[DA-005] GIS&T and Local Government

Abstract

GIS is an important tool for local governments. It is utilized to provide spatial information, metrics, and visualizations to constituents, businesses, and decision-makers. Internally, a well-managed GIS can be the basis for innovation and process improvement and can be a single source for employees to find a plethora of integrated data. This entry discusses how GIS supports local government, important considerations for maintaining a successful local government GIS, and current trends. This entry is based on the author's experience in a GIS program at a medium-sized city in the Rocky Mountain Region of the United States. Not everything discussed may apply to other areas of the country or world. Additionally, smaller-sized programs may not have the resources to implement everything discussed. The key purpose of this entry is to provide students and instructors with tangible examples of processes, skills, and organizational structures that make for an effective local government GIS.

Keywords: administration, enterprise GIS, government, local, municipal

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Explanation

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1. Definitions

Local government - the public administration of towns, cities, counties, and districts. This type of government includes both county and municipal government structures.

Enterprise GIS - A geographic information system that is integrated through an entire organization so that a large number of users can manage, share, and use spatial data and related information to address a variety of needs, including data creation, modification, visualization, analysis, and dissemination.

Realtime data - information that is delivered immediately after collection. There is no delay in the timeliness of the data provided.

SaaS - Software as a Service (SaaS) is a software distribution model in which a third-party provider hosts applications and makes them available to customers over the Internet.

COTS - commercial off-the-shelf software products (COTS) are packaged solutions that are configurable to satisfy the needs of the purchasing organization, rather than the commissioning of custom-made software.

Open data - data that can be freely used, shared, and built-on by anyone, anywhere, for any purpose.

Data Model - is an abstract model that organizes elements of data and standardizes how they relate to one another and to the properties of real-world entities.

Attribute Domain - Attribute domains are rules that describe the legal values of a field type. They are used to constrain the values allowed in any particular attribute for a table or feature class. They provide a method for enforcing data integrity by limiting what can be placed on a field to a valid list or range of choices.

Data Standards - Standards make it easier to create, share, and integrate data by making sure that there is a clear understanding of how the data are represented and that the data you receive are in the form that you expected. There are many types of geospatial data standards that can be specified, including data format, data content, data quality, layer naming conventions, spatial reference, metadata standards, cartographic standards, etc.

Metadata - a set of data that describes and gives information about other data.

Geoportal - a type of web portal used to find and access geographic information (geospatial information) and associated geographic services (display, editing, analysis, etc.) via the Internet

2. Why GIS Is Important to Local Government

Being able to spatially represent and visualize data and how they interrelate is a key component of Local Government GIS. The utility of GIS to local government includes creating efficiencies and saving taxpayers time and money (Artz 2009), as well as other reasons such as:

- Eliminating paper processes
- Using data models to reduce input errors

- Allowing data access and field data collection via mobile devices
- Reducing site visits
- Communicating information to constituents (where to vote, DMV locations, etc.)
- Spatially visualizing projects and plans for deconfliction (avoiding paving a street and then digging it up the next week to put in a new sewer line)
- Allowing business to be conducted online (plans review, permits, licenses, etc.)

Other uses include enterprise system integrations (asset management, 911 Computer Aided Dispatch, tax collection, permitting, and customer relationship management system, etc.) and performing simple and complex analysis to support decision makers.

A good example of of GIS enabling government efficiency an be found in West Jordan, Utah, population 114,000. The City uses a SaaS (Software as a Service) GIS application to have residents report service requests; animal control, code enforcement, parks & trees, streets, and utility issues (City of West Jordan, n.d.). This configurable application has a data model that error-proofs data through the use of attribute domains (see Figure 1). After the service request is submitted it creates a case in the City's work order system for a crew to be dispatched.

