Project Title: GIS Design for Local Government

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Abstract

Integrating and maintaining a well-organized Geographic Information Systems (GIS) within a local government organization provides numerous benefits and can improve the overall effectiveness of a governing agency. The problem faced today is that many local government agencies (particularly in rural areas) do not possess the resources or knowledge to implement a working GIS that fits the needs of their organization. There are many guides, resources, and case studies that exist, which cover the initiative to properly integrate GIS within counties or municipalities. Depending on the goals/objectives, existing GIS infrastructure, and needs of the municipality/county at hand, the approach to designing a GIS can vary greatly. This project aims to provide municipalities and counties who may be looking to develop a GIS from scratch, or improve an existing GIS, with an overview of the benefits and impacts associated with a successful GIS platform, as well as a scalable guide that can be followed to create/improve this system (suited to their organization's needs). This GIS development roadmap is broken down into four phases: 1.) A GIS marketing webpage. 2.) A GIS Needs Assessment section. 3.) A GIS Architecture Design and Development Section. 4.) An Implementation Steps section. The end GIS guide is located on the Southern Tier Central Regional Planning & Development Council webpage to be accessible by any local government interested.

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Project Background

It has become increasingly important for local governments to integrate technological advancements such as GIS into their organizations. A well-organized and implemented GIS in local government provides multiple benefits ranging from improved data storage and accessibility, to powerful geospatial analytics and visualization applications. Currently, many smaller counties and municipalities (such as towns or villages) do not have the appropriate resources or knowledge to implement and manage a Geographic Information System (GIS) to harness the full capabilities of their spatial data. The many different applications for GIS within a government agency (such as mapping for utilities, tax parcels, waste management, etc..) make it such a powerful tool that will improve the workflows of any organization, produce more informed planning decisions, and ultimately benefit the well-being of the community's residents.

As a GIS Specialist for an engineering firm in Upstate NY, I have worked with many municipalities that require regular assistance with mapping and organizing their spatial assets. Many of these municipalities have the potential to operate and manage their own GIS. However, they lack the resources, and funding, or they simply do not know the appropriate steps and components of integrating a working GIS into their organization. This capstone project is intended to provide insight on the benefits of GIS for municipal government, as well as deploy a GIS design roadmap in which small municipalities (who do not currently possess a GIS, or who are looking to improve a GIS) can implement to build and maintain a geospatial platform suited to their organization's needs. This includes a scalable approach for marketing the importance of GIS within local government, producing a GIS Needs Assessment, providing options for GIS design architectures and methods that municipalities can follow, and developing steps to implement a GIS.

Project Description

Local governments vary on their levels of resources (including financial, personnel, physical, and intellectual resources), but each local government has the single responsibility to function effectively in order to serve and protect its citizens and environment. In the case of many local governments (particularly in rural areas), there is a lack of development of their geospatial strategies and technology, leading to unorganized mapping methods and maintenance of spatial assets.

An example of a local government with little to no geospatial management is Schuyler County - a county located in the Finger Lakes region of New York State. Schuyler County has no full-time GIS employees, and doesn't have any type of GIS management strategy plan, but they currently utilize GIS as a tool within a few departments for mapping tasks. The County owns a couple of Esri ArcGIS Desktop licenses which are utilized by a couple different departments. However, many of the municipalities in the County rely on outdated (or non-existent) mapping methods. Much like any other county, if Schuyler County were to integrate a well-defined and organized GIS into their daily operations, they would find that their workflows would be enhanced, planning and management decisions would be improved (through spatial analytics), and the municipalities and citizens would be able to access a live collection of spatial data and

mapping applications. The challenges faced by this County, and many similar counties, is the lack of knowledge about GIS, the lack of resources (financial and experienced personnel), and also the lack of organizational support (or an individual or entity to spearhead the process of developing and organizing a GIS design roadmap).

Literature Review

There are numerous references available on the web highlighting organizations that developed an all-inclusive GIS roadmap for local government.

Literature # 1: <u>Getting Started with GIS - A Guide for Municipalities</u> *MassGIS. (2002)*

This paper examines 10 main topics related to GIS
1. *Introduction*
    a. *It starts out with services potentially covered by Municipalities*
    b. *"About 70 - 80 percent of all information required for local government operations is or can be depicted on a map."*
2. *Then goes over existing storage methods for municipalities and forms (maps, filing cabinets, different software) -many times found scattered in multiple locations. These methods are inadequate for the 21st century.*
    a. *Covers definition of GIS in regard to municipalities.*
    b. *Includes map features and databases*
        i. *Explains map features as "layers" and provides visuals and municipal government-specific examples of how these GIS elements work together*
    c. *Converting existing records to GIS*
    d. *GIS databases come with a high cost to construct in many cases*
3. *Highlights the current landscape of governments utilizing GIS (in Mass.), and the importance of GIS in today's world.*
    a. *"Now at least 80 communities have some level of GIS usage, with about 30 of those communities having one or more staff dedicated full-time to their GIS.*
4. *Purpose of Developing GIS*
    a. *Starts by explaining the need for GIS as well as the current landscape of GIS (how it has recently become easier to develop), by mentioning things like lower database costs, more open data (MassGIS), and easier to use.*
    b. *Provides multiple case study examples that a municipality may be faced with*
        i. *Quantitative Benefits of GIS: Can save municipality on time and finances, through requests for information by the public.*
    c. *Then goes on to provide multiple more examples of how GIS can save costs for a municipality.*
    d. *Spatial data and map-related records should be kept up to date with the newest technology, just as one would do with payroll, accounting, etc..*
    e. *Benefits can be tangible from GIS, and community may support*
5. *Developing a Single Department GIS*
    a. *While the report focuses more on multi-department GIS setups, it also includes an option for municipalities who may have limited funds, or may not have the support from other departments.*
    b. *Differentiated by Low and Modest Budget Scenarios*

       i.   *A low budget scenario focuses on the minimum features required for a working GIS, using the least amount of money possible:* **A computer, GIS software, some data, and a color printer.**
1. *Then look into each of the above in more detail*

       ii.   *A modest budget scenario is basically an upgraded version of the low budget. Again describes in more detail the characteristics and features offered.*

6. *Multi-Department GIS*
   a. *Identifies Users, GIS Team, Partnerships building, & Success and Failures of GIS*
   b. *Implementation needs to be a group effort and the municipality has to completely support the plan for GIS*
7. *How to Learn about GIS*
   a. *Workshops, Site Visits, Internet, Videos, Conferences, other meetings*
8. *Needs Analysis*
   a. *Who performs Needs Analysis (Consultant vs. in-house)*
   b. *Needs Assessment Inventory*
   c. *Needs Assessment Report*
   d. *Implementation Plan*
   e. *Database Development*
      i. *Reviews the type of info needed, where to acquire information/data, data maintenance, base maps, building out geodatabases, QA, & database costs*
9. *Software*
10. *Hardware*
11. *Staffing*
    a. *Considers municipal goals for GIS, community dynamics, and GIS consultants*
    b. *Also includes more detailed info about the GIS hierarchy such as program managers, admins, and end-users. Includes training*
12. *Funding for GIS*
    a. *Sources of funding from the State or other sources. Who pays how much*
       i. *Marketing & Continuing Costs*

MassGIS. (2002)

Literature # 2: <u>Steuben County - GIS Needs Assessment, Conceptual System Design, and Implementation Plan Report</u> *Fountains Spatial. (2009)*

This paper describes the GIS Needs Assessment, Conceptual System Design, and the Implementation Plan that Fountains Spatial inc. carried out for Steuben County, NY. It goes over the process of conducting a Needs Assessment in detail, starting with identifying all of the stakeholders involved with the GIS assessment and implementation, including County departments and some county-affiliated organizations. A large part of the paper deals with gaining user input in order to implement any type of GIS design plan. The Needs Assessment also assessed the potential applications for GIS within the County. This covers improving spatial data management on existing workflows/activities, as well as identifying ways that GIS enhances future activities. Finally, the Needs Assessment portion focuses on the required resources to meet the needs of the GIS, along with the data involved, and the GIS functionality.

