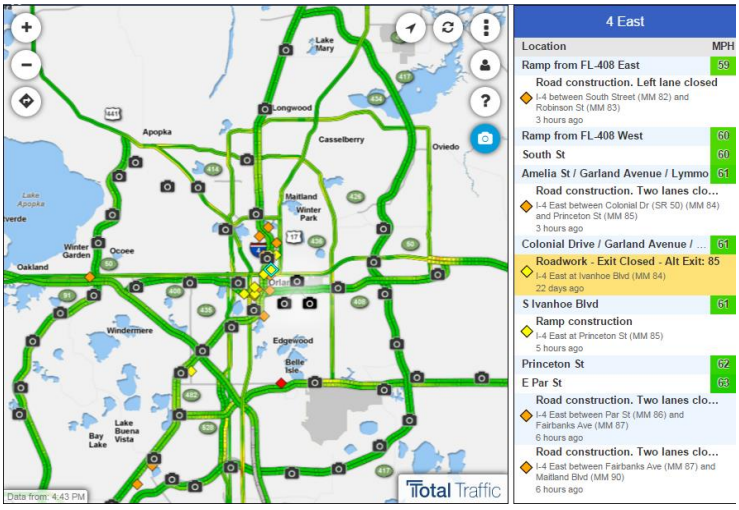


Figure 5 Orlando real-time traffic information map (source: here.com/traffic)



Orlando also provides traffic flow and speed, road closure, construction and traffic monitoring CCTV images via News13 web page (Figure 6) powered by Total Traffic and Orlando-Orange County Expressway Authority. This service facilitates drivers to make better route choices and save travel time.

Figure 6 Orlando real-time traffic information map (source: mynews13.com)

2.3 Safety and citizen security

2.3.1 911 Call center and self/online reporting

911 communications center (call center) within the Orlando Operations Center receives emergency police and fire calls from citizens and dispatches emergency vehicles according to the incident characteristic. For non-emergency incidents where there are no known suspects and no firearms or other weapons involved, citizens submit an online report to the Orlando Police Department. Such non-emergency incidents include harassing phone call, lost property, theft, vandalism and vehicle burglary.

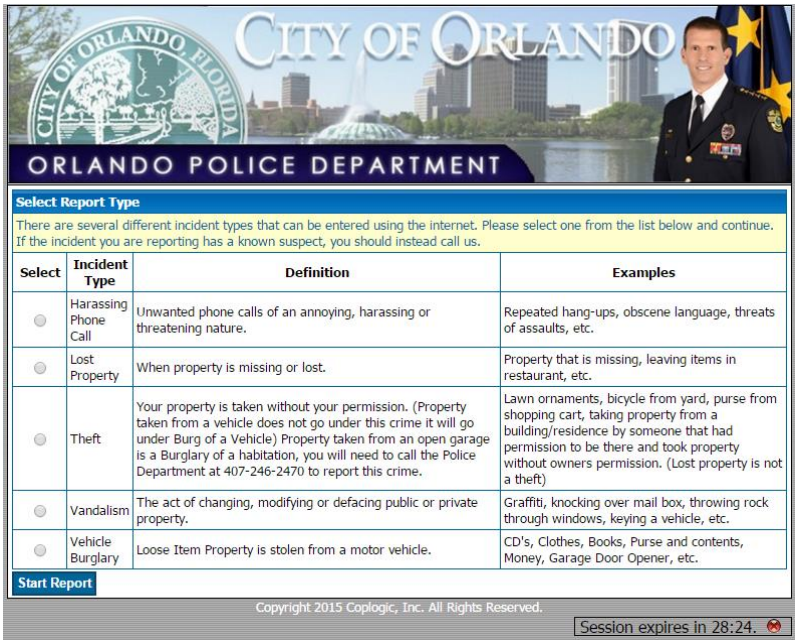


Figure 7 OPD online report webpage (source: www.cityoforlando.net/police/selfonline-reporting)

2.4 Emergency and response

Hurricanes, floods, tornadoes, fires and other natural disasters greatly impact the region and have severe implications for the Orlando Operations Center. The shared communications and information management infrastructure has been greatly enhancing the City's ability to respond to all types of natural disasters.

2.4.1 OCAlert.net

OCAlert is an alert system with nearly 14,000 registered subscribers that allows Orange County Government to contact citizens during an emergency by immediately sending message to email account, cell phone and smartphone. OCAlert is the citizens of Orange County's personal connection to real-time updates, instructions on where to go, what to do, or what not to do, who to contact and other important information under emergency situation. Alerts are available for life-threatening weather warnings (especially storm and tornado), amber alerts, highly disruptive road closures, evacuation, shelter in place information, points of distribution, public transportation route status, environment alerts such as lake, water body, air quality, government/school closings etc.

Figure 8 OCAlert.net (source: www.ocalert.net)

2.4.2 OCFL Alert application

The OCFL Alert application utilizes real time push notifications to provide information on open shelters, water distribution centers, evacuation routes and any other critically needed services during emergency activations. During non-emergency times, OCFL Alert provides contact information to local government and agencies as well as inform citizens of upcoming events, public service announcements, routine traffic, weather and amber alerts.

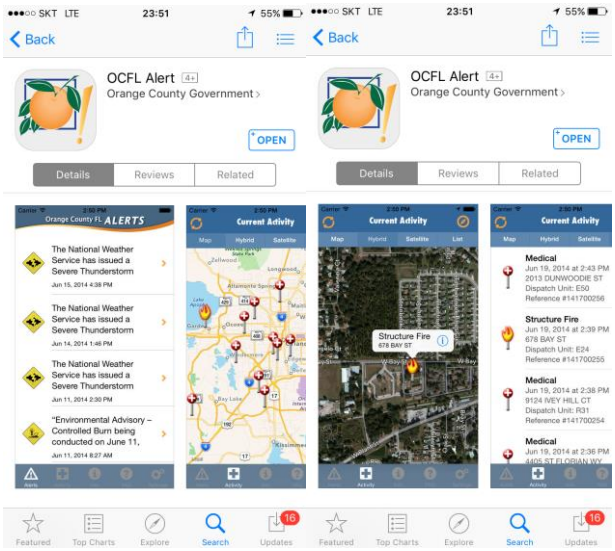


Figure 9 OCFL Alert application (source: Appstore)

2.5 Environment

2.5.1 Smart waste information

City of Orlando collects residential garbage twice per week. "Solid Waste Pickup" tab in the Orlando Information Locator powered by Esri GIS mapping software (Figure 10) provides information on garbage pickup days, recycling day, yard waste pickup day, etc. by location of the household.

Orlando began the procurement of hydraulic hybrid garbage trucks in December 2013 and aims to have technology in place that allow for recyling and energy development of most of the city's waste production by 2018.

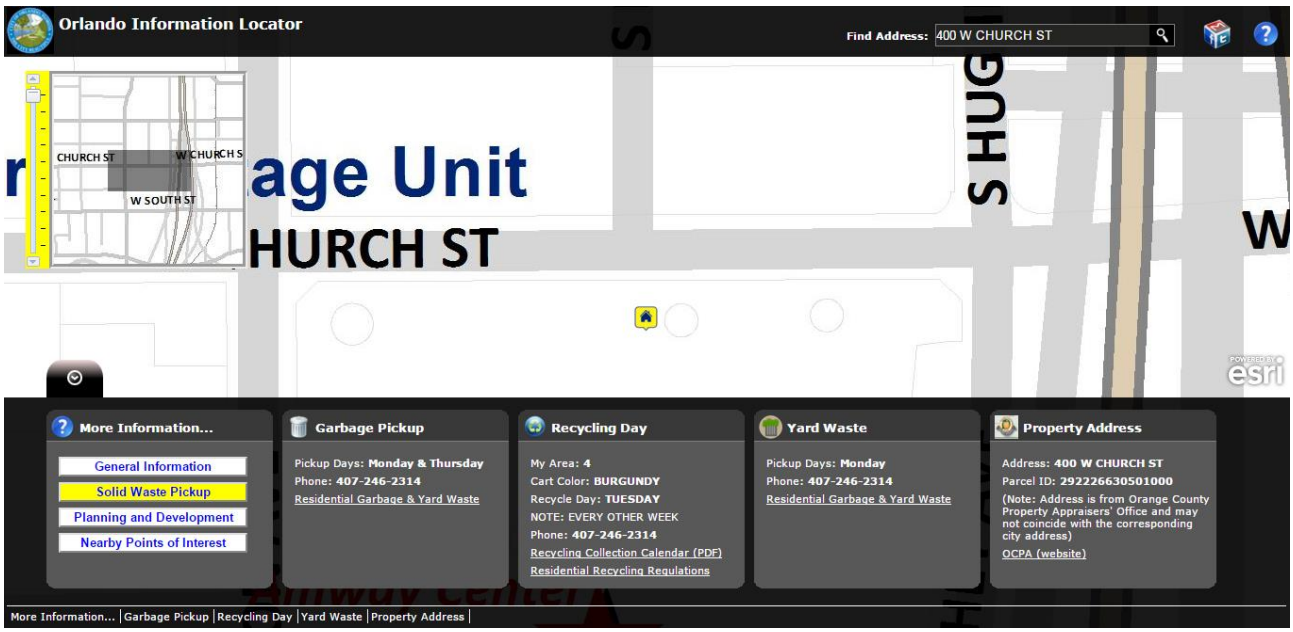


Figure 10 Solid Waste tab of Orlando Information Locator (source: www2.cityoforlando.net/orlandoinformationlocator)

2.5.2 Automated waste trucks

Figure 11 City of Orlando's automated garbage collection trucks (Source: FormerWMDriver, 2015)

From January 1, 2016, City of Orlando along with the Orange County will launch a new curbside automated garbage and recycling collection program affecting 205,000 Orange County residents, endorsed and supported by Orange County's Sustainable Advisory Board. This includes a new, 95-gallon County-issued roll cart for garbage, a second 95-gallon roll cart for mixed recyclables, and a reduction in the frequency of garbage collection from twice a week to once a week. Additionally, under this contract, haulers must switch to compressed natural gas (CNG) fuel vehicles within 18 months of the contract execution to minimize noise pollution and CO2 emission. This automated waste collection program is expected to increase recycling rates by up to 35 percent.

Key regulations of the new automated garbage collection are the following:

- The new automated trucks can only collect garbage in the carts provided by the City of Orlando.
- When left at the curb for collection, carts should be placed at least two feets from obstacles such as mailboxes, garages, utility boxes and poles, as well as trees and shrubs.
- All household garbage should be bagged and placed inside the cart to keep the cart clean and prevent it from blowing away when empied.
- Place the cart at the curb with the handle and the wheels facing the house.

2.5.3 Orange County Water Atlas

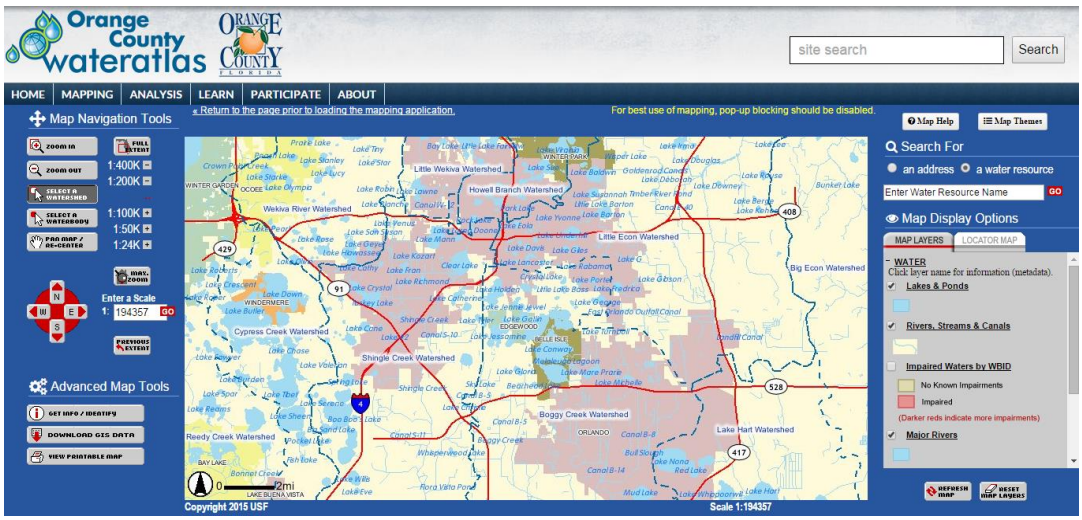


Figure 12 Orange County Water Atlas (source: www.orange.wateratlas.usf.edu)

The Orange County Water Atlas (Figure 12) helps researchers, resource managers, and the general public better understand and appreciate local water resources. The homepage provides the comparison of popular water resources' recent samples with historical samples such as secchi disk depth, water surface elevation, dailty cumulative rainfall, pH and flow. The water atlas advanced mapping enables the user to view lakes, ponds, rivers etc. along with other map layers auch as conservation lands, land use, rainfall sampling sites and wate quality sampling sites. The use can also select watersheds and waterbodies on the map to obtain general information, improvement projects, regulation, detailed data on water quality, water levels and flows, habitats and ecology etc. For example, for Little Wekiva River, the user can retrieve water quality index, nutrient chemistry, water clarity, bacteria, dissolved oxygen, salinity, and impaired waters data.