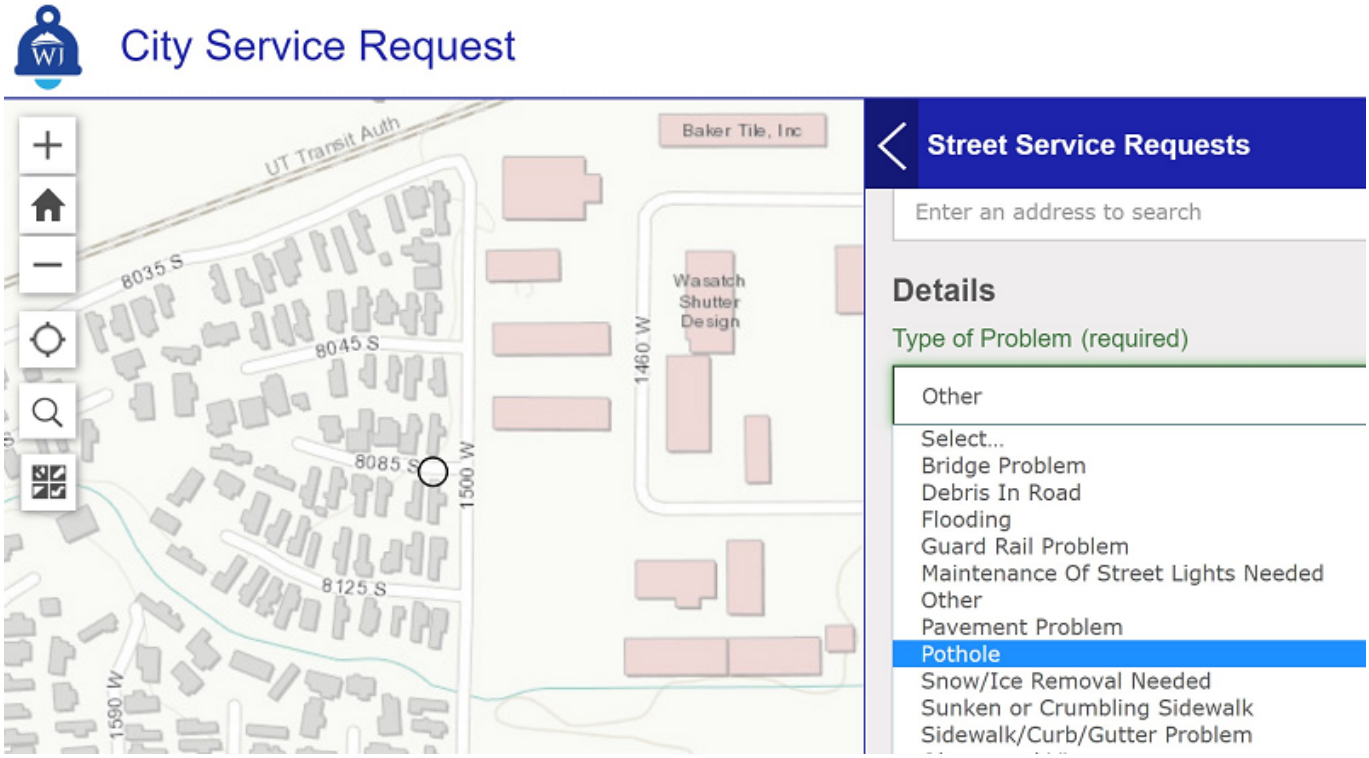


Figure 1. GIS makes the City of West Jordan, Utah, more efficient by ensuring data quality through a data model, attribute domains and an integration with the City's work order system. Source: City of West Jordan, n.d.

3. Important Local Government GIS Considerations

GIS is essential to local government efficiency. It is estimated that over 80 percent of governmental data has a spatial basis (Williams 1987). Regardless of the actual number, a large percentage of data created and consumed by local government has a spatial

component, be it geospatial coordinates (X, Y coordinates, latitude, longitude, etc.), an address, legal description, subdivision, or neighborhood name.

Spatial data quality standards help ensure reliable GIS. These standards ensure that data meet minimum accuracy levels for both geometry and attributes. This allows for easy reuse of data with other systems and applications. It also allows for accurate analysis results and decision making. Proper metadata, or detailed documentation of data elements, usage constraints, limitations, and contact information, help both internal and external users determine suitable uses for the data the metadata describes.