A few ways in which Fountains Spatial spread awareness and gathered input for the GIS Needs Assessment was through the following actions:

- **Educational Seminar** - Provided potential users with a background about GIS and outlined the benefits of implementing a GIS. Covered topics such as GIS terminology, technology, key concepts, data types, and capabilities. Also provided demonstrations and examples in the seminar.
- **Surveys -** These surveys were distributed to departments in the early stages of the Needs Assessment to collect information to better form questions to ask during the upcoming interviews and get an idea of what each department was looking for.
- **Interviews -** All of the department managers that were taking part in the Needs Assessment were interviewed. The interview covered the *Department Profiles* (resources such as personnel, hardware, and software currently available), *Data Sources* (existing data that could be used to populate the GIS), *Potential GIS Applications* (workflows/activities that could utilize GIS), and *GIS Functionality* (complexity, access, and deployment for high priority applications)
- **Municipal Government Surveys -** Similar to the first survey, this survey was sent to the Towns and Villages within the County to gain insight and a better understanding of the current GIS layout to assist with the Needs Assessment creation.
- **Development of Needs Assessment Report -** The report was produced with the knowledge gained from the previous actions. *Fountains Spatial. (2009)*

The report explains the 'GIS Applications' section of the Needs Assessment. These applications were determined from talking with the stakeholders (from the previous steps), and were classified as either high-priority or low-priority. These applications were then classified by *complexity levels*, *user access* (who would be using the application, *data access* (i.e. read-only, edit, read-write, etc..), and *potential deployment* (i.e. desktop, web-based, mobile, public, etc..). The report then covers those high-priority applications in more detail.

The study carried out by Fountains Spatial also highlighted the current computing and internet offerings that Steuben County currently had. In detail, it brought up the operating servers on-site, the computer access to employees (as well as browser versions), the internet connection (fiber/coax/satellite/dsl/etc.), and services offered to the public and county affiliates. Current Statewide GIS programs like the NYS GIS Clearinghouse are also covered within the paper. These programs offer resources, open data, and GIS assistance for a municipality looking to establish a GIS.

A summary of the Needs Assessment focuses for Steuben County is as follows:
- · Current Use of GIS Technology
- · Existing Resources
  - o GIS Software
  - o GIS Data
  - o Technical Expertise

       o Specialized Applications

       o IT Infrastructure

·   Potential GIS Applications

·   Priority Initiatives

       o Access to GIS

       o Establish a GIS Service Bureau

       o Expand GIS Data Repository

       o Training

       o Improved Data Sharing

After the Needs Assessment was finished, a Conceptual System Design was conceived to address the following:

- *"Develop web-based GIS applications as a means of providing access to*

general-purpose GIS functionality to county departments, municipal

governments, and others.

- *Establish a "GIS Unit' to consolidate resources and improve efficiency.*
- *Expand upon the existing geodatabase architecture to create a Master GIS*
- *Data Repository." Fountains Spatial. (2009)*

Lastly, an Implementation Plan was described to provide the county with a working GIS based on the previously determined requirements.

Literature # 3: <u>A GUIDE FOR SMART COMMUNITIES: Using GIS Technology for Local Government Management</u> *International City/County Management Association (ICMA). (2018)*

Esri's collaborations with local governments have made them a useful resource for GIS applications within municipal governments. This paper expresses Esri's push for 'smart communities'. From pairing with the International City/County Management Association (ICMA), Esri has been able to understand the needs of local government and develop GIS applications suited toward fulfilling those needs. This paper describes what it takes to be a 'smart community'. There is no one true definition of what makes a community 'smart', but it is rather an individual journey that cities/counties/municipalities must take in order to develop a smart community which utilizes the appropriate technology to meet their community's goals and objectives established by leadership.

"Smart communities have an overriding purpose that leaders want to address. To do so, they establish milestones and track metrics to determine their progress. They ask questions to determine what needs to happen for the community to achieve its goals." *International City/County Management Association (ICMA). (2018)*

Managers should be asking questions and establishing reachable tasks and objectives to meet the end goals of the community. IT-savvy managers should acknowledge the purpose of smart communities and be ready to implement the six steps to becoming a smart community:

1. Organize your data.

2. Improve operational efficiency.

3. Emphasize civic engagement.

4. Develop a "mobile-first" mindset.

5. Provide the tools for data-driven decisions.

6. Set up the infrastructure for the Internet of Things (IoT)

International City/County Management Association (ICMA). (2018)

In today's technological world, there are several breakthroughs and challenges that will arise when following the path to becoming a smart community. One of them is the **movement of analog to digital data.** While this is beneficial in terms of data organization and fewer paper copies to sift through to find data, it also presents the challenge of having data that gets "trapped in the transactional, siloed systems utilized by a single city agency." **Mobile devices** are another technological advantage when it comes to working in the field, and accessing web applications on the fly. However, these mobile devices many times will not have internet access in the field and will need to be area specific. **Social media** is an efficient and effective way to spread information and to gain feedback to and from the community. **Cloud computing and open-source** code provides cross-collaboration from one organization to the next, but only if organizations are open to sharing. *International City/County Management Association (ICMA). (2018)*

"GIS provides a platform to organize our data and visualize it in ways that make it useable to individuals and teams. Before going out to collect more data, our team first reviews what data are already being stored and maintained, and then uses that information to make data-driven decisions about resource allocation, policy development, and personnel deployment." - Lori Sassoon (Deputy City Manager/Administrative Services with the City of Rancho Cucamonga.

Literature # 4: <u>Enterprise GIS for Local Government - White Paper (2007)</u> *Environmental Systems Research Institute (Esri). (2007)*

This white paper addresses the issue of isolated GIS structures within organizations, and offers best management practices to better organize and consolidate GIS within an organization using Esri's ArcGIS Enterprise.

The term enterprise refers to looking at the entire governmental structure as a single entity supported by information systems that can be used to produce the information products required by end-users while minimizing data and process redundancies." *Environmental Systems Research Institute (Esri). (2007)*

The paper promotes Enterprise GIS (EGIS) for organizations that have a large number and variety of users. The perks of EGIS for government are that it centralizes, integrates, and organizes the data resources and software tools of an organization (if developed correctly). The white paper then brings up a model known as Service Oriented Architecture (SOA), which EGIS runs on as a data and software accessing the platform via the web.

"In implementing EGIS, it is important to focus on
- *Developing an organization-wide GIS approach using standards and consistent methodologies that address the needs of all units of the organization*
- *Migrating existing GIS applications and data to current GIS technology capable of supporting all potential users in a cohesive manner*
- *Integrating GIS data and services with other information systems within the organization as part of an overall enterprise information systems solution Adapting the GIS staffing structure to support the enterprise approach*
- *Training the IT and GIS staff to design, develop, and maintain the enterprise GIS resources*
- *Training staff in the departments new to GIS in the effective use of GIS specific to their business needs"* *Environmental Systems Research Institute (Esri). (2007)*

The white paper discusses some of the obstacles to consider when integrating EGIS into government. Some of these include the time and resources needed to implement EGIS as well as setting priorities of what to include with the EGIS. Also, the migration of the organization's existing GIS systems needs to be considered in order not to lose any previously created data or affect productivity. The four major components of EGIS include **applications, database, infrastructure resources, and organization/staffing.**

EGIS offers multiple levels of services including both web-based applications and desktop GIS functionality, high-level analysis and editing capabilities, department-specific applications and access to GIS resources, and much more.

"The tiers that comprise the application concept for an EGIS include the following:
- *User Access Tier—The user access tier contains the end-user application interfaces as determined by the underlying technology platform. Each of these interfaces is an entry point for department staff and, where appropriate, the public to gain access to GIS application functionality and data resources.*
- *Business Logic Tier—The business logic tier consists of the business rules and programming logic for using GIS and other software capabilities to fulfill the step-by-step requirements of each business function. The content of this tier directs the use of the service components and server and data infrastructure tiers to perform the business functions. For example, the business logic for creating a mailing list would exist in this tier and be used by all departments in creating their respective mailing lists.*
- *Service Components Tier—The service components tier contains the GIS-based services used by Web-based applications. It also provides service-based capabilities for desktop and mobile applications. Several types of services are identified in the figure, including:*
  - *Framework services that provide the most commonly used GIS functionality and data services such as geocoding*
  - *Public access and commercial services that provide easy access to available data and Web services from external sources such as federal government sources and ArcWebSM Services*
  - *Business application services and service adapters that enable the integration of the GIS with other business systems, such as building permits, within the organization as well as authorized external systems such as those of other government entities*
- *Server and Data Infrastructure Tier—The server and data infrastructure tier provides management of and access to GIS and other data resources needed to perform the departmental business functions. It is sometimes referred to as the authoring tier because GIS data creation and editing occur on this tier." Environmental Systems Research Institute (Esri). (2007)*