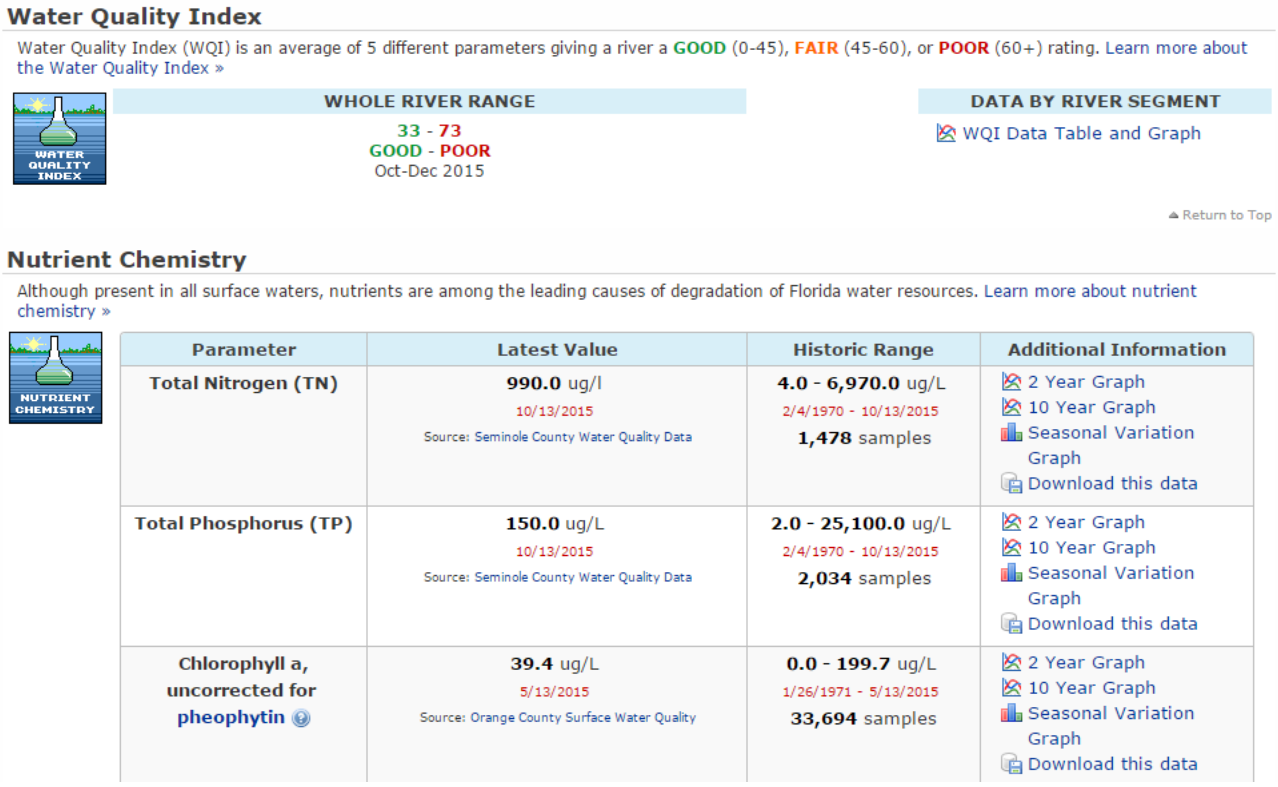


Figure 13 Orange County Water Atlas detailed water quality data sample (source: www.orange.wateratlas.usf.edu)

2.6 Energy efficiency

2.6.1 Power Pass Program

Orlando Utilities Commission (OUC)'s Power Pass is a program that allows customers to pay-as-you-go or pay in advance for utility services, offering the option of avoiding deposits, late fees and a monthly bill. Statistics show that pay-before-consumption programs result in lower electricity and water usage because customers are more aware of their amount of consumption. Customers can check their electricity bill or water usage every day using the OUC Power Pass portal or receive alerts via text, email and/or smartphone.

Customers can view their utilities usage status via the online dashboard called 'MyUsage' (Figure 14). On this website, customers can view daily energy charge chart for the last thirty days, daily account balance, unpaid balance etc. Alerts are sent to cell phone, smart phone, tablet or laptop when the balance is running low.

Figure 14 Myusage dashboard (source: Orlando Utilities Commission, 2015)

2.6.2 Building retrofit to enable real-time energy consumption tracking

In 2009, Orlando allocated USD 1 million of the American Recovery and Reinvestment Grant for energy efficiency projects. Over 1.5 year, City of Orlando targeted 28 public buildings ranging from fire stations to community centers to museums. Many of the retrofits included advanced controls that enable facility managers to track energy consumption in real-time and to receive notifications when large systems like chillers or condensing units are using abnormal amount of energy, allowing facility staff to quickly address problems.

City of Orlando is also one of the 10 pioneering cities of the City Energy Project, a national initiative/joint project of the Natural Resources Defense Council and Institute for Market Transformation of the United States to cut energy waste in large buildings. In the United States, buildings sector accounts for roughly 40 percent of total energy consumption and in Orlando, commercial buildings contribute to 51% of greenhouse gas emissions. The key strategies of the City Energy Project include providing information about building energy use through information communication technology that will help owners and managers cut waste.

2.7 Citizen interaction and communication mechanisms

2.7.1 GIS Infomap

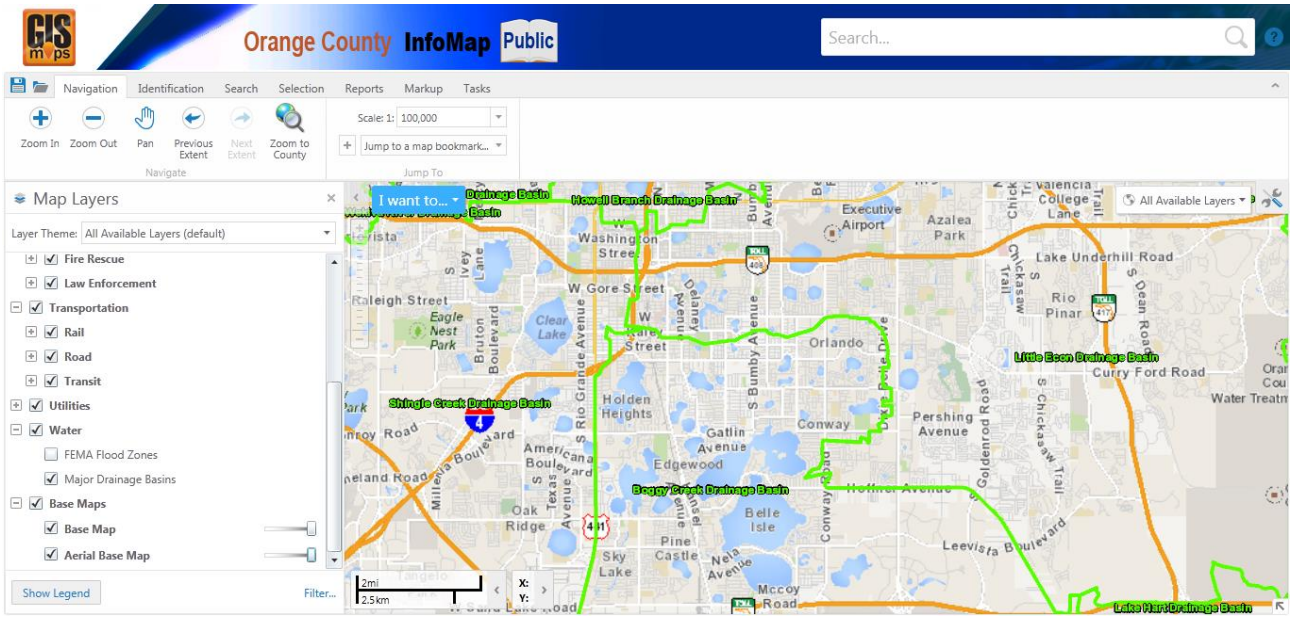


Figure 15 Orange County Infomap public access (source: http://ocgis3.ocfl.net/silverlightviewer)

The GIS Infomap is available in public version and internal version by the Orlando Operations Center and the Orange County. This infomap contains flood plains, lakes, drainages as well as video recording data on interactive web-based map. There are seven map layer themes: All available layers (default), Community, Planning, Real Estate, Zoning, Public Works and Transportation Planning. This GIS Infomap is a powerful tool for both government officials especially planners and the public to acquire better understanding of the resource allocation within the City of Orlando. Some of the useful information the user can retrieve include the reclaimed water/wastewater/water service providers, active violation code enforcement status, water management districts, major drainage basins, and LYNX bus routes/stops/park and ride etc. Users can also download GIS data on utilities water/wastewater service areas, collection zones and territories etc.

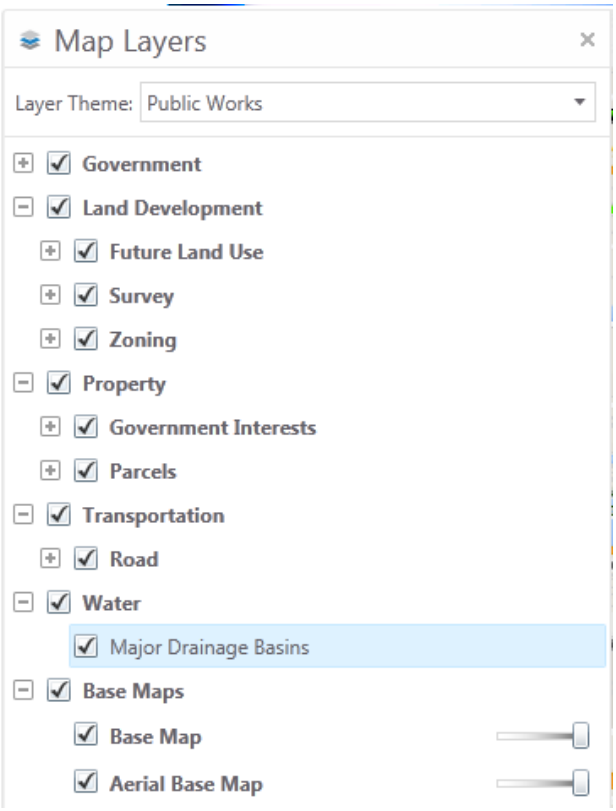


Figure 16 Infomap layer theme 'Public Works' (source: http://ocgis3.ocfl.net/silverlightviewer)

2.7.2 Online education programs

City of Orlando works largely in partnership with the University of Central Florida and University of Florida in providing such education programs on subjects like household hazardous materials and lake-friendly pet practices frequently through online materials and video. The City also offers information on volunteering opportunities online such as Storm Drain Marking Project, Florida Lake Watch Program, Yard Waste Minimization Project etc.