Addressing standards are a great example of the importance of applying standards. If a City or County has properly formatted address data, any other data tied to that address can be geolocated and mapped. This, in turn, empowers users of these data and map products to visualize, analyze, and model spatial relationships using GIS.

One example of this would be a spreadsheet listing non-profit organizations with which the Human Services Department wants to work. If the addresses are standard and valid, they can be easily geocoded, mapped based on the addresses, and then overlaid with US Census poverty-level data. This would give the Human Services Department the information they need to decide which non-profits to work with based on the proximity of the locations to areas with greater poverty.

4. Enterprise System Integrations

Many non-GIS enterprise applications are enhanced by having mapping, spatial analysis, and/or GIS based data validation capabilities. One current method of GIS system integration is through web services. A web service is a software service used to communicate between two devices on a network. More specifically, a web service is a software application with a standardized method of providing interoperability between disparate applications (What is a Web Service? n.d.).

To make a distinction, GIS can be integrated into an enterprise application, but it can also be used to integrate data from a single or many different applications. One example of GIS to enterprise application integration would be a local government's tax collection system. The enterprise system is very specialized for tax collection purposes. An integrated map would show similarly valued homes to help analyze parcels for tax valuation. Additionally, GIS geometry services can automatically populate tax district information during data entry. A web address service is also used to validate new addresses added, to ensure data quality.

An example of GIS integrating many systems would be the City and County of Denver's Situational Awareness Tool. This tool was created for the Office of Emergency Management for its Emergency Operations Center. The system uses a SaaS dashboard with a map to display real-time data:

- Police and fire 911 call type and location from the Computer Aided Dispatch System
- Filtered 311 non-emergency calls (tree limbs, flooding, downed powerlines, sinkholes, etc.) from the Customer Relationship Management System
- Special events from the City's permitting system

- Street closures from the City’s permitting system
- Traffic conditions (external service from Esri/Here)
- Weather conditions (external service from National Weather Service)
- Social media streams
- Stream gauge levels (external service from Urban Drainage and Flood Control District)
- Power outages (external service from utility)

The system can overlay, query, and analyze the above data with the City’s enterprise GIS layers. This tool uses the power of GIS data integrations to manage situations faster and allow for better-informed decision-making.

Figure 2, below, shows the architecture of the City and County of Denver’s Enterprise Application integrations. Read-only web services are created from the Distribution enterprise GIS database. Systems connected by the green lines consume web services to display maps, perform analysis, or perform geometry functions to populate fields in the enterprise application, or give proximity alerts. Editable web services are created from the Maintenance enterprise GIS database. The applications that use these services (the blue lines) directly edit the GIS data in the Maintenance database via these services. The data is then replicated (copied) to the Distribution database at regular intervals. The systems connected by the red lines validate addresses entered into the enterprise application against the GIS address layer via a web service to the Distribution database. This ensures address quality by only allowing valid addresses to be entered into these systems.