Figure 1
Enterprise GIS Application Concept
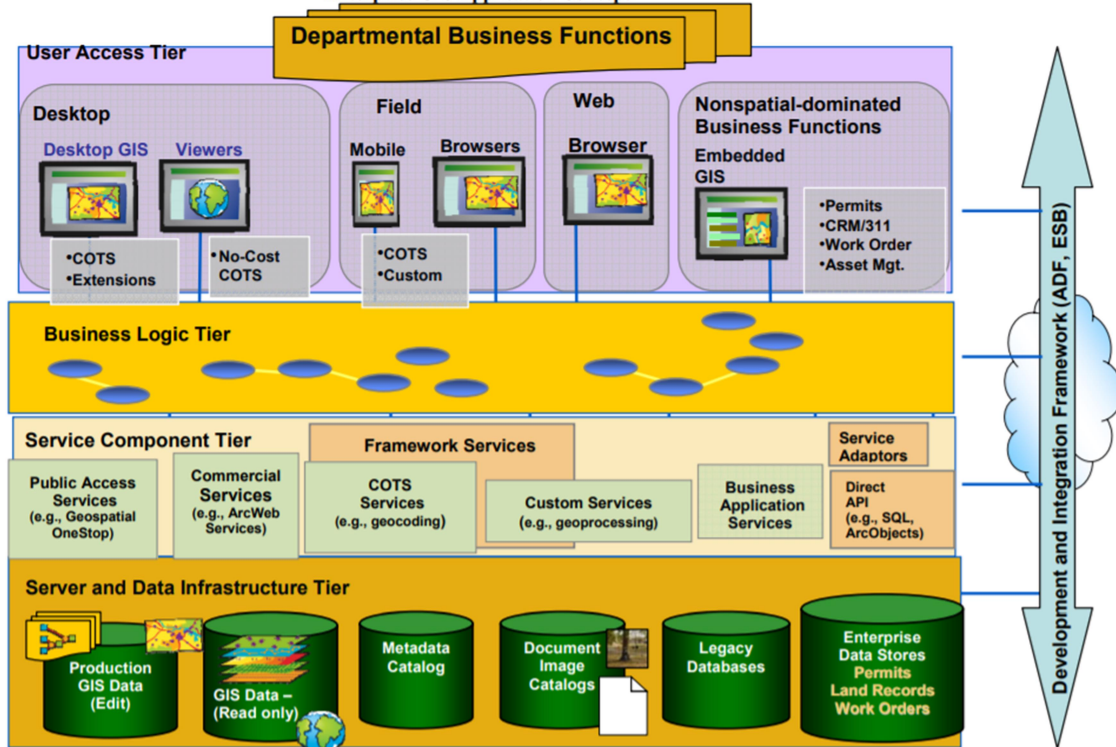
Environmental Systems Research Institute (Esri). (2007)

The white paper then goes into a detailed process for implementing EGIS into a Government organization. One of the main points to consider here is that the implementation process takes time, and is generally completed in phases in order to ensure consistency and a smooth transition. The migration of existing data from the organization can be broken up into spatial and nonspatial data. Each comes with their own challenges for migrating into the EGIS and ensuring data quality. Below is a diagram of this migration process.

Figure 2
Migration Concept

A. Typical Mixed GIS Environment

B. Transition Phase

C. Final Enterprise GIS
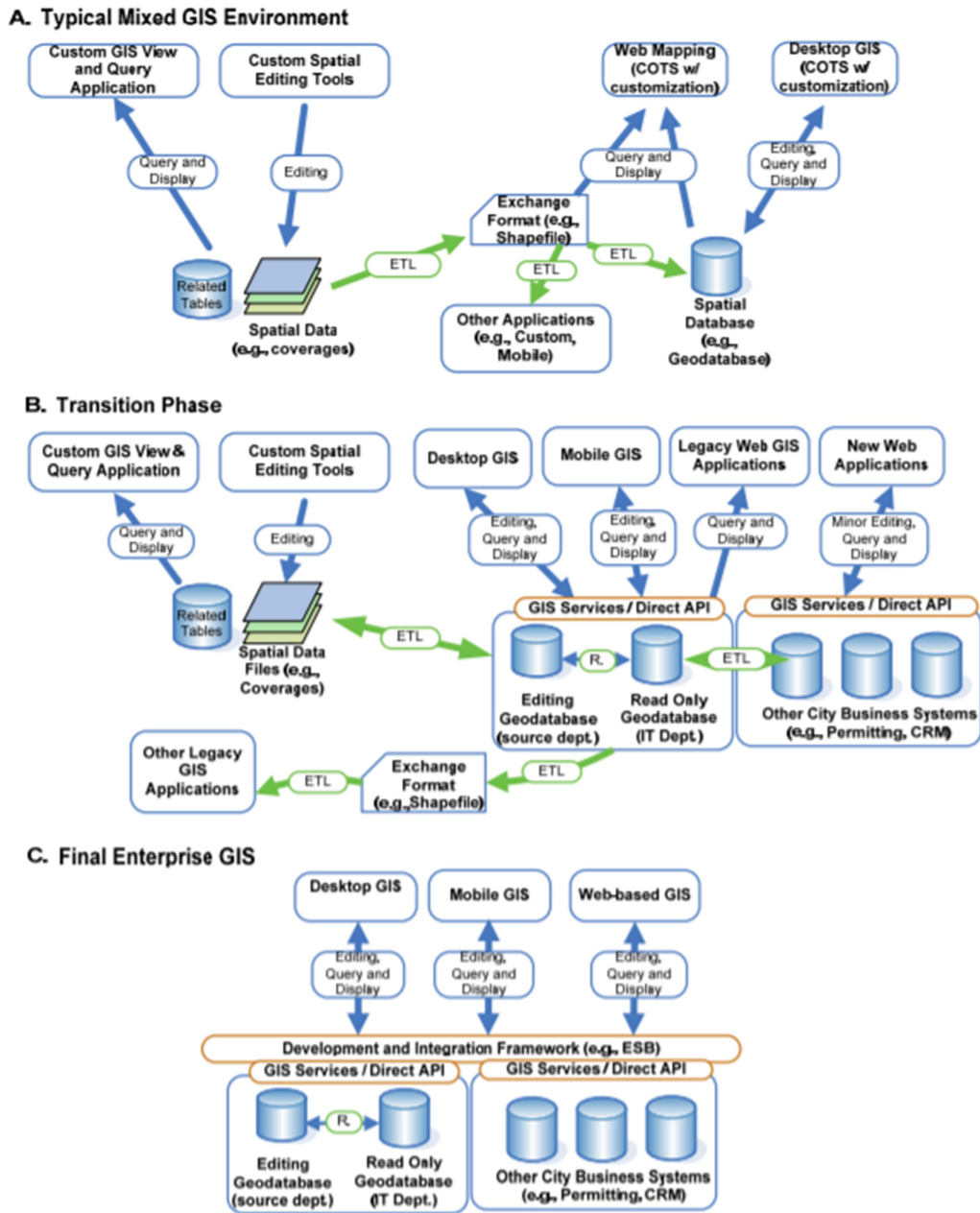
Environmental Systems Research Institute (Esri). (2007)

Literature # 5: <u>Best Practices for Local Government Geospatial Programs</u> *National Geospatial Advisory Committee. (2011)*

This paper covers a few best practices for utilizing GIS in local governments. It's broken down into four steps: **1. Establishing a Geospatial Program 2. Developing and Maintaining Data as an Asset 3. Taking an Enterprise System Approach 4. Share it with the Public.**

The first step aims to gather the appropriate people and resources needed to grow a GIS within a government. This includes planning initiatives, sustained coordination, and proper execution of the end goal. The second section sheds some light on the maintenance, organization, and accessibility of datasets that are or will be owned by the government agency. It then provides best practices for storing this data. The third group reviews and recommends an enterprise approach for governments to implement their GIS. This is mainly because of the ability of an enterprise GIS to accommodate multiple departments, software applications, workflow integration, and data types. Finally, the paper discusses the need to share the end GIS products with the public and provides options that make this possible, such as web-based data hubs.

Filling in the Gaps:

These three papers cover multiple aspects of installing GIS for local government. The first paper focuses on a scalable approach to establishing a working GIS for counties and municipalities while focusing on many different aspects to consider in the process. The second paper goes into great detail on setting up a Needs Assessment for GIS implementation, a systematic approach to produce this Needs Assessment, and then creating a Conceptual Design and an Implementation Plan. This paper only focuses on the County/municipal level, however. The third paper focuses on the marketing aspect of GIS for local government, and uses terms such as 'smart communities' to set the foundation for GIS planning within a government.