The Streets and Stormwater Division of the city government also offers free education presentations to school classroom, scout groups or volunteer organizations, neighborhood associations or businesses within the City of Orlando in the areas of lake water quality, management, sampling and habitat improvement, stormwater runoff and pollution, illicit discharge prevention etc.

Figure 17 Examples of City of Orlando's online education materials (source: www.cityoforlando.net/parking)

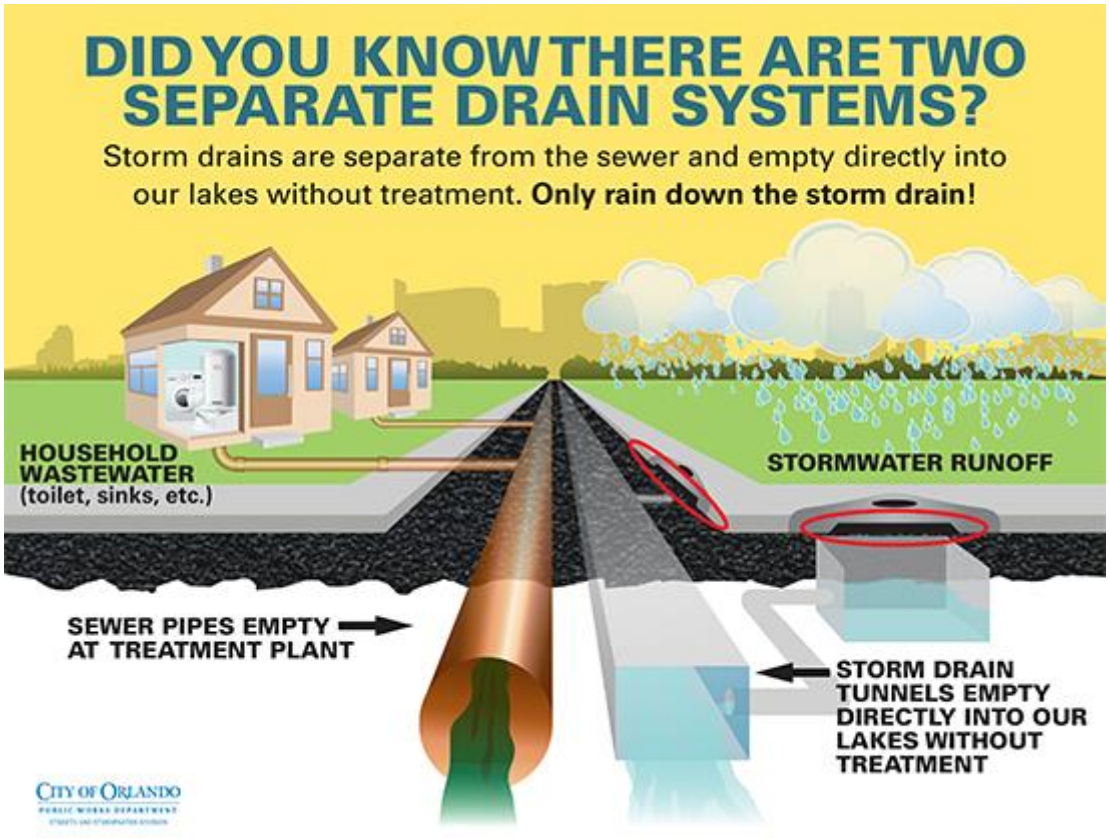


Figure 18 City of Orlando's citizen education material sample (source: www.cityoforlando.net/streets-stormwater)

3. System Configuration

3.1 Overview

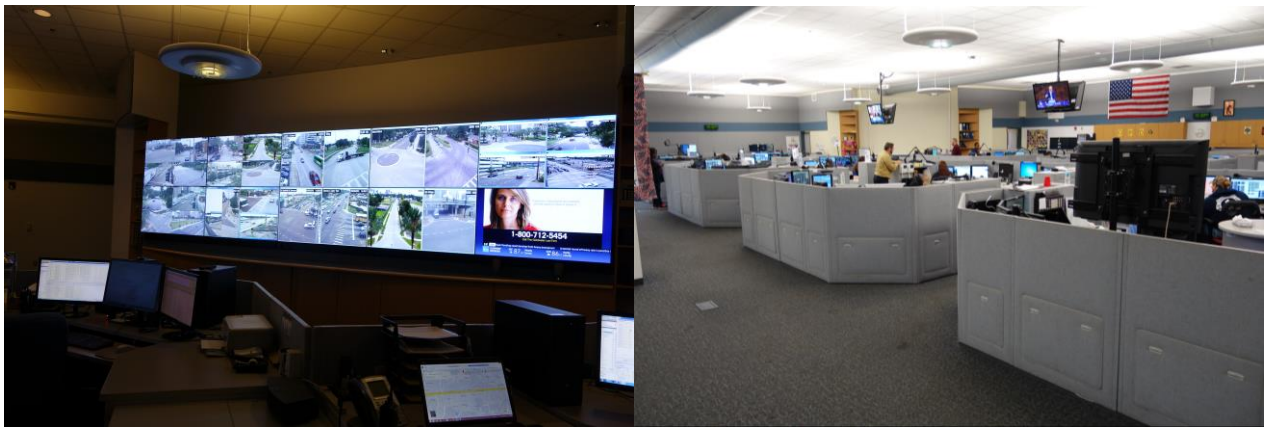


Figure 19 Traffic Management Center / 911 Communications Center (Police & Fire) (source: Kwon, 2015b)

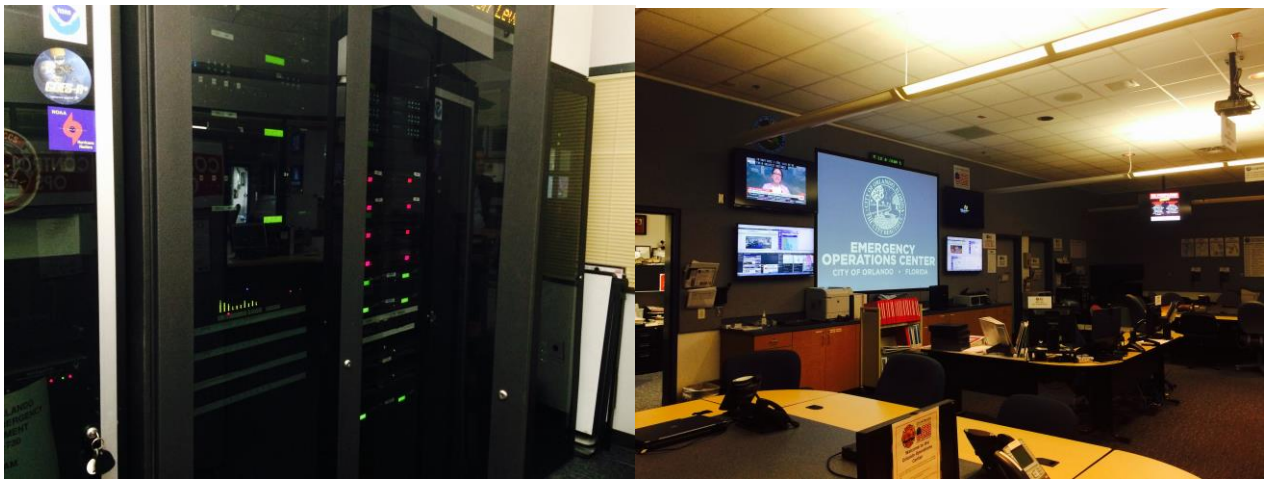


Figure 20 Network Operations Support and Emergency Operations Center (source: Kwon, 2015b)

Orlando Operations Center (OOC) is a stand-alone 1-storey building (28,000 sq ft) built in 2001 to provide joint facility for four sub-centers: Traffic Management Centre, 911 Communications Centre, Network Operations Support and Emergency Operations Centre. 911 Communication Center is composed of dispatched staffs from the Orlando Police Department (OPD) and Orlando Fire Department (OFD). For other areas of city management such as water, energy and e-government, City of Orlando provides services through responsible city government divisions especially the Orlando Utilities Commission.

As for the integrated operation center, technologies such as AVL and CAD fundamentally changed the way public safety and other City Departments operate on a daily basis allowing dispatchers and managers to receive real-time information on closet unit location, incident location with history and special hazards, as well as myriad of other status management information. All of this information combines to give the operations manager capabilities that previously did not exist to more efficiently manage responses on a real time daily basis. In addition to AVL and CAD technologies, advances in traffic management, remote cameras, real-time Doppler radar weather and the internet all

combined to offer the operations manager a new set of tools to better manage the daily operations as well as times of disaster. More importantly, greater benefits from the economies of scale and increased efficiencies in responses were projected to occur by bringing these tools together into one Operations Centre.

As of 2015, OOC is in the procurement stage of installing new 2x5 or larger monitor panels on walls throughout the center. It plans to install screens on four walls in the Emergency Operations Center, one wall in the common discussion room, two walls in the 911 communications center, and one wall in the decision-making room.

3.2 Physical system integration and interoperability between government entities

In 2001, the City of Orlando combined the Police Department Dispatch, the Fire Department Dispatch, and a portion of the Transportation Engineering Bureau known as the Traffic Management Center together, in a combined facility, while creating a new, permanent Emergency Operations Center (EOC). These agencies are situated together in the dedicated integrated center called Orlando Operations Center (OOC), and only divided by partition walls without doors. The synergy of co-location in a single facility has been providing citizens, visitors and businesses with a reliable, efficient public safety communications and emergency operations system, accomplished by managing communications, traffic, and event coordination in a central/secured facility and integrating new technologies.

There are many cases that require co-work between the sub-centers. For example, Traffic Management Center and 911 Communications Center (police & fire) cooperate together in dealing with incidents that involve severe weathers and natural disasters such as flooding, falling of tress, abruption of power line etc. In these cases, traffic cameras are first used to view the situation. For example, when the 911 Communications Center receives call regarding tree fall from storm entangled with power line and traffic light outage, they inform Traffic Management Center to dispatch engineers out to fix the road status and traffic light damage. The OFD unit dispatches staff to tape off the area and treat any injury, and the OPD unit dispatches staff to block the street. In such case, the OOC gets the local power company involved thorough direct line at the OOC.

In other cases, where cooperation between units within OOC is necessary, each unit is able to view each other cameras: traffic cameras are installed high up and provide wide view of the traffic flow while police camera network is installed closer to the roads/streets and enables face detection. In larger emergency situation, the Emergency Operations Center (EOC) also gets involved with representatives from many emergency support functions such as food & water, energy, military, utilities etc. EOC is able to adjust the focus of the support depending on the incident type: natural disaster, large security operation, special event such as major sporting or convention event etc. In this kind of major incidents where multi-department approach is required, the EOC takes the lead and have other departments under the command of EOC. In case of incidents that take place near the jurisdictional boundary, the OFD unit at OOC and the Orange County OEM support each other by dispatching the nearest emergency vehicle units to the incident site etc.

The centralized emergency call receiving system at OOC receives all 911 calls including criminal incidents, health-related emergencies, road incidents, tree-falling etc. and the call gets routed either to the OFD unit, OPD unit or Traffic Management Center depending on the incident type.

3.3 Integrated Center System

For security, separate building access control systems have been implemented at City Hall and Police Headquarters. This system is compatible and programmable to allow a single-card authorized access to multiple facilities, which minimizes the number of cards needed by support personnel that typically provide service to more than one facility.

As for the Communications Center, the Network Support group provides services to support up to 50 communications consoles. The Network Support group designed the Orlando Operations Center's data network infrastructure to accommodate up to 12 functionally separate Local Area Networks (LANs). Each LAN has an initial capacity of 22 devices (expandable to 100) and is attached to a high-speed backbone for access to local enterprise servers. In addition, connectivity to the City's WAN is possible which enables data transfers among the Center and the other City computer facilities.

The computer center serves as the technology hub within the OOC. Centrally located in the facility, it houses the critical systems and network components supporting each operation, secure from unauthorized access. Due to the critical functions of the systems contained within the OOC, power within the entire facility is protected by redundant Uninterruptible Power Supply (UPS) systems with fail-over capabilities. UPS can power the entire facility for at least one hour to ensure effective response in the event of a generator failure. Also, the City's Systems & Networks Bureau provides on call support for computer and communications equipment and service related problems.