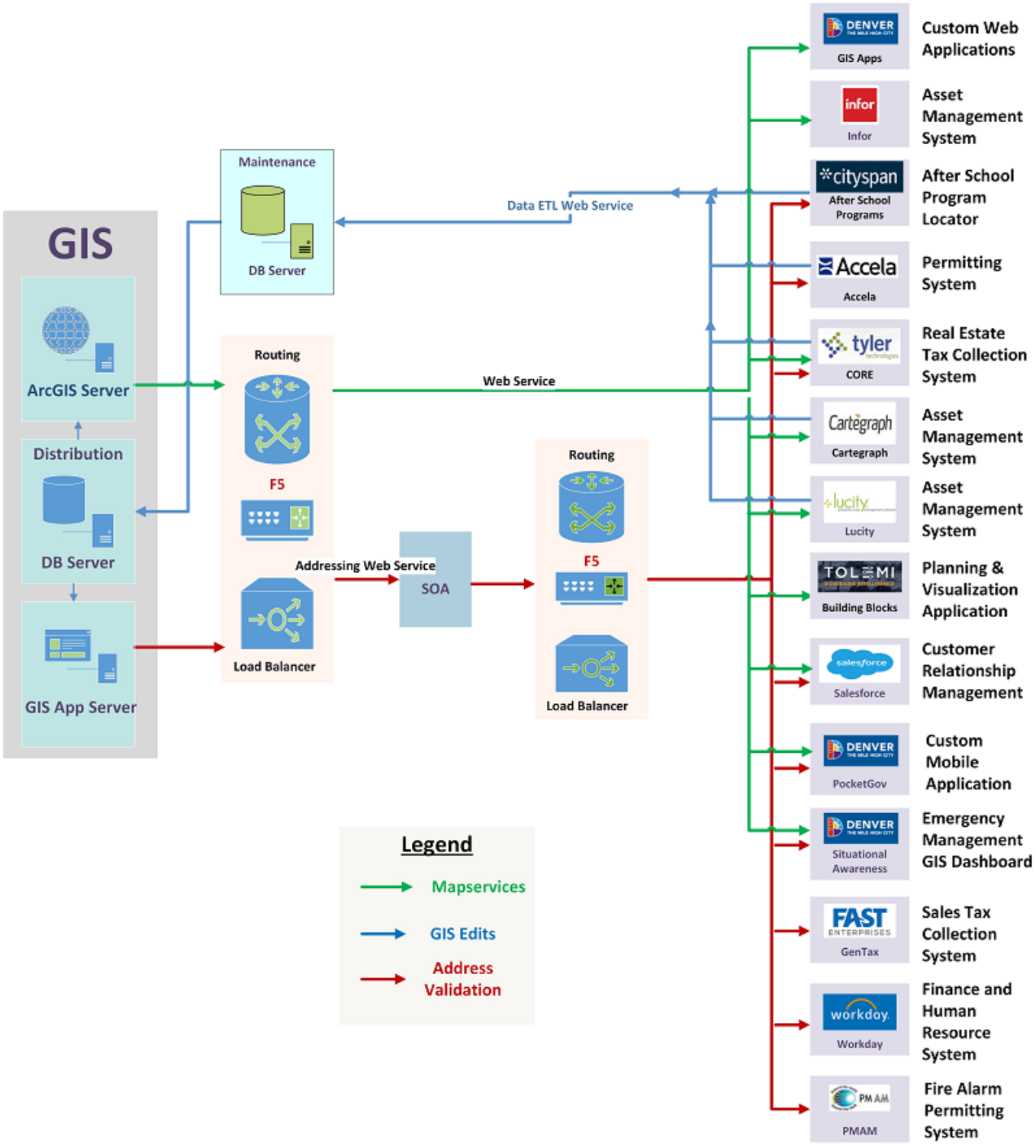


Figure 2. This architecture diagram highlights the variety of GIS integrations from an enterprise geospatial database to the City and County of Denver's Enterprise Applications. GIS layers are published as web services by ArcGIS Server software and then consumed by; custom web applications, Asset Management Systems, Permitting Systems, Emergency Management Situational Awareness Dashboard, Tax Collection Systems, Customer Relationship Management System, Finance and Human Resources ERP. Source: Sisodia, 2019.

5. Local Government GIS Structures

A local government GIS may consist of one or two users or have hundreds. Larger local governments generally have their GIS teams centralized, decentralized, or use a hybrid of these two approaches. A decentralized GIS has users or teams in various departments working independently. A centralized GIS configuration has one department that supports the whole locality's GIS needs. A centralized/decentralized hybrid model has one department, normally IT, that supports groups of users in other departments. For example, the City of Simi Valley, California GIS Assessment and Revitalization Plan contains diagrams and very detailed benefits and drawbacks of each organization model (Geographic Technologies Group 2018).

Regardless of which model is used, the concept of enterprise GIS—where data is mapped once and used by many—is paramount. This requires various agencies to take a holistic view of GIS and work together to make the data benefit other department's needs as well as their own (Peery 2019).