A specific aspect that I will focus on improving from the literature referenced above is the integration of web GIS and enterprise systems (primarily dealing with Esri software). Many of these pieces of literature are slightly outdated and reference older GIS software. One of the primary topics covered in the literature that I will focus heavily on in my project is the Needs Assessment, which would be vital for any government to deploy when considering implementing a GIS. I'll use the Needs Assessment produced by Fountains Spatial (for Steuben County, NY) and the one produced by the State of Massachusetts (both in the literature review) as a reference, while adding material from my own experience and Penn State courses to develop a scalable Needs Assessment outline.

Methods

Goals and objectives

As seen in the Literature Review section, documented material has already been developed to assist municipal governments in crafting a functioning GIS. This project aims to develop a scalable framework that any municipality can follow to plan for, design, and implement a working GIS into their organization. This will be accomplished by referencing the information found in the above literature, as well as applying knowledge gained from personal professional GIS experience, and content learned in GEOG 868 & GEOG 583 and other Penn State MGIS courses.

The Marketing section (Appendix A) of my project will explain the importance of GIS for local government, and provide examples of how it may benefit the planning, management, financials, and the overall day-to-day operations of a government agency. For this section, I will reference previous works, such as ESRI web pages and story maps, while adding my own visual and organizational touch. This section is intended to capture the audience's attention and hopefully relate to their organization's needs. It will be in the form of a webpage hosted on STC's website.

The GIS development guide is the next major component of my project. This GIS guide (or roadmap), offers strategies and ideas to consider when creating/updating GIS infrastructure. This guide is broken down into three sections: 1.) The GIS Needs Assessment (Appendix B), 2.) GIS Design & Development (Appendix C), and 3.) Implementation (Appendix D). These sections are compiled together into an Esri Story Map, which is accessible through the Marketing section webpage, located on STC's website.

Analysis/Development

The three main deliverables for this capstone project are the Report, the Marketing webpage, and the GIS Guide Story Map. which will contain information a local government needs to know to make a well-informed decision on how to utilize GIS in their agency.

Marketing Section

- What is GIS
  - Definition
  - Components
- How it fits into a local government system
  - Includes the benefits acquired by integrating GIS
- GIS applications
  - Provide examples from 'Smart Cities/Communities based on common municipal responsibilities
- Resources available for training and learning more about implementing GIS
- Financial
  - Cover the potential costs and money saved by using GIS within the organization

○ Include Federal and State grants available to municipalities

Needs Assessment Section

- Define purpose and goal of GIS in the organization
- Define GIS users, applications, software/hardware
- Reference course material and existing case studies
  ○ Reference Geog 583 – Lessons 2 & 3
  ○ Reference Steuben County Needs Assessment report & Massachusetts report
  ○ From these, I will produce my own version of a Needs Assessment specified to any size municipality.

Architecture Design & Development Section

- In this section, I will produce diagrams and cover the necessary hardware, software, and other GIS infrastructure to give the audience an idea of what a potential GIS architecture would look like.

  o Since there are multiple ways to configure GIS within an organization, I will focus on Esri's Enterprise because of its ability to effectively integrate into any organization, and its web accessibility.

  o Here, I will also briefly cover Desktop GIS options, and Open-Sourced GIS options.

- Reference course material and other available resources
  ○ Reference Geog 583 – Lesson's 5 & 8, and Geog 868
  ○ Reference Steuben County Needs Assessment report & Massachusetts report
  ○ Reference Enterprise for Local Government – Esri whitepaper

Implementation Section

- Create a list of steps to follow to implement the GIS into the organization

Challenges and/or limitations

The primary constraint associated with this type of project is the willingness of a municipality to want to support a GIS improvement project. To test out my GIS roadmap strategies, I reached out to Schuyler County (mentioned in previous sections) to offer assistance and guidance to improve their GIS. After many attempts of contact, and very little cooperation, I realized that it is not only necessary for engagement from the government organization, but also that the GIS marketing aspect is a vital first step to highlight the importance of GIS. Without discussing the benefits and relevant applications that a GIS can bring to an organization, there is little chance that the project will gain any traction. This is where a leader or GIS Champion from within the organization would need to come forward.

There are also a handful of other challenges associated with improving/creating a GIS within a local government, to name a few:

- Lack of funding/resources from the organization
  - Includes insufficient personnel, hardware, and budgets
- Lack of interest from the local government
- Time allocation to work on a GIS improvement project
  - A sufficient GIS needs assessment and design development takes plenty of time
- Hesitancy of organizations to adapt to geospatial technology
- Lack of government's understanding on GIS and technology in general

Future considerations - What comes next?

As a continued effort to ensure this project has some type of impact, I will continue to reach out to STC and the municipalities within the Southern Tier region to see if they have questions or interest in improving their geospatial management. The webpage and GIS roadmap story map will be available to the public on STC's website. For municipalities interested in improving/developing a GIS, I will work with them and STC to identify their needs and develop an effective solution to get them set up and trained with a functioning GIS.

Expected Results:

The final products for this project include the following:

1. **This Report**
2. *What is GIS? -* **Webpage** (https://www.stcplanning.org/what-is-gis/)
   a. An easy-to-access resource for government employees and managers to review to understand the benefits and applications of integrating a well-organized GIS into their organization.
3. **GIS Design Strategies for Local Government - Esri Story Map**
   (https://storymaps.arcgis.com/stories/f643f14ed9b34a139826793ad61f682e)
   a. Contains the methods, steps, and components for a local government to consider when creating or improving a GIS.
   b. Includes two Questionnaires used to gather information from government agencies to develop the Needs Assessment.

Timeline

Marketing Section: October - November

Begin Report Draft

Start Designing Webpage

***Needs Assessment Section:** November - January*

***Architecture Design Section:** January - February*

***Implementation Section:** February - March*

Conference

Present at <u>STC Regional Leadership Conference</u>

- March 31st, 2022 @ Corning Community College

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*Images & Diagrams produced and sourced from Lucidchart.*

Appendix A

GIS Guide for Local Government - MARKETING SECTION

- *This GIS Guide highlights the multiple benefits that a GIS offers when integrated properly into a local government, as well as provides the foundation of what to consider if you are a part of a local government that is seeking to create, expand, or improve GIS within your agency.*

Example Web Map:
STC Service Area Map

- **What is GIS?**
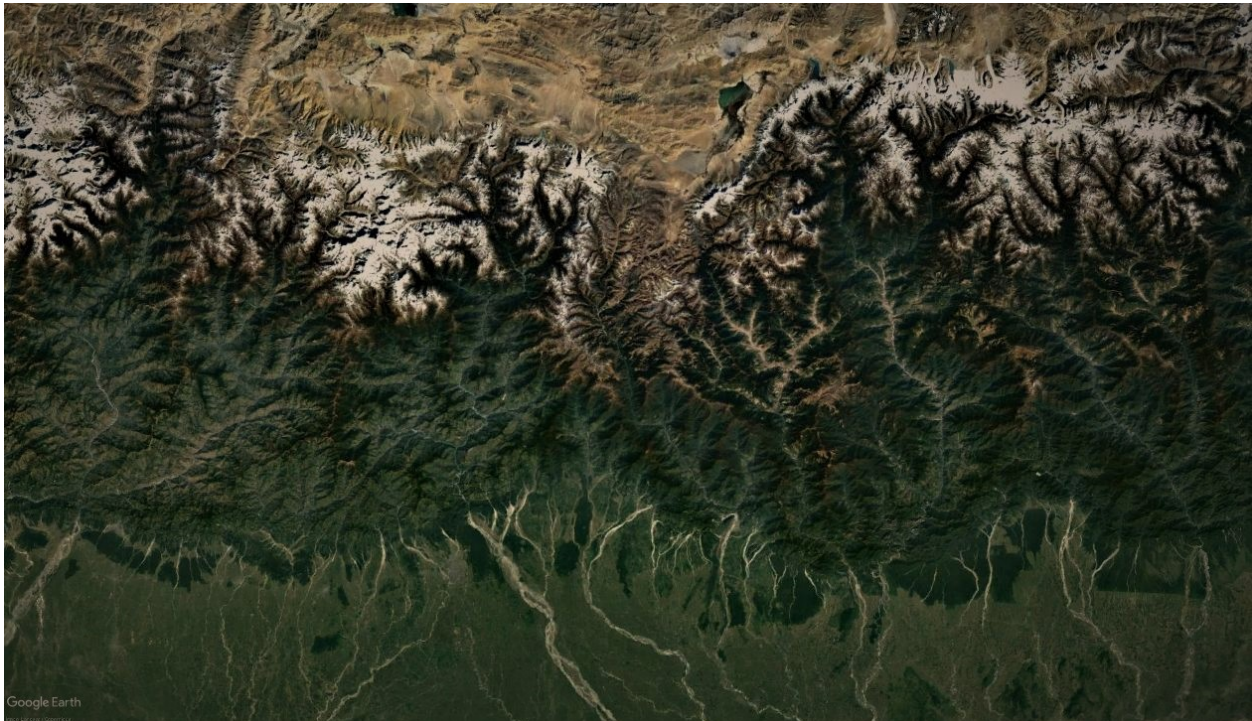
   - A Geographic Information System (GIS) is the platform (composed of software, hardware, data, people, and methods) used to track geospatial information and perform tabular and spatial analysis in order to gather useful information and devise informed decisions. It is what mapping has progressed to in today's technological age, through using spatial data to produce maps, and identify patterns and relationships.