The computer operators are expected to have the capability to monitor the Florida Department of Transportation (FDOT) incident surveillance system on Interstate-4, the traffic signal control systems for various agencies in the Central Florida area, as well as any future surveillance system installed by OOCEA. The primary system within the Traffic Management Center is the Orlando traffic signal control system.

3.4 Field system

Smart city sector	Sub-system	Technology / field device
Transport and urban mobility	Adaptive traffic signal control	TOD plan, Special signal pattern for rail, emergency vehicles, buses and special events
	Red light violation enforcement	Detectors and cameras at 14 intersections Software: America Traffic Solution
	Bus management	Automatic Vehicle Location (AVL) Provides bus information service to citizens via bus stop kiosks and smartphone apps
Citizen safety and security	911 communications center system and emergency vehicle dispatch	CCTVs CAD and EMD software Automatic Vehicle Location (AVL)
Emergency and response	Incident information management and distribution	Feeds from Doppler radar and satellite for weather data Live camera feeds from expressways Automatic Vehicle Location (AVL)
	911 call center system and emergency vehicle dispatch	CCTVs, CAD and EMD software Automatic Vehicle Location (AVL)
	Functional group operational area and executive policy group room	Video conferencing system
Environment	Garbage truck tracking	GPS
	GIS water management	GIS, sensors and meters
Energy efficiency	Pre-paid Power Pass	Advanced Metering Infrastructure (AMI)
	Smart metering and analytics	Advanced Metering Infrastructure (AMI)
Citizen interaction	Media room and SNS communication station	Broadcasting system

Table 1 Technology and field devices by smart city sector

3.5 Communication system

From a wide-area view, Orlando Operations Center has become a significant site in the City's Metropolitan Area Network (MAN), with extensive remote communications requirements. In addition to connectivity within City-administered systems and networks (City Hall, Public Safety Headquarters, the existing Traffic Management Center, etc.), the agencies and services housed in the Orlando Operations Center connect with a variety of external law enforcement public works and health services networks. The City's Network Support group, based upon information from the Orlando Police Department, the Orlando Fire Department, Orlando Traffic Management and others design, specify, order, receive, install, administer and maintain the equipment and external services in support of the Operations Center wide-area network (WAN) connectivity.

The first step toward establishing WAN connectivity to the Orlando Operations Center was to provide a physical data path from the City's current networks. A conduit system was arranged, constructed for the Orlando/Orange County Expressway Authority (OOCEA), for City-owned, fiber-optic cable connection between City Hall and a point approximately ½ mile south of the Operations Center.

The Orlando Operations Center has four fiber optic networks shared between departments, of which one is self-owned. The sharing of networks between departments significantly decreases the network size requirement.

3.6 Sub-systems and functions

3.6.1 Transportation and urban mobility

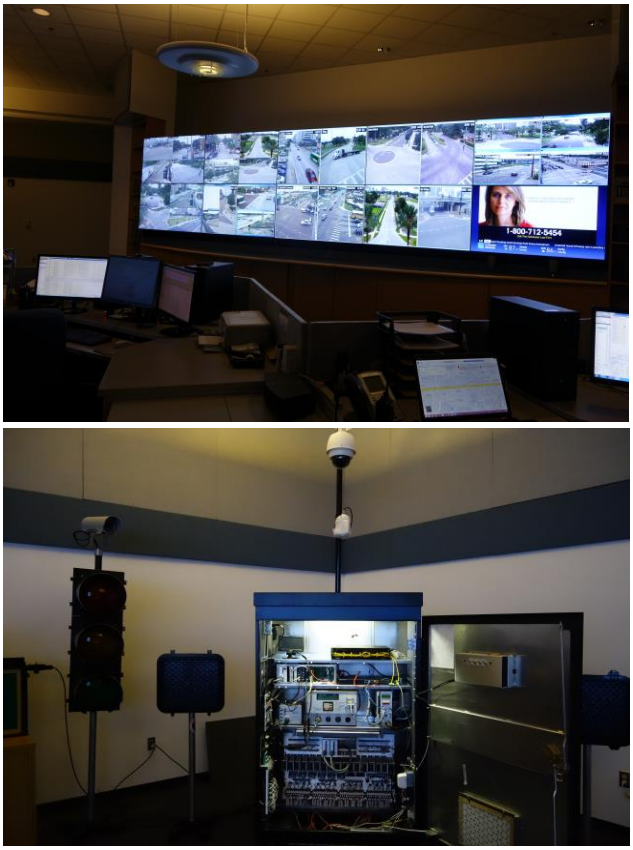


Figure 21 Traffic Management Center within OOC (source: Kwon, 2015b)

The Traffic Management Center within OOC has a 2x5 wall with 55' monitors that display the traffic CCTV cameras within the City of Orlando and enables the operators to pan, tilt and zoom. The wall also displays local news feed especially regarding weather patterns to enable prompt response considering the tropical climate of Orlando.

A. Adaptive traffic signal control

The Traffic Management Center within the OOC controls about 80% of the traffic signals within the City of Orlando. As for other 20%, county roads get managed by the Orange County, interstate highways are run by Department of Transportation, turnpikes by turnpike corporation, expressways by expressway corporation.

The center uses software produced by 'TrafficWay', run in time-of-day (TOD) plans. In the daytime the signals are mostly run in coordinated pattern, and sometimes at night they run freely. The operators adjust signal timing to clear tracks for the railway network SunRail that passes through Orlando. Also, different signal patterns are run in case of large events such as basketball games and concerts at Amway Center, major league games at soccer stadium, events at the Orlando Convention Center etc.

The center uses radio-based system that enables vehicles to send their locational information to the center. The operators preempt signals to facilitate the movement of emergency vehicles, and run transit signal priority for buses.

B. Red light violation enforcement

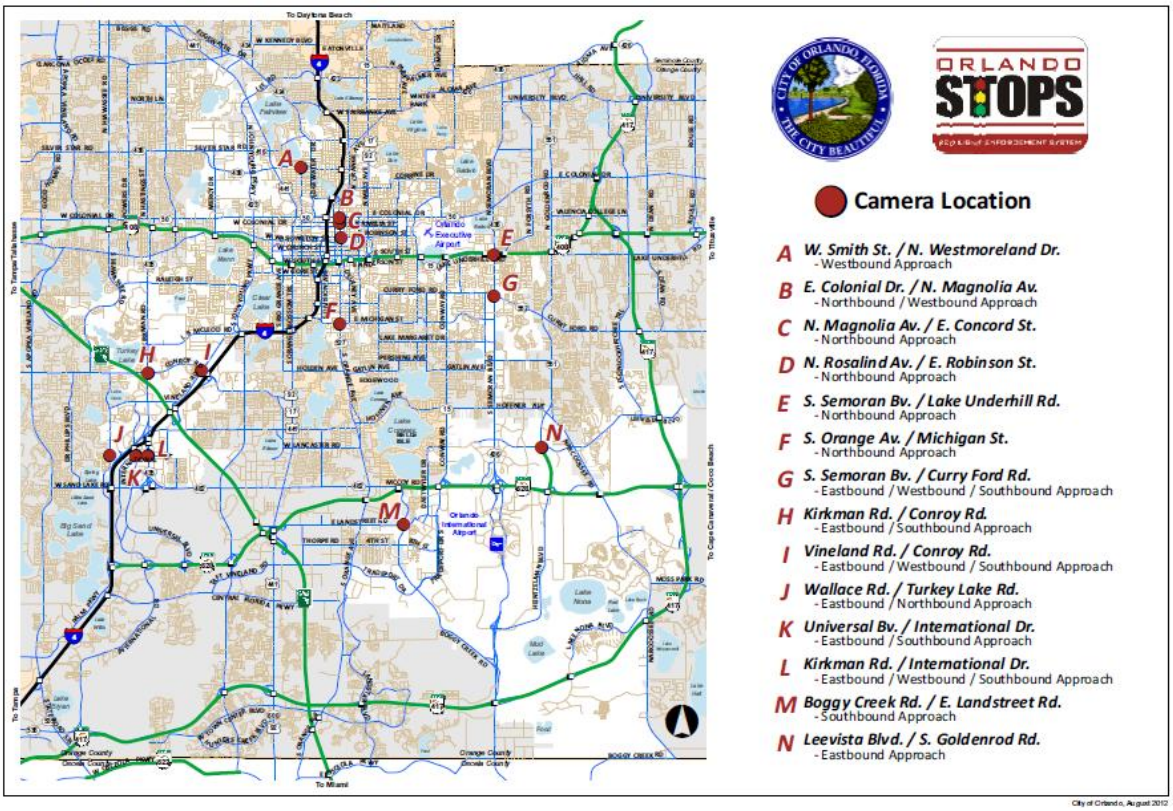


Figure 22 Location of red light violation enforcement cameras (source: Kwon, 2015c)

Orlando has about 500 speed cameras but does not enforce speed violation; the city only enforces red light violation at intersections since 2008. Red light violation enforcement became the state law in 2010. There is an initial fine of $158 which increases to $262 if not paid within 60 days from notice. Out of the $158, $75 goes to City of Orlando, $83 to the State of Florida, $10 to the Brain and Spine Research Trust, and $3 to the local trauma center.

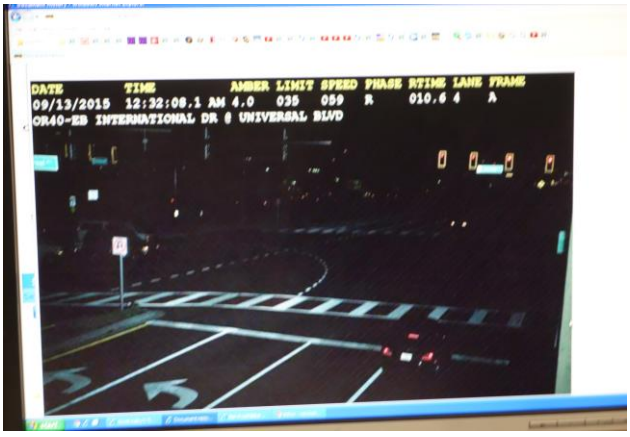


Figure 23 Red light violation enforcement software at the Orlando City Hall (source: Kwon, 2015c)

Orlando uses the national software produced by Zona called America Traffic Solution (ATS) for viewing the DVR video saved in the camera when two sensors on ground detect speed violation of vehicle. 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.

The Code Enforcement Division within the Orlando City Hall work closely with the transportation engineers to select the sites with largest number of angle accidents. In many other cities the city government officers perform the approving of violation and the rest is handled by vendors. In Orlando, city government officials handle the back office of violation enforcement with belief that having the enforcement function within the city hall helps building trust amongst public. The tickets are not sent out automatically for red light violation in order for the city government officials to verify and approve the ticket issuance with clear image evidences. For unpaid tolls on toll roads, the tickets get sent automatically to drivers.

C. Bus management system

The Traffic Management Center within OOC has secured the fiber network to enable the communication of bus arrival information by Automatic Vehicle Location (AVL) via kiosks at bus stops and smartphone applications. In terms of the handling of such public transport information provision, Central Florida Transit Authority (LYNX) is in the charge.

3.6.2 Citizen safety and security

A. 911 communications center system and emergency vehicle dispatch

The 911 Communications Center within the OOC has access to security cameras called IRIS for crime prevention purpose, managed by the Orlando Police Department Headquarters to enable synchronized action at the outbreak of incident. The images of these IRIS cameras are recorded 24/7 and stored for 45 days whereas traffic cameras do not record images. The monitors within the OOC 911 Communications Center have Automatic Vehicle Location (AVL) function that enables the OOC staffs to track the movement of police cars, fire trucks, emergency medical vehicles etc. A call that involves violence gets handled by the OPD unit within the OOC, with cooperation of OFD unit for fire or medical attention.