It may be difficult or impossible for a small local government to develop an enterprise GIS. The trend toward web-based GIS offers these entities some SaaS GIS options. These cloud-based solutions can eliminate the need for internal GIS infrastructure and lower the cost of operating a GIS. GIS data can be created in the SaaS or uploaded from desktop GIS software. Once in the cloud, webmaps and configurable applications and dashboards can be created with no or little custom development required. The data are stored as web services and can be integrated with other systems.

Free and Open Source Software (FOSS) is another lower-cost option for local government GIS (Moreno-Sanchez 2018). FOSS geospatial software has both desktop and server components. A local government can create the data in an open source desktop software and then use the server component (ex. Geoserver, Mapserver, etc.) to publish the data in a variety of formats, including web services

Successful local government GIS benefits from guidance and coordination, often generated through a GIS advisory committee and a parallel GIS user committee. These names may vary, but the purpose is the same in many local governments. The Advisory Committee, consisting of department heads or local officials, acts as a champion for the program. It evaluates and prioritizes GIS projects and initiatives. It also has a role in presenting business cases for budget approval.

A GIS User Committee consists of persons that use the technology on a regular basis. It meets regularly to communicate what projects departments are working on, enterprise considerations for new data layers, any needs for licensing and training, and to learn about new technologies. It also has a role in developing use cases and business justifications for the GIS Advisory Committee, and in reporting any issues back to the User Committee.

As embedded as GIS is in local government, success takes a staff that embraces new technology and is skilled in presenting and selling it to demonstrate and capture its business value. The committee chair, or coordinator, needs to engage users and let them know about the data and tools available to them. Outreach events and targeted GIS presentations improve agency/department engagement.

6. Regional Data

As the world does not end at a jurisdiction's boundaries, it is important for local governments to establish strong relationships with other neighboring local governments, and at the regional, state and federal level. Many local governments collaborate through regional organizations (ex. North Central Texas Council of Governments, Denver Regional Council of Governments, etc.) or formally through regional governments (ex. Portland Metro, Metro Twin Cities, etc.) to obtain large data sets (aerial photography, LiDAR, impervious surfaces, etc.) at greater accuracies and resolutions for reduced costs. Data sharing can be formal (intergovernmental agreements) or casual (open data). The current trend toward open data and data sharing has greatly improved local governments' ability to access many data sources beyond their borders.

7. Open Data

Historically, the majority of local government GIS programs employed cost recovery, where data is sold to cover development and maintenance costs. Many local governments found that the effort of cost recovery was outweighed by the benefits of open data. In 2010, all 10 counties in the Metro-Denver, Colorado region charged for their geospatial data. As of 2019, all but Gilpin County have open data sites.

In the US, while local governments are not subject to the Freedom of Information Act, most States and local governments have open records laws. In 2007 Orange County, California, was sued by the Sierra Club for charging for their GIS data, and eventually lost (Supreme Court of California Resources, n.d.). The Sierra Club argued successfully that the GIS data was public record. While open data policies do reduce open records requests, they do not eliminate them entirely. Outside the US, over 100 countries have open records or "sunshine" legislation.

Open sites allow for students, businesses, constituents, and other local governments to access curated and documented authoritative GIS and tabular data. Traditional sites allow for the data and metadata to be downloaded in a variety of formats. The current trend is to provide web services or application programming interfaces (APIs) that can be accessed via GIS, Business Intelligence (BI) and a variety of other software.

The benefit of services is that the user always has access to the most current data. Most downloaded data become stale in a matter of days—or even hours. Other benefits of Open Data include an increased level of government transparency and accountability, use of data by university and high school programs, and indirect economic benefits from the businesses and researchers that utilize this free resource.

Johns Creek, GA, population 84,350 (2017), is a good example of what a small GIS program can do with SaaS solutions and open data (Pratt 2018). The Johns Creek Data Hub launched in 2016 allows for the public to explore data features and attributes, view layer dashboards, and either download or connect to the data through web services. A dedicated GIS staff of two configured the site and built automated methods for pulling in data from City systems.