   - Humans have forever benefited from mapping, from the ancient Babylonians mapping their perceived view of the known world in the fifth century BCE, to

aerial imagery flown by airships for planning strategic wartime advancements in WW1.

○ Today, with the accessibility of the internet, cloud-based computing, and user-friendly software, mapping has become more widespread and effective for organizations to better plan, improve workflows, and provide more accurate services.

○ A traditional GIS setup is composed of software that offers intricate analysis and spatial analysis that can be performed on the underlying GIS data. The data that makes up a GIS can range from any object that has a spatial attribute to it (houses, roads, ice cream stores, national parks, etc.). The true power of GIS lies within the ability to track the spatial positioning of this data, along with any associated information tied to it, and then the ability to perform relational and other types of spatial analysis with the data to gather additional information.

○ GIS, when utilized properly, will enrich an organization's planning, asset management, and decision making through understanding where spatial data is located, what information is associated with it, and how this data reacts to each other and its environment. This is why GIS is so widely integrated within government agencies.

DIAGRAM 1:

SVG (Transparent Background) - file:///C:/Users/pwmann08/Downloads/Capstone%20(1).svg
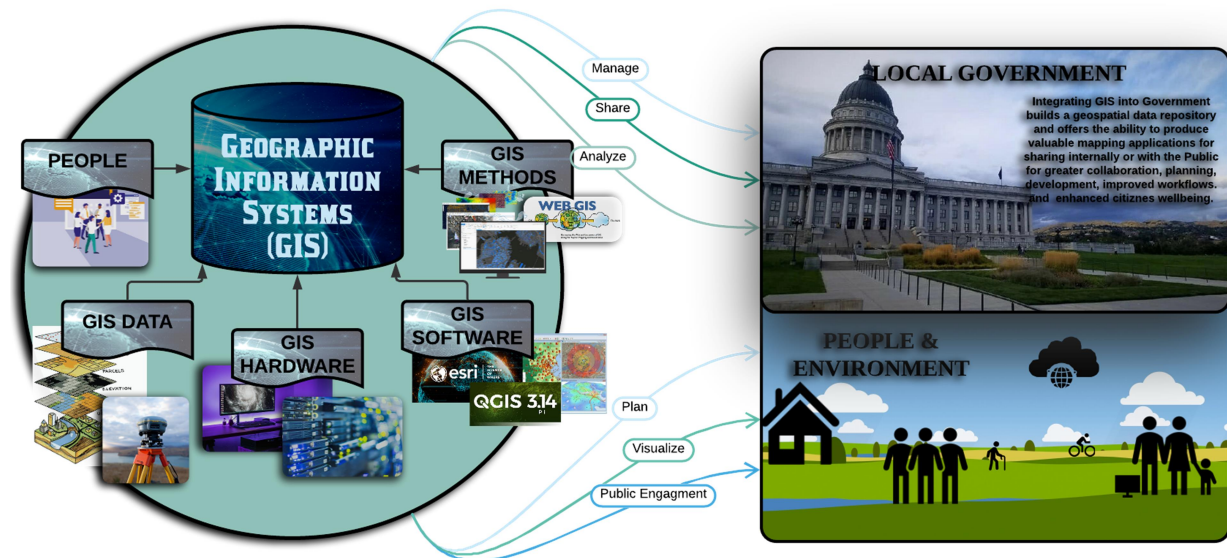
(Made with Lucid Chart)

● **Blending Geography, Local Government, and Technology**

- ○ Whether it's in the form of hand-drawn paper maps, or custom-designed web mapping applications, each government that owns or maintains a functioning infrastructure can understand the importance of tracking its spatial assets.
- ○ **LOCAL GOVERNMENT**: Government (no matter the size) has a critical role to provide for its citizens in multiple aspects of life.
  - ■ Policy - Decision Making
  - ■ Services
    - ● Multi-Departmental
      - ○ Infrastructure (Utilities)
      - ○ Emergency Management
      - ○ Planning
      - ○ Natural Resources
  - ■ Citizens
    - ● Public Health/Safety
    - ● Community engagement
- ○ GEOGRAPHY: Living on a 3-Dimensional planet, we are fortunate to be surrounded by geography and all of the Earth's elements everywhere we go. As a government, this habitation amongst geospatial objects leads to the responsibility to appropriately plan, manage, and protect the integrity of these geographic resources, along with those living among them.
  - **Fun Fact:** *About 80% of data captured has some type of geospatial component.*
  - ■ *Geospatial relationships*
  - ■ *Geospatial Patterns*
  - ■ *Prediction of patterns through spatial modeling*
  - ■ *Tracking object's location within Earth's changing environments*

- ○ TECHNOLOGY: With technology exponentially becoming part of how we operate in our daily activities (specifically in the work environment), our ability to integrate our mapping of these geospatial aspects can drastically improve the well-being of a government. Web-based computing allows for the sharing and accessibility of information and applications.
  - ■ User-friendly Software
  - ■ Cloud-based computing
  - ■ Web Applications
  - ■ Web Sharing
  - ■ Open Data/Big Data
- ● **Where is Your Community at?**
  - ○ *Example of a Rural Community with hard-copy mapping practices*
    - *Municipality X*
      - ● *A Rural community that is home to 6,000 inhabitants*
      - ● *Maintains Public Services such as:*
        - ○ *Sewer/Water/Stormwater Management*
        - ○ *Waste services*

- ○ *Parks & Recreations Services*
- ○ *Emergency Management Services*
- ● *Some Infrastructure assets are mapped, but these are found only on engineering drawings, and the few remaining hard copy maps.*
- ● *Some spatial data exists at Municipality X, but it is scattered across multiple folder drives, hard drives, and on individual employee's computers.*
- ● *Has no GIS in place, but over the years, Municipal X employees have utilized desktop versions of GIS software, such as Google Earth, ArcMap, and QGIS.*
- ● *Municipality X relies heavily on Contractors to produce and maintain their maps and asset tracking. Many times, the mapping products and solutions made by these Contractors don't make it back to Municipal datasets for inventory.*
  - ○ *Example of Smart Community with GIS-integrated mapping practices*
    GIS for Municipalities (arcgis.com)
  - ○ UNDERSTAND YOUR COMMUNITY AND YOUR GOVERNMENT'S ROLE WITHIN IT TO IDENTIFY YOUR MAPPING NEEDS.
- **How Does GIS Work?**
  - ○ **DATA**

    At the foundation of a GIS is spatial data. This data can be compromised of any type of physical object, as well as non-physical information that is tied with that object (i.e., Census Blocks, which contain information about population, demographics, etc..).

    Today, there is an abundance of open-source GIS data that can be accessed on the web.

    Geospatial data can also be created from the following methods:
    - ● Field data collection
      - ○ Using high accuracy GPS devices
      - ○ Tablets/Mobile devices
    - ● Digitizing data - digitally drawing in spatial data through a GIS software.
      - ○ Vector data - points, lines, polygons
      - ○ Reference objects through aerial/satellite imagery
      - ○ Reference objects through georeferenced engineering drawings
    - ● Capture aerial imagery with planes or drones
      - ○ Raster data - a mosaic of images spatially referenced.