3.6.3 Emergency and response

In the City of Orlando, emergency and response gets mainly dealt by the Orlando Operations Center (especially the Emergency Operation Center and 911 Communications Center (Police & Fire) within OOC), in cooperation with the Orlando Fire Department Headquarter and Orange County Office of Emergency Management etc. The OOC deals with disasters such as residential fires, wildfires, floods, hurricanes, sinkholes, terrorism, tornadoes, thunderstorms, pandemic flu etc.

In case of large scale disasters that impact wide area, the Orlando Operations Center works in close collaboration with the Orange County Office of Emergency Management and acts as one of the major players of the Orange county emergency response team.

In emergency situation, designated emergency support function personnel facilitate coordination of disaster response and recovery activities, comprised of the following representative city departments.

Emergency Support Function	Representative Departments
ESF#1 Transportation	Public Works
ESF#2 Technology Management	OBFS – Information Technology
ESF#3 Public Works	Public Works
ESF#4 Firefighting	OFD
ESF#5 Emergency Management	OFD
ESF#6 Mass Care Support	FPR *Mass Care provided by American Red Cross

ESF#7 Procurement	OBFS – Procurement
ESF#8 Emergency Medical Services	Orlando Fire Department
ESF#9 Search and Rescue	Orlando Fire Department
ESF#10 Hazardous Material	Orlando Fire Department
ESF#11 Food & Water	OBFS – Procurement
ESF#12 Utilities	*N/A: Dealt by Orlando Utilities Commission
ESF#13 Military Support	*N/A: Dealt by Florida National Guard
ESF#14 Public Information	OCNR
ESF#15 Volunteers and Donations	Office of Community Affairs
ESF#16 Law Enforcement	OPD
ESF#17 Animal Care	*N/A: Dealt by Orange County Animal Services
ESF#18 Business & Industry	Economic Development
ESF#19 Damage Assessment	Economic Development
ESF#20 Facilities	OBFS – Facilities

* OBFS: Office of Business and Financial Services
* OFD: Orlando Fire Department
* FPR: Families, Parks and Recreation
* OCNR: Office of Communications and Neighborhood Relations
* OPD: Orlando Police Department

Figure 24 OOC emergency support functions and departments (source: Orlando OEM, 2014)

A. Incident information management and distribution

Emergency management is essentially information management under stress so the Emergency Operation Center within the OOC uses a variety of different information technologies to develop the needed data to properly manage an incident. Weather data gets gathered by Doppler radar delivered through the local cable as well as a satellite delivered system in conjunction with the Internet. Communications include a fire department console and other radios capable of communicating with any department within the City. Live camera feeds from the cameras on I-4 and East/West expressway are available in the EOC. In addition, the EOC has its own network that is capable of communicating with any of the other City networks. A complement of telephone lines is installed to support a full EOC activation. Additional technology includes live feeds of the automatic vehicle location (AVL) systems in the City to include all public safety as well as civilian units. Video systems project the appropriate feeds dependent upon the incident. In addition, a number of TV's capable of showing all of the local media simultaneously keep the EOC up to date with local, state, and national coverage of events.

B. 911 communications center system and emergency vehicle dispatch

The Orlando Fire Department (OFD) units in the OOC have motored data terminal that displays OFD dispatched vehicles' movement in real time which enables the OOC staff to dispatch the vehicle unit (fire trucks, ambulances, rescue trucks, tower trucks etc.) closest to the incident location. The color of vehicle icon turning from red to yellow on the screen means that the vehicle is responding. From yellow to green indicates that the vehicle has arrived at the scene of incident.

CAD and EMD software enables efficient communication with the caller as well as automatic sending of caller information to be displayed on screens installed in emergency vehicle units. The EMD software also generates codes based on the caller/patient information put in, which automatically selects the appropriate vehicle to dispatch.

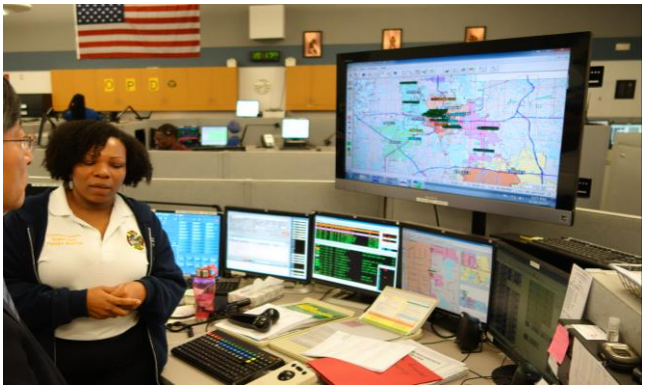


Figure 25 911 Comm. Center (source: Kwon, 2015b)

C. Functional group operational area and executive policy group room

EOC features an operational area with workstations for functional groups including police, fire, health, infrastructure, finance/administration, GIS personnel and supporting agencies. EOC has access to radar, cameras, power outage maps and flood sensors as well as web-based log-in programs to record incident actions. EOC not only deals with disaster emergencies such as hurricanes, but with virtually all kinds of incidents and events that require multi-agency approach for example sporting events such as MBA All Star, ECHL Hockey etc. EOC has lines of communication with 17 embassies, councils and honorary councils to support the international crowd. The facility also has an Executive Policy Group Room where decision-level managers convene to set strategic and executive level objectives and share incident information.

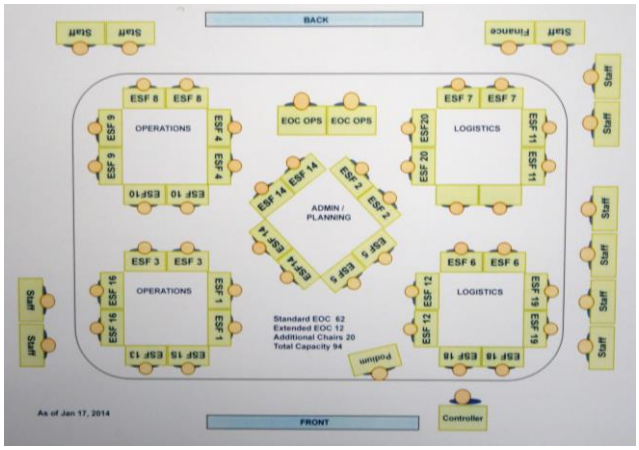


Figure 26 EOC layout (source: Kwon, 2015b)


Figure 27 Functional groups (source: Kwon, 2015b)

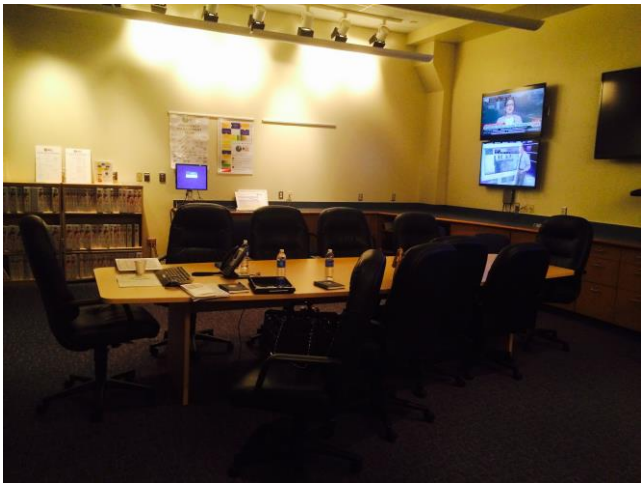


Figure 28 Executive policy group room (source: Kwon, 2015b)

3.6.4 Environment

A. Garbage truck tracking

City of Orlando's waste management division has a camera system with GPS tracking system that allows the tracking of garbage trucks around the city. The camera starts recording automatically for few seconds at the stoppage of garbage trucks and sends the video to the City Hall so that the information such as amount of garbage collected gets recorded. This system enables understanding of waste generation pattern of the city, setting of optimum routes for garbage trucks, and preventing of illegal dumping.

B. GIS water management

The GIS water management system of Orlando allows officials to share, update, and retrieve information within a central database of the St. John River Water Management District in which the City of Orlando belongs to. The District developed GIS data standards by designing the ArcSDE enterprise database, standardizing data storage, and developing and implementing District-wide customized applications for retrieving ArcSDE database information.

System Design

ESRI software and extensions

ArcInfo 8.2 Desktop (more than 100 clients) **plus a core of UNIX-based ArcInfo Workstation users**

ArcView 3.x
(150 desktop applications; these users will be migrating to ArcView 8 Desktop over the next several years)

ArcSDE 8 (two database instances with Oracle8i [8.1.7])

ArcIMS 4 (four ArcIMS servers supporting eight ArcIMS intranet Web sites and two ArcIMS Internet Web sites)

DBMS:	Oracle8i (version 8.1.7) with limited usage of Oracle Spatial
Operating System:	Windows NT/2000 and Solaris 8 servers
Server Configuration:	DB server 1-Sun Enterprise 3500 with four 400 MHz processors DB server 2-Sun Enterprise 3500 with two 400 MHz processors App server-Sun Enterprise 5500 with six 400 MHz processors ArcIMS servers (4)-Dell Poweredge 2550 with dual 1 GHz processors
Number of Layers:	130 layers in ArcSDE
Type of Data:	(1) Basemap-hydrology, administration, contour roads (2) Natural Resources-land use, geological, ecoregions, soils, sea grass, wetlands (3) Regulatory-consumptive use permit, environmental resources permit, water supply (4) Planning-flood zone, state public land, District land, habitat conservation area
Size of Database:	50 GB of vector data stored in Oracle with ArcSDE, 100 GB of departmental vector data stored as files and in ArcSDE, and 300 GB of imagery stored as files

Figure 29 GIS water management system design (source: ESRI, 2015)

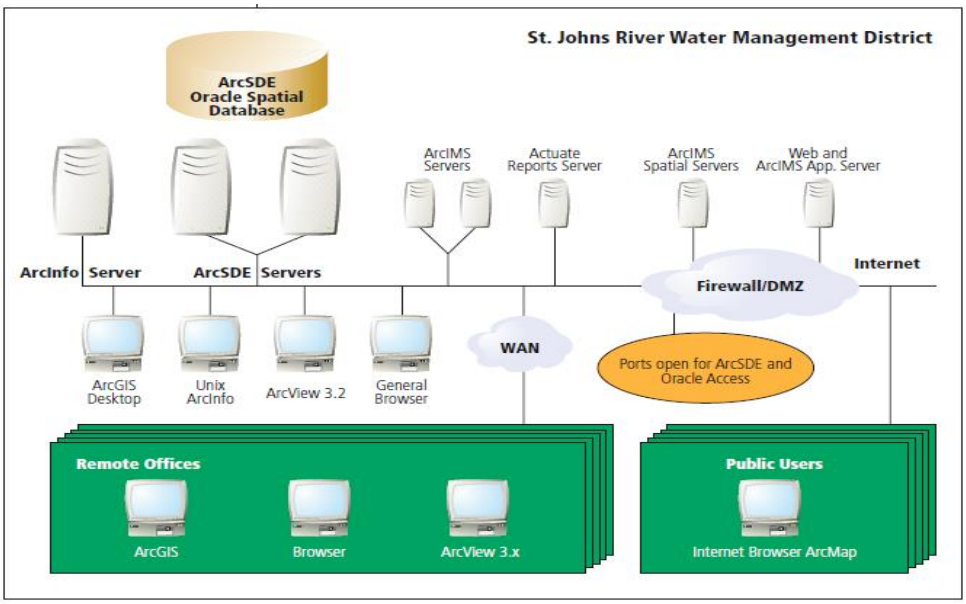


Figure 30 GIS water management system (source: ESRI, 2015)

The Department of Information Resources is responsible for District GIS program management, coordination of GIS activites, and the provision of GIS support for all departments. The engineering division conducts hydrodynamic modelling, water quality analysis, water storage analysis, watershed modelling, and surface water runoff analysis. The centralized ArcSDE database provides the most current data for these users.

3.6.5 Energy efficiency

A. Prepaid Power Pass

Orlando Utilities Commission (OUC) uses a third party software from Exceleron to manage its prepaid metering program. 'MyUsage Prepaid' is a web-based solution that communicates with Advanced Metering Infrastructure (AMI) and Customer Information System (CIS) to manage prepaid accounts for electricity, water and other utility services.