8. Local Government GIS Trends

Currently, Web GIS or web maps and applications are a major focus of the GIS industry. Fewer requests are made each year for traditional printed paper maps. Users and the public have become more web savvy, and GIS application user interfaces have become more user friendly. This allows for fewer custom-developed and more configurable GIS applications. This saves local governments time and money by enabling faster delivery times and less custom code to maintain. Web GIS can be either cloud-based (Saas) or on-premise (Geoportal) solutions.

The development of Storymaps, digital maps that combine GIS and multi-media, has allowed for local governments to communicate a geographic narrative using pictures, videos, and even sounds to enhance the message of the map elements. Originally developed as a SaaS solution by the vendor Esri, Mapbox has released their own multimedia mapping SaaS solution. The City of Kitchener, Ontario, Canada provides a great example, explaining water infrastructure fees.

Real-time data and dashboards are currently in high demand from decision makers in local governments. Situational awareness is greatly enhanced by utilizing web GIS applications to visualize and provide metrics based on nearly instantaneous data from the multitude of sensors now commonly used by local governments. A good example of this are the abundance of GIS-based dashboards streaming:

- Snow plow, garbage truck, street sweeper, and other fleet vehicle locations
- Emergency vehicle locations
- 911 data
- Rental scooter and bike locations
- Traffic conditions (Waze, Mapbox, etc.)

Mobile GIS and field data collection are another growing trend in the local government GIS sector. In the past, large survey-grade GPS units were required to collect data with high accuracy. These units required a great deal of knowledge for use, transfer of GIS data to other formats/devices, and were very expensive.

Local governments are now collecting data through mobile phones and tablets, with small, inexpensive GPS Bluetooth-enabled receivers. SaaS solutions can also stream editable GIS data layers (feature services) to these devices, which eliminates the need for data downloads or format changes. Theses systems also have disconnected editing capabilities, where data is stored locally on the device when out of cellular service range.

Jefferson (County Colorado) Open Space has dramatically increased efficiency and eliminated paper processes by using SaaS based GIS collection software, tablets, and portable Bluetooth enabled GPS receivers to collect both tree and noxious weed inventory data. By using a data model and attribute domains, only valid attributes can be collected by the field worker (species type, treatment applied, date collected, etc.). Both databases were designed to meet the State of Colorado’s reporting requirements. A quick export and the data are ready to be sent to the State. Previous to this implementation, data was collected on paper forms in the field and then entered digitally upon return to the office.

Unmanned aerial vehicles (UAVs) are rapidly being adopted by many local governments. They are used primarily for taking pictures or videos of inaccessible locations and capture

high resolution aerial photography. In one example, UAVs are used to document the asset condition of storm water outfalls along rivers and in wetlands. UAVs can also be equipped with other sensors such as thermal detectors and LiDAR.

Indoor Mapping is being used to integrate space management, Building Information Modeling (BIM), and GIS, along with indoor wayfinding and navigation. An example, Hartsfield-Jackson Atlanta International Airport in Georgia using Bluetooth mobile device signals to determine wait times at security and to decide when to open more lines (Esri 2015).

The advent of 64-bit processor technology and better functioning 3D software have enabled the creation of impressive 3D maps for local government. Some uses include:

- Reviewing new building permits in relation to view planes
- Zoning and urban planning
- High-rise building maps for Fire Departments
- 3D Address mapping

9. Useful Skills for Local Government GIS

The following skills and fundamental knowledge are useful for jobs in the local government sector:

- Fundamental geographic concepts
- Data modeling
- Understanding of GIS standards
- Cartography
- Analysis
- Expertise in one or more GIS applications (open source and COTS)
- Relational databases
- System integrations
- IT skills - security certificates, fire walls, Network Area Storage, load balancers operating systems, etc.
- Geospatial Programing and Development
- Python, Java script, SQL, Arcade, and other scripting language
- Java frameworks
- .NET frameworks
- Web GIS
- Statistics R, SAS, etc.
- Power BI, Tableau, and other data analytics/visualization software
- Documentation
- Business Analysis/requirements gathering
- Oral and written communication of complex topics in plain language
- Attention to detail

10. Case Study: City and County of Denver, Colorado, USA

10.1 Overview of GIS in the City and County of Denver

The City and County of Denver, population 750,000, has a Centralized/Decentralized hybrid GIS structure (Sisodia 2019). The City has approximately 400 desktop GIS installs with a concurrent usage of approximately 100 users. The City GIS Program was formed in 1999 and currently has over 750 GIS layers.