    GIS Data Standards
    - ● Open Geospatial Consortium (OGC) Standards and Resources
    - ● International Organization for Standardization (ISO)

  - ○ **GIS SOFTWARE & HARDWARE**

The technology of maintaining a local GIS infrastructure has changed drastically in the past 20 years alone. Prior to the cloud-serviced platform that exists for many GIS architectures today, organizations would need to purchase large computing systems and servers (stored in-house) to support their desktop GIS applications. Today, GIS software providers will work directly with their customers to ensure that the software and hardware needed will be intertwined with the organization's existing infrastructure, budget constraints, personnel, and other constraining resources.

With the web-based GIS being the norm for most GIS platforms, it allows for users to work independently on their desktop applications, but it also allows them to share and access data to and from the web. Esri's Web GIS is one of the leading geospatial architectures due to its connectivity. Integration and accessibility of a wide range of publicly available GIS resources.

- ○ **MAPS & APPLICATIONS**

  Maps are the physical by-product of a GIS. They allow field crews to locate physical structures in the real world. They provide managers and decision-makers with the spatial insight needed to produce quality decisions. And, they allow a government to convey important information to their citizens in a visually pleasing and informative manner.

  Today, hard-copy and digital mapping applications can be produced by using GIS software. Being able to create these digital and physical maps to be tailored towards the needs of the end-user is a primary advantage of owning and operating a GIS.

  Esri's Web Mapping applications consist of shareable online Web Maps (either for the public or within an organization), Dashboards, Field Collector Apps, and other custom-made mapping applications for spatial analysis or viewing applications.

- ● **Benefits & Applications of GIS**
  - ○ Some governments are fortunate to have greater resources, budgets, technology, and staffing than others, but all governments are capable of integrating a GIS into their work environment.
  - ○ Take some time to consider how spatial resources are currently managed within your government. Could they be improved?
  - ○ Examples of how GIS could fit into a local government
    - ■ Management and tracking of government-owned and maintained infrastructure
    - ■ Improved planning and policies due to the ability to identify patterns, relationships, and geographic distribution of information.
    - ■ Enhanced public engagement opportunities
    - ■ Improved accessibility, sharing, collection processes, and analysis of municipal data.

- ○ GIS can be applied to the following Government Departments.
  - ■ Public Works
    - ● Water, Sewer, Stormwater, Waste Management, Electric, etc. (Example City of Aurora Wastewater & Stormwater Web Maps for public use)
    - ● With the infrastructure of each of these departments encapsulated into a well-organized GIS, users can access (view, edit, create, or analyze) data with much quicker and easier processes than if the data were stored outside of a GIS database.
    - ● Mylars, Engineering Drawings, and other Plans can be scanned in and incorporated into the GIS database for the enhanced organization of government assets.
  - ■ Real Estate (Find Example)
    - ● Tax Parcel Mapping
    - ● Land Acquisitions
      - ○ The ability to reference multiple layers within GIS (whether they are publicly available or captured internally) when making land management decisions can greatly influence the quality of the decision.
      - ○ Multiple types of geospatial and data analysis can also be performed to answer any type of question about the land at hand.
  - ■ Emergency Management
    - ● Fire, Police, Health Management, Emergency Response services
  - ■ Natural Resources/Parks and Rec.
    - ● Environmental Mapping Services
    - ● Trails (Outdoor Activities in Steuben County (arcgis.com))
    - ● Parks
    - ● Endangered Species
    - ● Protected Areas
    - ● Agriculture
  - ■ Community Engagement/Public Health
    - ● COVID-19 Map - Johns Hopkins Coronavirus Resource Center (jhu.edu)
  - ■ Transportation
    - ● Mapping Roads, Highways, Bridges, etc.
- ○ Benefits include:
  Decrease of community finances through improved management decisions, more accurate data, and saved time on workflows.
  With Cloud technology and more seamless GIS integration into existing workflows, it's easier now than ever to implement.
  The growth of GIS/geospatial infrastructure is a forward-thinking process for a sustainable government for future generations.

- **Resources & Training**
  - Like any new software or work procedures implemented in your organization, GIS requires regular training for staff to stay up to date with the newest mapping technology and better maintain spatial assets.

    Do not hesitate to reach out to GIS consultants, regional planning committees, or even educational institutes to gain more information. Fortunately, Esri and other GIS organizations provide an abundance of training courses and online articles (for free) that allow any employee access to all of the GIS information they need.

    Where to find GIS training?
    - Free GIS Resources | Get Started with GIS (esri.com)
    - https://www.nypl.org/collections/nypl-recommendations/guides/gis
    - Learn GIS for Free - GIS Lounge
    - Esri Community | GIS Professional Community
    - Literature # 3: A GUIDE FOR SMART COMMUNITIES: Using GIS Technology for Local Government Management

      Esri's collaborations with local governments have made them a useful resource for GIS applications within municipal governments. This paper expressess Esri's push for 'smart communities'. By pairing with the International City/County Management Association (ICMA), Esri has been able to understand the needs of local government and develop GIS applications suited to fulfilling those needs. This paper describes what it takes to be a 'smart community'. There is no one true definition of what makes a community 'smart', but it is instead an individual journey that cities/counties/municipalities must take in order to develop a smart community that utilizes the appropriate technology to meet their community's goals and objectives established by leadership.

      "Smart communities have an overriding purpose that leaders want to address. To do so, they establish milestones and track metrics to determine their progress. They ask questions to determine what needs to happen for the community to achieve its goals."

      Managers should be asking questions and establishing reachable tasks and objectives to meet the end goals of the community. IT-savvy managers should acknowledge the purpose of smart communities and be ready to implement the six steps to becoming a smart community:
      1. *Organize your data.*
      2. *Improve operational efficiency.*
      3. *Emphasize civic engagement.*
      4. *Develop a "mobile-first" mindset.*
      5. *Provide the tools for data-driven decisions.*
      6. *Set up the infrastructure for the Internet of Things (IoT)*

      In the technological world today, there are several breakthroughs and also challenges that arise from these breakthroughs that will arise when following the path to becoming a smart community. One of them is the movement of analog to digital data. While this is beneficial in terms of data organization and fewer paper copies to sift through to find data, it also presents the challenge of having data that gets "trapped in the transactional, siloed systems utilized by a single city agency." Mobile devices are another technological advantage when it comes to working in the field, as well as accessing web applications on the fly. However, these mobile devices many times will not have internet access in the field and will need to be area specific. Social media is an efficient and effective way to spread information and to gain feedback to and from the community. Cloud computing and open-source code

- **Funding & Grants**
  - While many governments currently own and operate some form of GIS, it is always in the best interest for all governments, including the State and Federal levels to operate a well-managed GIS. With a continuous need for improved GIS architecture at all levels of government, State and Federal grants are often available for small to mid-sized municipalities for technology projects that will improve the operation of these governments.
    > Some municipalities and local governments that already rely on state and federal grants for infrastructure or other capital improvement projects may already be aware that mapping can play a large role in applying for these grants.
    > Many times smaller governments and municipalities rely on private firms to take control of their mapping needs. This option is fine; however, the process of going through a firm to access municipal-owned assets may not always be ideal.
  - Grant Resources to get started:
  - Other Funding Opportunities:
    > Pair with non-for-profit organizations, such as K-12 schools, Community Colleges, universities, regional planning commissions, and state agencies.
    > Work with Esri to come up with viable, cost-effective GIS solutions.
    - Or explore FOSS GIS alternatives.
  - Understand that the upfront and maintenance costs for implementing, improving, and managing geospatial operations are very often outweighed by the monetary and overall benefits that a GIS offers.

https://storymaps.arcgis.com/stories/cd9fc97e778041ee94a50af034520811

Snow removal Web map:
https://gis.edmonton.ca/portal/apps/webappviewer/index.html?id=c69d03c2d216415e820c45d7ea2566bf

Community Development & Future Zoning Web Map:
https://www.arcgis.com/apps/Viewer/index.html?appid=6ee490c8e45f44a18e2e93f697e3fc7f

Appendix B

GIS Guide for Local Government - Needs Assessment

VI. THE NEEDS ANALYSIS

Why do the needs analysis? How is it conducted? Answers to these important questions are below.

The needs assessment serves multiple purposes.

1. It results in an inventory of existing geographic information.

2. It forces the GIS project team to take a global look at geographic information resources and use across all departments.

3. It identifies how geographic information is presently used, thus laying the foundation for reaching agreement on what GIS capabilities you want to develop, with related decisions about the content of and priorities for building the various parts of your GIS database.

4. It helps you identify strengths and weaknesses in your existing map resources; this information will be important to know as you start planning how to build and what to budget for your GIS database.