Exeleron's Prepaid Account Management System (PAMS) is a software solution that manages day-to-day functionality of the prepaid system and is integrated with the OUC's Customer Information System (CIS), Mobile Device Management (MDM), website and Interactive Voice Response (IVR). Usage and fees are calculated daily and are deducted from account.

B. Smart metering and analytics

Orlando Utilities Commission's entire service area is in the process of being upgraded to digital electric and water meters. The electric meters were completed March 2014 and the water

meters are expected to be completed within the end of 2015. Digital meters are easier to read and provide detailed information about customers' daily energy and water use. Meters also can be monitored remotely which can reduce costs and time while ensuring accurate and timely reading for customers. Remote monitoring also allows OUC to better predict and prevent outages and restore power faster.

Figure 31 Smart metering implementation timeline (source: Orlando Utilities Commission, 2015)

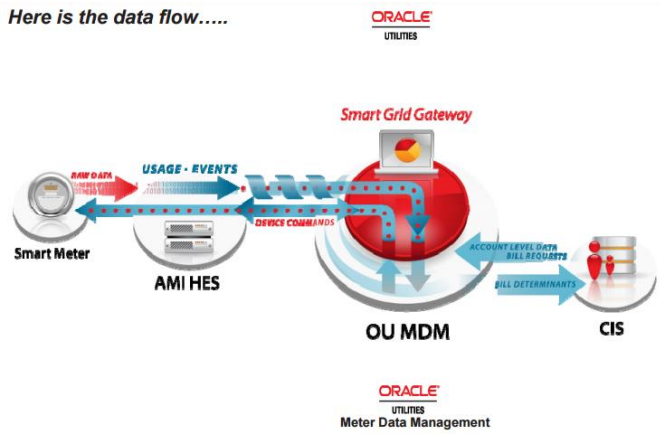


Figure 32 Data flow of smart metering system (source: Orlando Utilities Commission, 2015)

3.6.6 Citizen interaction

A. Media room and SNS communication station

The Orlando Operations Center has a media room where the Mayor of Orlando makes announcements regarding city management and citizen safety issues. The OOC has a monitoring station for web-responses, especially facebook and twitter, on incidents through keyword search technology. Information that citizens upload on certain incidents such as picture images can be helpful to understand the situation before the officers reach the location. Monitoring the SNS also enables the Center to take action if wrong information is being spread.

Figure 33 Media room (source: Kwon, 2015b)

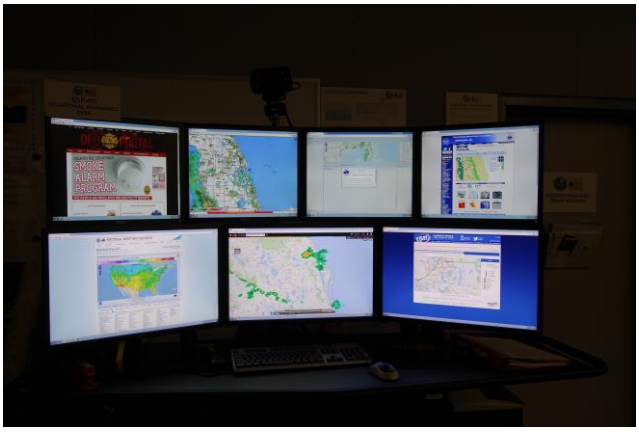


Figure 34 Web-response monitoring station (source: Kwon, 2015b)

EOC has several levels of redundancy for critical systems such as electricity, internet and communications to ensure that they can continue the operation under disaster environments when primary systems may become unavailable.

4. Organizational Structure

4.1 Governance model

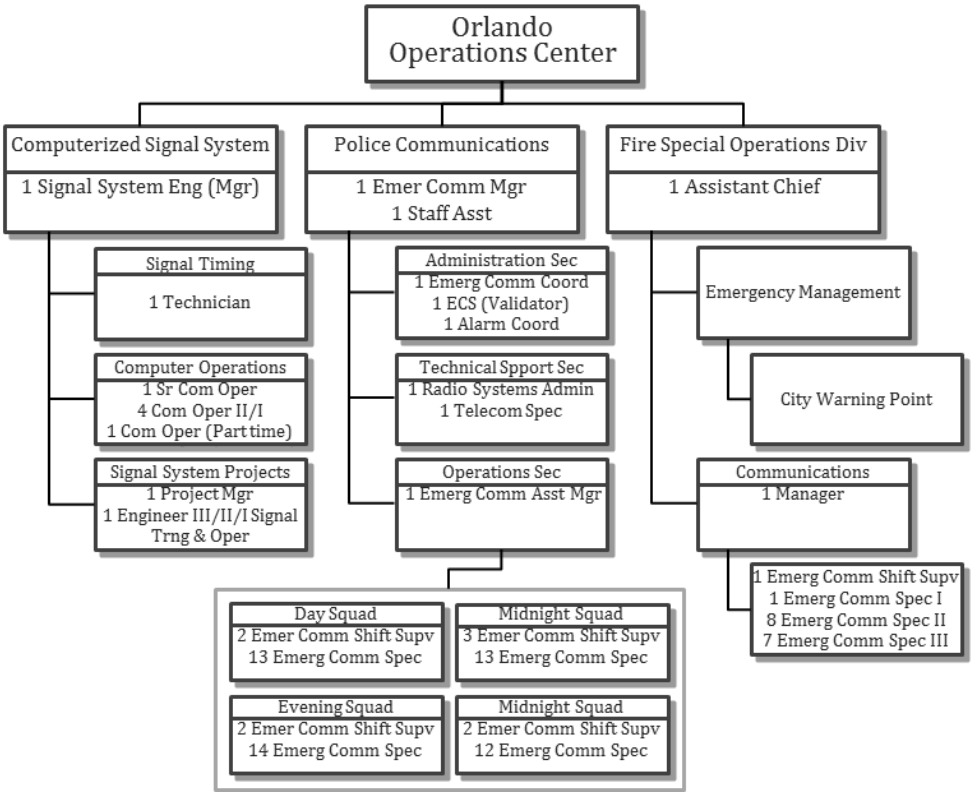


Figure 35 OOC organizational structure (source: Orlando Operations Center, 2001)

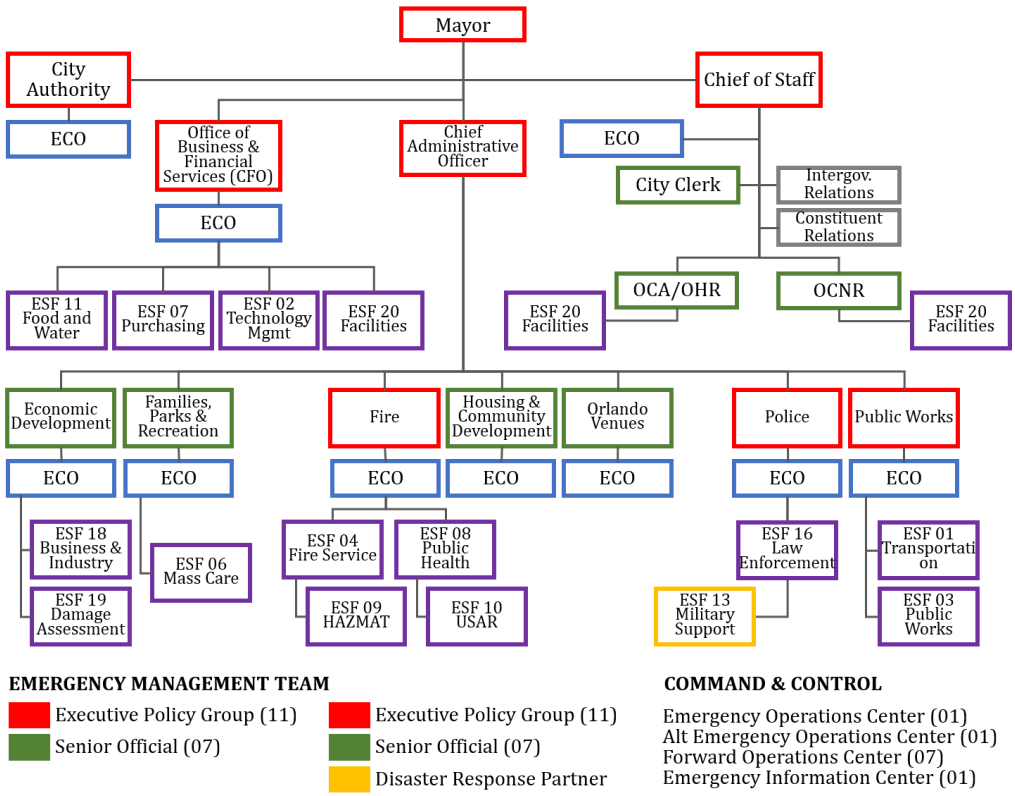


Figure 36 EOC command structure (source: Kwon, 2015b)

4.2 Human resources

The Orlando Operations Center has around 53 staff during daytime and 23 during night time. OOC hires several private sector contractors to provide maintenance service.

The Orlando Police Department emergency dispatch staff services calls for over 600 police officers as well as civilian Community Service Officers and Crime Scene Technicians. The Communications Center within the OOC has 77 employees dispatched with functions as call taker who handles incoming emergency and non-emergency calls using a computer aided dispatch system (CAD), and Radio Dispatch who dispatches call for service to the citizens of Orlando via an 800 MHz radio system, directs and tracks officer activities and enters them into the CAD system.

Among the Orlando Fire Department emergency dispatch staff, the Emergency Management Coordinator works under the Assistant Chief and make sure that the City Warning Point is manned 24/7 and that day-to-day operations are coordinated with the County and State Warning Points, as well as other City Departments. The OFD Communications Manager runs the fire department communications department and manages personnel, infrastructure, and the day-to-day fire communications activities in the Orlando Operations Center.

The Traffic Management Center within the OOC is a 24-hour per day operation, which operates the computer system that controls 343 of the City of Orlando's 419 traffic signals. The system is an area-wide multi-jurisdictional system with a physical cable plant that also connects to 74 traffic signals in the City of Maitland, the City of Winter park, and Orange County The system monitors 60 Orange County traffic signals for Orange County Traffic Engineering. The TMC also houses the Lymmo transit system computer and contains equipment so that the City can provide backup monitor and control functions of the I-4 Video Surveillance System for the Florida Department of Transportation.

The TMC staff numbers ten where the systems engineer oversees the day-to-day operation of the TMC, provides technical support to the traffic signal maintenance group, and assists the review of traffic signal plans. The rest of the staff includes five full-time computer operators and one part-time computer operator that man the TMC 24/7. They monitor the various traffic control devices that are connected to the computerized traffic signal control system, answer the Traffic Signal Problems line (telephone number) and notify the appropriate agency or department based upon the type of problem. Two other staff members, a civil engineer and a signal-timing technician, provide services for the timing and synchronization of the traffic signals.

4.3 Information control, ownership and sharing

The information is controlled by the organization that owns the data collection device. For traffic, data sharing is much easier but security and crime related information is more sensitive; OOC staffs can view the OPD cameras but the authority to control the cameras belongs to the OPD headquarters. The request to view cameras has a very simple procedure internally within the key players such as the OOC, City Hall, OPD headquarter and OFD headquarter etc. When in an emergency situation, representatives from various departments gather up at the EOC to enable quick response to needs such as camera pan, tilt, zoom etc.