The IT Department, Technology Services, manages the Enterprise GIS. Most agencies have GIS staff and curate their GIS layers in a centralized database. This ensures GIS data are created once and shared throughout the City, eliminating duplication of effort. COTS and custom GIS software serve the data to internal Agencies and the Public respectively.

A GIS user group communicates and coordinates major initiatives and day-to-day tasks among the City's Agencies. Its other purpose is to justify the business value of data collection and other GIS projects to enable their approval. A GIS Advisory Committee prioritizes projects and assists in procuring budget for those projects.

Centralized GIS responsibilities:

- Software licensing
- Sever and database administration
- Administer centralized editing (Maintenance) and view only (Distribution) environments
- Enterprise integration with other non-GIS system
- Automation of routine tasks
- Custom GIS application development and maintenance
- GIS program management
- Agency engagement
- Organize GIS Outreach Initiatives (GIS Day, Mayor's Cabinet in the Community, etc.)
- Open Data Catalog
- SaaS User Administration
- Organize/conduct GIS training

Agency GIS Responsibilities:

- Create and maintain enterprise GIS standards compliant data
- Create metadata
- Act as a Subject Matter Expert (SME) for their agency/department
- Attend\participate in GIS User Group Meetings
- Participate in GIS outreach initiative (GIS Day)

City and County of Denver Positions

- GIS Technician
- GIS Analyst
- Senior GIS Analyst
- GIS Data Administrator
- Staff GIS Developer
- Associate GIS Developer
- Senior GIS Developer

10.2 Successful GIS Projects in the City and County of Denver, Colorado

- **The Fire Facilities Master Plan -** In 2002, the City and County of Denver first started using GIS for Fire Department response-time analysis and to perform site suitability analysis for future fire stations. The plan's analyses are re-run yearly to ensure fire stations are built in the correct locations. This project has saved the City millions of dollars over the past 17 years. The project has allowed for site acquisition years in advance, when land is at a lower cost. It has helped find opportunities for partnerships with nearby local governments (Glendale and Englewood). This has saved all three municipalities money while providing better fire service coverage.
- **GIS Upgrade –** In 2017, Technology Services completely upgraded the City's GIS infrastructure. The scope of the project encompassed servers, enterprise geodatabases, relational databases, desktop software, and 11 enterprise system integrations. The upgrade used a tiered approach through Development, Test, QA, and Production servers. All migration tasks, load tests, and enterprise integration QA were performed on each tier, ensuring a successful migration. Rolling editing freezes allowed most agencies to work until it was time to migrate their data to the new production servers. The length of the freeze depended on the size of the data needing to be moved. A software upgrade package was created and silently pushed out to users. The GIS User Group educated users on any new functionality in the new desktop software.
- **Marijuana Regulation and Licensing –** In June 2009, there were three existing medical marijuana dispensaries in the City and County of Denver. By December of that year, this unregulated industry had grown to support more than 280 dispensaries. The Denver City Council directed the Excise and Licenses Department to regulate the industry, and the department decided to use minimum distance requirements—similar to regulations that control liquor licensing:
    - 1,000 feet from schools
    - 1,000 feet from another dispensary
    - 1,000 feet from daycare providers

A GIS analysis was performed to determine maximum buildout of dispensaries, and approval for the licensing recommendations was received from City Council. This logic was then built in, via GIS integration, to the City's licensing application. The system uses web services to validate addresses, bring back owner information from the parcel layer, and give proximity warnings if the applicant's site does not meet minimum distance rules.

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