5. It may help you identify a GIS capability that you can deploy relatively early, thus giving you an early successful result for your GIS project.

6. It will reveal if any individual departments have already embarked on software projects with a GIS component. For example, your public works department may have purchased a pavement management system that displays a pavement status map by color-coding a street network. Likewise, your assessor's property valuation software may enable you to display assessing information as a map. While these two systems serve the specific needs of their departments, the GIS data required could be beneficial to other departments as well. However, that benefit can only be realized if departments collaborate on building a shared GIS resource. This kind of a finding is particularly valuable as it helps make the case for developing a shared GIS database.

7. It provides the raw information you need to develop an implementation plan for your GIS project that includes a project design and scope, schedule, and budget.

A needs analysis accomplishes these results by systematically collecting detailed information about the following:

- Currently used maps;

- Currently used databases and files containing a link to a geographic location (e.g. address, parcel identifier, etc.);

- Existing processes (e.g., plan review) in all departments that use maps and other geographic information) - any processes (e.g., building permits) that involve multiple departments, boards, or committees should be described and diagrammed and the geographic information required at each stage should be identified;

- The responsibilities of existing departments as they pertain to the use and maintenance of maps and any records that could be associated with a geographic location;

- Existing computers and computer networks (if any); and

- Existing software.

"The first step of any design activity should involve efforts to understand what the new GISystem needs to produce, who its users are, and what context the system will work within. This phase of design is called Needs Assessment (also called Requirement Analysis in some cases). Defining the "needs" of the new system up front allows you to identify key design issues before implementation starts, and also provides a set of benchmarks against which you can evaluate the final system." (PSU, 2021 - GEOG 583 Lesson 2)

NOTE: The Needs Assessment process may be performed through a variety of methods, which focus on specific elements of the GIS. These methods can be selected by the organization designing the GIS to best plan for their system's success. Covered within this Guide are a few of the fundamental Needs Assessment components that should be considered for any organization designing a GIS.

Before jumping into the requirements of a Needs Assessment, there are a few suggestions to consider that drastically improve design and planning progress. Like any project, implementing or revamping a GIS within a local government requires hours of strategic planning, and truly understanding the purpose of the GISystem, and its role in the organization. Below are some important strategies to consider to aid in the project development (PSU - GEOG 871):

1. Develop a strong internal GIS planning team.
    a. Consider including organizational employees from different disciplines, departments, or municipalities
    b. Reach out to existing partnerships or consultants within the community for assistance
    c. Also, remember to stay on top of progress. Includes regular meetings, setting tasks, and allocating responsibilities.

2. Develop a project scope to formally establish the organization's commitment and expectations for the project, as well as determine a vision of how GIS will be integrated within the Organization..
    a. Understanding the scope of the project will provide goals and objectives for the GIS implementation/improvement project and will help set benchmarks to track progress.
3. Consider outsourcing work to a GIS implementation consultant.

4. Learn as much about GIS as possible. Research online examples of other municipalities GIS implementation journeys (see an example of Steuben County's Needs Assessment). Other ways to acquire knowledge on GIS include:
    a. Professional Conferences
    b. Instructional Videos (Esri posts many of their webinars on YouTube for free)
    c. Training Workshops
    d. Ask existing colleagues or hire professional GIS consultants

Needs Analysis Components:
    a. Who performs Needs Analysis (Consultant vs in-house)
    b. Needs Assessment Inventory
        i. Identify Purpose for System
        ii. Identify Users
            1. Primary functions
            2. Scenarios
            3. Personas
        iii. Existing Resources
            1. Current Database and Record Structure
            2. Existing Hardware/Software
            3. Existing GIS/Mapping Applications
            4. IT Infrastructure
            5. Technical Expertise
            6. Existing Budget
        iv. Potential GIS Applications
        v. Priority Initiative
            1. What needs to be completed in order to implement a working GIS?
    c. Needs Assessment Report

Creating Prototypes to conceptualize your design (either paper or hard-copy) allows the planners to piece together the multiple components determined in the Needs Assessment to come up with an implementation Plan for the GIS.

Literature # 2: Steuben County - GIS Needs Assessment, Conceptual System Design, and Implementation Plan Report

This paper covers the GIS Needs Assessment, Conceptual System Design, and the Implementation Plan that Fountains Spatial inc. carried out for Steuben County, NY. It goes over the process of conducting a Needs Assessment in detail, starting with identifying all of the stakeholders who will be involved with the GIS assessment and implementation. This covers the County-ran departments, as well as some county-affiliated organizations. A large part of the paper deals with gaining user input in order to implement any type of GIS design plan. The Needs Assessment also assessed the potential applications for GIS within the County. This covers improving spatial data management on existing workflows/activities, as well as identifying ways that GIS enhances future activities. Finally, the Needs Assessment portion focuses on the required resources to meet the needs of the GIS, along with the data involved and the GIS functionality.

A few ways in which Fountains Spatial spread awareness and gathered input for the GIS Needs Assessment was through the following actions:

- ***Educational Seminar*** *- Provided potential users with a background and benefits of GIS, and well as covering things like GIS terminology, technology, key concepts, data types, and capabilities. Also provided demonstrations and examples in the seminar.*
- ***Surveys -*** *These surveys were distributed to departments in the early stages of the Needs Assessment in order to collect information to better form questions to ask during the upcoming interviews, as well as to gain an idea of what each department was looking for.*
- ***Interviews -*** *All of the department managers that were taking part in the Needs Assessment were interviewed. The interview covered the Department Profiles (resources such as personnel, hardware, and software currently available), Data Sources (existing data that could be used to populate the GIS), Potential GIS Applications (workflows/activities that could utilize GIS), and GIS Functionality (complexity, access, and deployment for high priority applications)*
- ***Municipal Government Surveys -*** *Similar to the first survey, this survey was sent to the Towns and Villages within the county to gain insight and a better understanding of the current GIS layout to assist with the Needs Assessment creation.*
- ***Development of Needs Assessment Report -*** *Produced with the knowledge gained from the previous actions.*

The report explains the 'GIS Applications' section of the Needs Assessment. These applications were determined from talking with the stakeholders (from the previous steps), and were classified as either high-priority or low-priority. These applications were then classified by complexity levels, user access (who would be using the application, data access (i.e. read-only, edit, read-write, etc..), and potential deployment (i.e. desktop, web-based, mobile, public, etc..). The report then covers those high-priority applications in more detail.

The study carried out by Fountains Spatial also highlighted the current computing and internet offerings that Steuben County currently had. In detail, it brought up the operating servers on site, the computer access to employees (as well as browser versions), the internet connection (fiber/coax/satellite/dsl/etc..), and services offered to the public and county affiliates. Current Statewide GIS programs like the NYS GIS Clearinghouse are also covered within the paper. These programs offer resources, open data, and GIS assistance for a municipality looking to establish a GIS.

A summary of the Needs Assessment focuses for Steuben County is as follows:

- *Current Use of GIS Technology*
- *Existing Resources*
  - *GIS Software*
  - *GIS Data*
  - *Technical Expertise*
  - *Specialized Applications*
  - *IT Infrastructure*
- *Potential GIS Applications*
- *Priority Initiatives*
  - *Access to GIS*
  - *Establish a GIS Service Bureau*
  - *Expand GIS Data Repository*
  - *Training*
  - *Improved Data Sharing*

After the Needs Assessment was finished, a Conceptual System Design was underwent to address the following:

- *"Develop web-based GIS applications as a means of providing access to general-purpose GIS functionality to county departments, municipal governments, and others.*
- *Establish a "GIS Unit' to consolidate resources and improve efficiency.*
- *Expand upon the existing geodatabase architecture to create a Master GIS*
- *Data Repository."*

Lastly, an Implementation Plan was described to provide the county with a working GIS based on the previously determined requirements.

Questionnaire 1:

Preliminary Survey - Used to gauge initial Local Government's GIS status

Questionnaire 2:

GIS Users Survey - Sent to each Department/Municipality to understand GIS users, data/software/hardware, applications, and goals

B. Map Use/Maintenance

Office/Department/Organization _____

Contact _____ Phone _____

Please indicate characteristics and features of each map that your office uses, maintains, or updates. Complete a form for each map or map set. Identify and attach a sample map copy, index map, and map legend.

Official Map/Map Set Name _____

Common Map Name _____

Scale _____   Sheet Size _____   # Sheets in Set _____

Source _____ Accuracy (+/- ft., if known) _____

Area of Coverage _____

Features Shown _____

Media: Paper _____   Mylar _____   Linen _____   Sepia _____   Other _____

Are the map features computerized? _____   If yes, Using what software (GIS, CAD, consultants)?