EOC can view the traffic cameras through any monitors. These monitors can also bring in IRIS cameras (crime CCTVs) to share operational images

4.4 Protocols and procedures of decision making

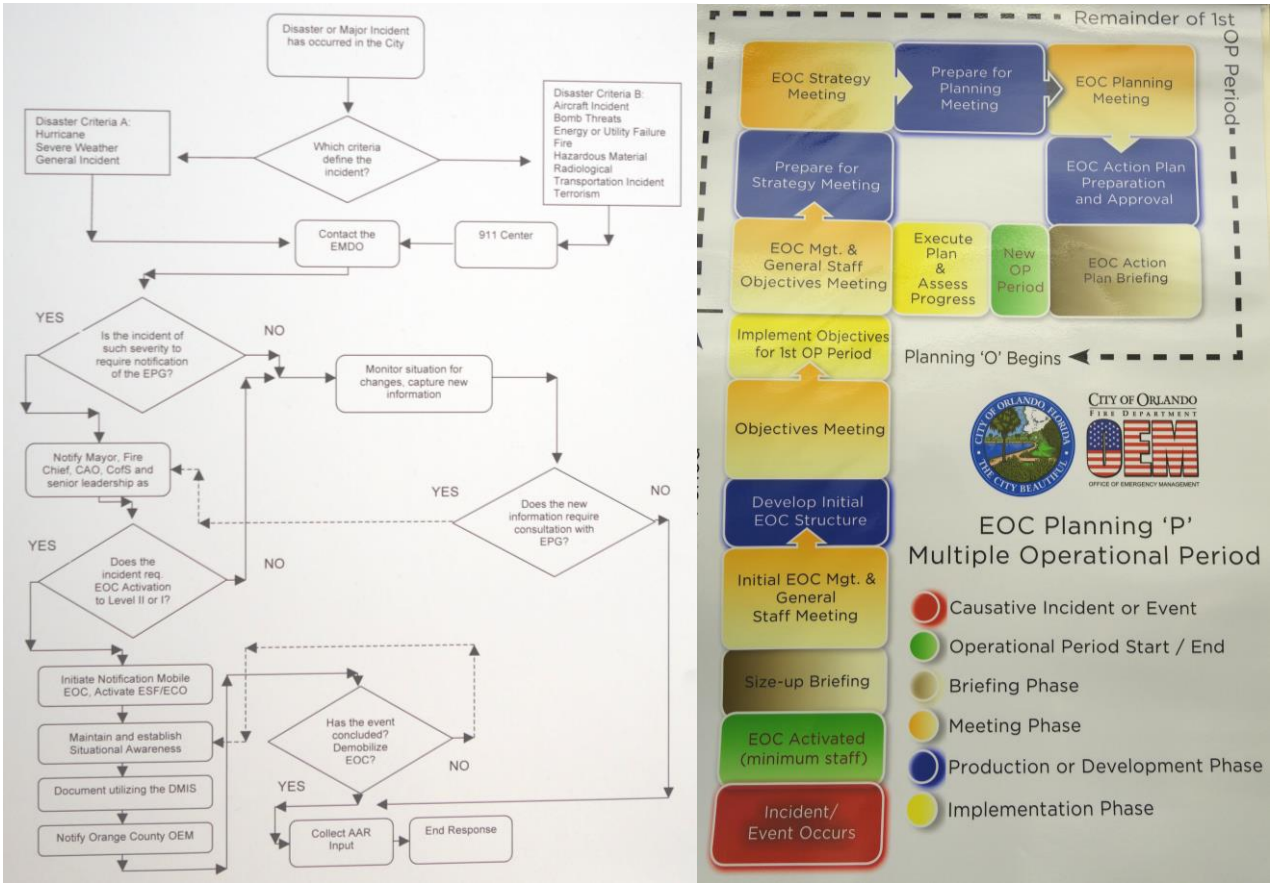


Figure 37 EOC notification process (left) and emergency handling procedure (right) (source: Kwon, 2015b)

4.5 Cost system

The cost benefit analysis of the OOC facility during the planning stage is shown in Figure 38.

Compared to the alternative option of renovating the existing Orlando Police Headquarters into new OOC, the analysis concluded that building a new facility had more long-term benefits, especially the ability to provide room for expansion in the future. The funding for construction and maintenance of the OOC came from the Orlando City Council as well as additional revenue sources such as grants and rent or service charge from outside organizations that utilize the facility. As of 2015, Between 25-35,000 USD gets spent on large expenditure items such as power and water every two months.

Orlando Operations Center
Project Costs $8,695,000
City Costs $5,220,000
- New facility and land
- Room for expansion
- Superior functionally
- Utility space allows ease of installation and maintenance
- Much less impact during construction
- Frees up space at OPD for future growth

Life expectancy 30+ years

Orlando Police Headquarters
Project Costs $5,250,000
City Costs $3,300,000
- Cheaper initially
- Centrally located
- Makes use of an existing facility

Life expectancy 5 years

Potential exists to equalize the costs of the two options through grant and forfeiture dollars

	Projected Cost	Alternative Funding	Total
Orlando Operations Center			
- Renovations / FFE	$2,700,000		
- Sanitary Sewer Relocation		$ 525,000*	
- Road Extension / Survey	$ 620,000		
- Radio Consoles		$2,000,000**	
- Computer Equipment & Optic Lines	$1,300,000		
- Traffic Mgmt. Equipment / Move		$ 950,000***	
- Operational Consultant	$ 100,000		
- Contingency (10%)	$ 500,000		
• Subtotal	$5,220,000	+ $3,475,000	= $8,695,000
• Currently Funded	- $ 500,000		
TOTAL	$4,720,000		

* *To be funded from Wastewater Fund*
** *Expected to be funded by traffic ticket surcharge*
*** *Expected to be funded by grant funds / federal government*

Figure 38 Cost benefit analysis of OOC facility (source: Orlando Operations Center, 2001)

5. Monitoring and Control

5.1 Benefit items

It is believed that since the operation of OOC, there has been significant benefit in terms of shortened decision-making and response time, service quality to citizen, better management of city traffic, better management of incidents and disaster through cooperation between transport, fire and police department. Also, it is thought that the increased real and perception of public safety is adding to the inflow of tourists, investment and business. OOC regards one of its purposes as to support the economic engines of the city running, especially the visitor attractions within the city.

5.2 Quantitative and qualitative measures for benefit analysis

3.7.1 Transportation and urban mobility

Orlando city government's red light enforcement program, the Orlando STOPS program has brought the following benefits:

- 65% reduction in right angle crashes associated with red light running (2009-2013)
- 91% of vehicles issued a red light running violation did not receive a second violation
- The monthly average red light running violations per camera per month have decreased by 28$ (FY13-14)
- The ratio of drivers being issued Notice of Violations (NOV) have decreased in Orlando by approximately 20%
- In 2012, in every 1,995 vehicles going through red light camera intersections were issued a NOV
- In 2013, one in every 2,403 vehicles were issued a NOV
- 53% of all violations issued, went to owners of vehicles registered in Orlando
- During the 2014 fiscal year, police have requested videos at least 50 times as a tool for investigating collisions, crimes and vairous other events under police investigation
- 40-60K given to supportBest Foot Forward public safety initiative

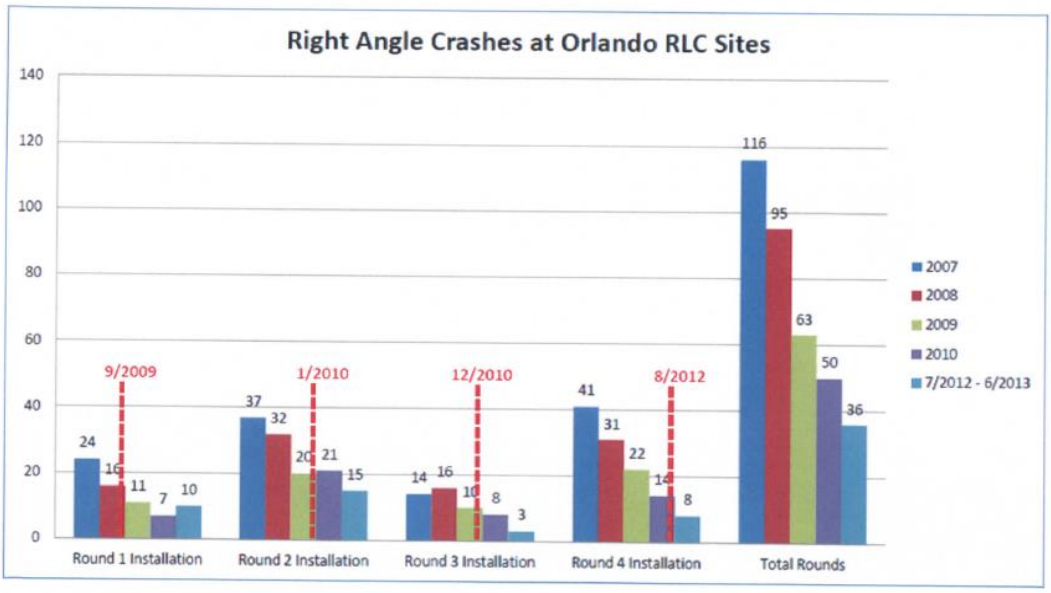


Figure 39 Right angle crashes at Orlando red light control sites (source: City of Orlando, 2014b)

3.7.2 Safety and citizen security

Orlando Police Department's online reporting system increases citizen convenience by allowing them to easily report non-emergency incidents such as lost property, harassing phone calls, petit theft etc. at any time online while enabling the Police Department to address to cases more efficiently and promptly through receiving comprehensive reports online as opposed to via phone call or visit.

3.7.3 Emergency and response

The OOC measures the performance of the Emergency Operations Center upon the Emergency Management Standard by Emergency Management Accreditation Program (EMAP) incepted in1997. Orlando Operations Center has received EMAP accreditation as first in Florida and 7th in the country in 2014.

EMAP is an independent non-profit organization, fosters excellence and accountability in emergency management and homeland security program by establishing credible standards applied in a peer review accreditation. The following EMAP elements are used to evaluate an emergency management program of a city.

- Administration and Finance
- Laws and Authorities
- Hazardous Identification, Risk Assessment and Consequence Analysis
- Hazard Mitigation
- Prevention
- Operational Planning
- Incident Management
- Resource Management and Logistics
- Mutual Aid
- Communications and Warning
- Operations and Procedures
- Facilities
- Training
- Exercises, Evaluation and Corrective Actions
- Crisis Communications, Public Education and Information

There are ten members on the EMAP Commission – five members appointed by the National Emergency Management Association (NEMA) and five members appointed by the International Association of Emergency Managers (IAEM) with the term of three years. These commissioners represent a broad spectrum of public and private sector groups. For purposes of developing an American National Standard, all members of the EMAP Commission and its Committees, Subcommittees and Work Groups are classified as Public Representatives, Private Representatives or General Interest Representatives.

3.7.4 Environment

A. Automated garbage collection

City of Orlando's Autocar/Runwise equipped garbage truck implemented since December 2013 consumes an average of 48% less fuel than the normal diesel trucks on routes that collect waste from 900 to 1,100 homes per day. The collection routes productivity increased by 7% to 10%, while completing scheduled routes 30 minutes to one hour earlier. In first seven months, the City of Orlando saved USD 25,000 in diesel fuel. City of Orlando's nine Hybrid garbage trucks have saved 226,492 lbs of CO2 emissions within 16 months of operation. Over a 10-year life, the CO2 emissions avoided will total 2,839 tons on the nine Hybrid trucks only (as of April 2015 the city has 18 hybrid trucks). Based on recent EPA figures, this reduction in CO2 emissions is equivalent to removing 542 mid-sized vehicles from the road, or planting 66,038 tree seedlings and allowing them to grow for 10 years. A case study on the Annual Cost Avoidance for the City of Orlando's nine Autocar/Runwise Hybrid Units has revealed the following:

- Estimated annual brake savings: USD

12,000 per truck

- Estimated annual fuel savings: USD 10,000 per truck (50% compared to conventional truck)
- Estimated collection time reduction: 10%
- Estimated carbon emissions reduction: 48 tons per year
- Estimated annual productivity savings: USD 9,000
- Estimated cost avoidance over 10-year period: USD 2.8 million for the initial nine hybrid trucks compared to the equivalent truck

B. GIS water management

St. Johns District of Water Management where the City or Orlando belongs to has been able to generate the following benefits from its GIS water management system.

Map generation has improved communication in all aspects of District operations—among staff and with decision makers, governmental partners, and the public. Maps have been a powerful tool for communicating the District's mission and the results of its projects. For example, staff members rely on maps for clearly informing their Governing Board about permits being considered, greatly reducing confusion, saving time, and allowing the Board to focus on the decisions to be made. Non-GIS staff members are able to incorporate spatial information in their daily tasks, increasing efficiency and improving the work product. Public notification of the District's permitting activities has been enhanced. It is much easier now for citizens to find out about permits being considered or approved for their neighborhoods. Data sharing with other agencies has been simplified. For example, the consumptive use permit database is now being shared live by other agencies via the Internet using ArcIMS.

3.7.5 Energy efficiency

City of Orlando has set a goal to transform the city into a national leader in energy efficiency for new and existing buildings that reduce waste and pollution with the following target.

Metrics	2010 (Baseline)	2018 (Targets)	2040 (Goals)
Renewable Energy	1.8 %	8%	Obtaining 50% of electricity from clean, renewable sources
Energy Use (KwH per capita)	12,003	11,403 (5% reduction)	Reducing total electricity consumption by 20% from 2010 levels; Ensuring 100% of new and existing buildings meet green building standards
Greenhouse Gases (GHG)	5,803,851 tons of CO2	4,352,888 tons of CO2 (25% reduction)	Reducing greenhouse gas emissions by 90% from 2007 levels

Table 2 City of Orlando's energy efficiency goal by 2018 (source: cityoforlando.net/greenworks)

A. Pre-paid Power Pass Program

The Power Pass program of Orlando Utilities Commission where customers can pay-as-you-go or pay in advance for utility services. As of early 2015, the Prepaid Power Pass deployment status is the following:

- Over 4,648 customers
- Av. customer payment/month: USD 23.94
- Total alerts by call: 48,958
- Total alerts by text: 244,762
- Total alerts by email: 151,737
- Total debt recovered: USD 431,638
- Total deposits returned: USD 1,470.734

Orlando Utilities Commission has received Exceleron Software Presidential Award of Excellence in 2014. The benefits of the Power Pass Program are as follows.

Customer benefits	OUC benefits
• No deposits or deposit bill-ups • No late fees • No disconnection or	• Greater customer satisfaction • Improved cash flow • No financial risk on

reconnection fees • Can be used to pay down/off arrears • Increased customer satisfaction with their utility • Budgeting control over their utility expenses • Detailed information on their daily energy and water use • Ability to see current balance • Conservation effect (5 to 10 percent)	prepaid accounts - No write-offs - No bad debt - No collection services/payment plans • Can collect on old debt and past due balances • Reduced billing/mailing costs • Fewer disconnect/reconnect trips • Long-term reduced staffing • Conservation effect (5 to 10 percent)

Table 3 Benefits of Power Pass (source: Orlando Utilities Commission , 2015)

B. Building retrofit to enable real-time energy consumption tracking

City of Orlando's energy efficiency project of retrofitting 28 public buildings to track energy consumption in real-time led to average 31 percent annual utility cost reduction. For example, the 8,000 square foot L. Claudia Allen Senior Center's energy bill dropped to USD 15,500 from initial USD 37,000 after installing the advanced controls, which is a 58 percent reduction. Furthermore, the facility team noticed a significant improvement in the indoor air quality and overall comfort in the senior center after the retrofit in terms of temperature and humidity level. Another example is Orlando's Fire Station 7, which cut its energy costs from USD 28,500 to USD 18,500 annually by installing informative web-based control systems.

C. Smart metering system

The Smart metering system of Orlando offered real-time interaction through web. The result was 12-minute elapsed time from payment at a location to service reconnection, and less than 7 minutes for the IVR/Web as can be seen in Figure 40. Orlando Utilities Commission won the "Smart Grid Infrastructure Award" for Large Utilities in CS week 2014. The resulting cost saving factors are shown in Table 1Table 4.

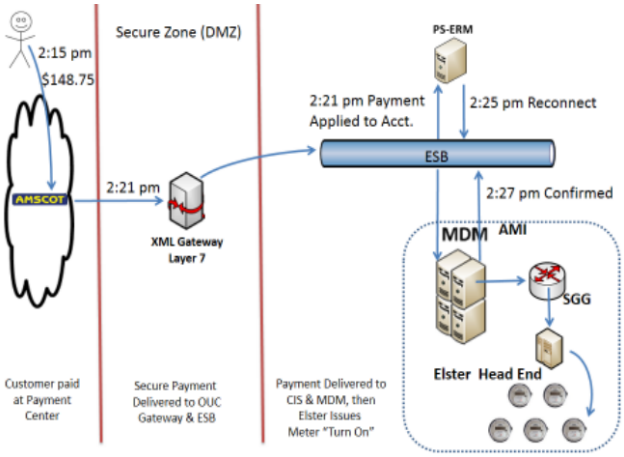


Figure 40 Response time since smart metering (source: Orlando Utilities Comission, 2015)

Metric	Current State	Future State	Improvement	Benefits
Increase annual e-Payment Transactions	703,152	853152	21%	$75,000/Yr
Decrease Rep call volume through Form Automation	663,792	586,992	12%	$436,224/Yr 6.4 FTE reduction
Decrease Overall call volume through IVR Upgrade	1.6 Million	1.4 Million	14%	$966,072/Yr 14.1 FTE reduction
Decrease operations costs by closing 3 OUC Service Centers and transition customers to new payment methods	308,220	0	100%	$1,730,892/Yr 21 FTE reduction
Raise Customer Satisfaction by adding New Third-Party Payment Locations	2 Vendors 125 Locations	116 Vendors 495 Locations	114 Vendors 370 Locations	NA
Enroll 2.75% of customers into Pre-Paid/Power Pass™ in the first year	0	2.75%	2.75%	$300,000/Yr
Reduce window to identify leaking or defective meters and avoid high-bills to the customer	30 days	5 days	83%	$50,000/Yr *(Billed Consumption to the Customer)*

Table 4 Cost savings of smart metering system (source: Orlando Utilities Comission, 2015)

5.3 Integration level and synergy effect

Orlando Operations Center has a relatively high degree of integration level, combining the several functions of city management in one single physical facility such as traffic, 911 communications (police & fire), emergency, and network operations.

The Center Head of OOC believes that there are more advantages from have many functions integrated in one center to create synergy effect compared to the cost of the vulnerability towards hacking. He believes that the security team can focus the attention on one center as opposed to putting security efforts into each center separately. OOC has backup centers in Atlanta and New Jersey on top of the data center in the basement.

6. Lessons Learned

Orlando's approach for smart city management suggests the following three lessons for other cities to take account of.

Firstly, Orlando's case demonstrates the importance of the Mayor and city government officials' strong initiative in identifying the city's need and the establishment and maintenance of such center. During the 1997 Atlantic hurricane season that closely affected Orlando, the Mayor and city officials observed the inefficiency of having to request data to each departments and agencies and realized the importance of integrated one-stop information platform that enables synergy effect through data share and collaborative decision-making especially for the areas of city management that requires rapid response such as road, crime, disaster incident and emergency management. Orlando Operations Center is a good case where emergency operation takes the lead of other functions as natural disasters especially hurricanes are large threat to the City of Orlando. It is crucial that the Mayor and the city officials take the lead in identifying the priority areas of the city that ICT application can most effectively reap the enhancement of city management and civic service provision.

Secondly, the case of Orlando indicates that a facility like the OOC and the smart systems and services of the city creates measurable and non-measurable benefits to the city and citizen. Both Orange County EOC and Orlando Operations Center agreed that the return on investment for having a dedicated operation facility like the OOC is on minimizing the economic impact of a disruption such as airport closing or road evacuation especially considering that Orlando has a large tourism industry and business convention industry. Public perception on the city government having the response capability towards emergency situation is very crucial, yet this perception of safety knowing that the city or county has good security and disaster response system is something intangible to turn it into quantitative terms.

Thirdly, as can be seen in Chapter 5, the City of Orlando has been closely monitoring the benefits of ICT application to city management and civic services in a quantitative manner. This included specific benefit items such as the reduction of car accidents, reduction of traffic violation as well as evaluation structure for emergency management accreditation. The performance of waste collection has been measured by items such as reduction in waste vehicle fuel consumption, reduction in CO_2 emission, annual savings in monetary terms for break and fuel, and collection time reduction. For the sector of energy as well, the City of Orlando set specific targets for reduction in energy use and greenhouse gas emission as well as outlines the benefits of its pre-paid power pass program and the real-time energy consumption tracking system on public buildings including the improved cash flow, reduced billing and mailing costs, and energy bill reduction in monetary terms. The cost savings from the smart metering system especially demonstrates the City of Orlando's focus on recording the performance of its ICT-applied city management programs and the improvement of indicators in numbers and percentages, as well

as deducing the financial benefits in monetary terms (Table 4). Such detailed quantitative performance monitoring is crucial for effective project justification and securement of funding, which is an important point to be noted by other cities that wish to implement smart city initiatives.

7. Conclusion

City of Orlando is a good example of a case where an integrated city operations center harnessing ICT was established relatively early in 2001 before the international popularity of smart city approach got heightened. Orlando Operations Center was formed not by the federal or state push of smart city initiative, but by the Mayor's identification of a need for rapid civic response on special events and natural disasters. Orlando is an especially good case as a reference for efficient emergency and disaster management in line with the city's large tourism industry and hurricane-prone nature.

ANNEX A - Bibliography

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Photographs

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2. Kwon, H., 2015b. Photographs taken at the site visit to Orlando Operations Center on 28th September 2015.

3. Kwon, H., 2015c. Photographs taken at the site visit to Orlando City Hall on 28th September 2015.

4. Kwon, H., 2015d. Photographs taken at the site visit to Orange County Emergency Operations Center on 28th September 2015.

Interviewed stakeholders

1. Mr. Manuel Soto, Emergency Manager, Orlando Operations Center

2. Dave Freeman, Manager, Orange County Office of Emergency Management

3. Mr. Benton Bonney, Transportation Systems Manager, Orlando Operations Center

4. Mr. Kory Keith, Orlando Stops Operations Manager, Code Enforcement Division within Economic Development Department, City of Orlando

5. Wendy Horency, Assistant Division Manager, Code Enforcement Division within Economic Development Department, City of Orlando

6. Representatives of Orlando Fire Department Dispatch, Orlando Operations Center

ANNEX B – Service spectrum

Key smart city service spectrum		Smart city functions and medium				
Service domain	Service system	Monitoring and data collection	Control	Data processing and information production	Information communication with citizens	Information sharing with agencies*
		Signal controller, image detector, BIS, CCTV, web portal…		Patten analysis, route optimization…	VMS, internet, mobile, call center, open-API, broadcasting…	Information platform (control, ownership and sharing)…
Transportation and urban mobility	Bus Information and management	4	4	4	3	3
	Parking information	4	4	4	3	3
	Traffic information	4	4	4	4	4
	Adaptive traffic signal control	4	4	4	4	4
	Red light violation enforcement	4	4	4	3	3
Safety and citizen security	911 communications and emergency vehicle dispatch	4	4	4	4	4
	Self/online reporting	4	4	4	4	3
Emergency and response	Emergency alert applications	4	4	4	4	4
	Incident information management and distribution	4	4	4	4	4
	911 call center system and emergency vehicle dispatch	4	4	4	4	4
Environment	Smart waste information	4	4	4	4	3
	Automated waste trucks and GPS tracking	4	4	4	3	3
	Water atlas and GIS water management	4	4	4	4	3
Energy efficiency	Pre-paid power pass	4	4	4	4	3
	Real-time energy consumption tracking in buildings	4	4	4	3	3
	Smart metering and analytics	4	4	4	4	3
Citizen interaction and communication	GIS infomap	4	4	4	4	4
	Online education programs	4	4	3	3	3
	Media broadcasting and SNS communication	4	4	4	4	4

* **Agencies**: Police officers and petrol cars, community groups, fire stations, military bases, related departments (road, public transport, river management, water management, environmental preservation…) etc.

* This table summarizes the key smart city services and systems investigated in this research. The above list does not represent the full spectrum of the city's services and systems.

* **Performance level**:

4 – Advanced

3 – Moderate

2 – Basic

1 – Absent

T – To be introduced in the future


IDB