_____

What do you use this map for? _____

_____

How often do you use this map? _____

Who updates this map? _____

Briefly explain procedures for updating _____

_____

Source of updates _____

How often is it updated? _____

List any inaccuracies or inadequacies in the mapping _____

_____

C. Database/Record

Office/Department/Organization _____

Contact _____   Phone _____

*Please indicate the characteristics and features of each database or record (including card files)
in a file cabinet that your office utilizes, maintains, or updates. Complete a form for each
database set. If a blank copy is available, please attach a copy to this form.*

Database/Record Name _____

Do you maintain this database/record? _____ Yes   _____ No

If no, who maintains it?_____

Computerized (Yes/No)? _____   Do you Share this database with another dept.? _____

If database shared, are there any Problems with Sharing the Data? What? _____

_____

Reference to location is: ____Property ID ____Address ____Other

If computerized:

Software type?_____

Database on what kind of computer: _____

Approximate # of current records _____

Approximate number of new records added annually: _____

# of people needing access to this information _____

Any problems/issues with the current system? _____

_____

If not computerized:

Approximate # of paper files_____

Approximate number of new records added annually: _____

Frequency that files are updated _____

# of people needing access to files _____

Location of files_____

Would you like to have these files computerized? _____ Yes   _____ No

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Appendix C

GIS Guide for Local Government - Design & Development Section

Strategic GIS Planning and Management in Local Government (routledgehandbooks.com)

The design and development portion of implementing a GIS for local government is heavily dependent on the agency's current operational, financial, and technological makeup. There is no set way for building (or improving) a GIS architecture within an organization. The beauty of GIS today is that it is extremely customizable and flexible to fit into the operations of any organization. Evaluating the findings of the Needs Assessment will pave the road for building out your GIS.X

- There are many FOSS (Free and Open-Sources Software) GIS options out there, and these may be suitable for your agency.
    - Great for individuals who use GIS as a tool for producing quick maps, analysis, reports, etc..
    - Many of these options also include high-level spatial analytical tools and functions, which one would find in proprietary GIS software.
    - Worth exploring
- Another important factor to consider when designing a GIS for government is to consider the overall use of the system.
    - Will it be a one-user GIS, or a multi-user?
    - Where will the Data come from to support the GIS?
    - Will users be creating data, analyzing data, editing data, or a combination of these?
    - What are the end products that GIS users will be producing? Web maps? Hardcopy Maps? Both?
- Sharing GIS within multiple departments of government agency, as well as publicly sharing GIS material
    - Offers many advantages, like data accessibility
    - Ability to develop custom GIS Web Mapping Applications to share with the Public, or internally.
    - For this option, may look into an Enterprise GIS setup

5 Main Components of GIS:
- *Data: A GIS without data to populate it would be like a grocery cart with no food in it. Spatial data accounts for a point, line, or area that is defined in relation to its geographical space on the Earth. In addition to this spatial representation of an object, related tabular information can be associated with it to give the data specific characteristics. Data can be created in-house, or acquired from data providers across the world. A GIS provides the platform to integrate this spatial data with other datasets (through Relational Database Management Systems, or through GIS software tools), which then allows for analysis of data relationships, ability to produce maps of data interactions, and many more powerful uses.*

- Multiple formats of spatial data: ex: Shapefiles, KMZ, GeoJSON, raster data (images geo-referenced to their actual ground coordinates), and many more.
- Centralizing and standardizing spatial data is an important step to operating a successful GIS. There are many different methods to do this, and they are dependent on the structure of the mapping infrastructure at hand.
- Open -sourced data is often available via web searches, and through ESRI's data hub. This data sometimes may be downloadable for manipulation and further analysis, and other times it may just be viewable as a reference layer.
- Note: There are multiple standards to follow for proper geospatial data creation and sharing.
  - See example of Data standards from <u>Federal Geographic Data Committee (FGDC)</u>

- **Software**: GIS software includes the tools and graphical user interface (GUI) platform for storing, visualizing, and manipulating geospatial information to perform data analysis and produce maps. Oftentimes, a GIS software uses a relational database management system (RDBMS) to store and relate its data. GIS software can range from desktop installed options to completely web-based solutions.
  - There are many Free and Open-Source GIS software solutions to explore.
  - ESRI is the leader of the GIS market, and their products offer a wide range of flexibility to suit the needs of any organization.
    - ESRI's ArcGIS Enterprise is a GIS option to strongly consider for local government agencies. It accounts for a multi-user GIS environment, with accessibility and sharing to and from a web environment to an individual user's desktop.

- **Hardware**: The Hardware of GIS includes the computer on which GIS operates. Today, there are multiple locations that a GIS could be housed, including an individual's desktop computer, a GIS Server (stored in-house or externally), or in a cloud environment. Depending on the GIS software and use required, the GIS Hardware for your organization could include a blend of different hardware options.
  - Other GIS Hardware includes data collection equipment, such as GPS devices, Tablets/Mobile Devices (for data collection through GIS web map applications), drones for collecting aerial imagery, and many more.
- **People**: While a GIS is a very powerful tool, it still requires people to operate and maintain it.
  - Expertise and GIS professionals within the organization:
    - IT Staff
    - GIS Administrators
    - GIS Analysts
    - GIS Specialists
    - Field Crews
- **Methods** An organization's model for GIS will vary from organization to organization. However, organizing a well-designed geospatial system is key to the success of a GIS. This process of identifying the needs, applications, and maintenance of a GIS in your organization is one that involves hours of planning and input from specialists who understand the foundation of a GIS architecture.

(**https://www.highpointnc.gov/DocumentCenter/View/1900/What-is-GIS-PDF?bidId=#:~:text=A%20working%20GIS%20integrates%20five,data%2C%20people%2C%20and%20methods.&text=Hardware%20is%20the%20computer%20on,stand%2Dalone%20or%20networked%20configurations.**)

> **"With both ArcGIS Enterprise and ArcGIS Online, you have access to templates and configurable apps to get started, as well as a suite of Esri apps for the office and the field. In addition, you can take advantage of a vast collection of geographic data and information through ArcGIS Living Atlas of the World.**

> *ArcGIS Online is a highly scalable software-as-a-service (SaaS) offering from Esri. It is hosted on Esri servers and completely scaled, managed, updated, and maintained by Esri. Because Esri controls the update schedule, you are not responsible for upgrading or patching the system themselves. What is current in ArcGIS Online is always current for any user around the world. As your usage and data needs scale, ArcGIS Online dynamically scales with you without the need for you to provision additional servers or infrastructure, though additional data stores are available to you if required. With ArcGIS Online, all you need is an organizational subscription and you are ready to go.*

> *ArcGIS Enterprise is software that is installed on infrastructure you control and manage, whether in the cloud, on-premises, or on virtual machines. This allows you to design a highly customized system that meets your organization's business needs and service level agreements. You can choose to deploy all base ArcGIS Enterprise components on one machine or scale out to many machines. High availability and disaster recovery strategies are supported, as well as deployments that are completely disconnected from the internet. With ArcGIS Enterprise, you have complete control over your system, whether that is when to patch the system or when to upgrade to the next version of the software.*

> *ArcGIS Enterprise typically has one to two releases per year, whereas ArcGIS Online typically updates four times a year. Though ArcGIS Enterprise does not include all features and functionality that ArcGIS Online has and vice versa, you can typically expect to see most ArcGIS Online features within the ArcGIS Enterprise portal in the next few ArcGIS Enterprise releases following an ArcGIS Online update. (ESRI Source)"*

Esri has two general GIS software architectures available for individuals and organizations to subscribe to. Both of these software design systems integrate web and cloud based technology for sharing and accessing spatial data, maps, and applications from within your organization or from/to the public. These two options differ primarily in the hardware required, maintenance and administration needed for the system, and features/capabilities offered. The section below provides a brief overview of these two design architectures.

ArcGIS Desktop (with ArcGIS Online) Architecture

The ArcGIS Desktop license is available in three levels of functionality - **Basic, Standard, & Advanced**.

ArcGIS Desktop software:
- **ArcGIS Pro** - This is the desktop application for creating, visualizing, and analyzing spatial data. It connects directly to ArcGIS Online, allowing data and content to be accessed or shared to/from the web.

- **ArcMap -** The previous ArcGIS desktop application (prior to ArcGIS Pro). No longer updated by Esri.
- **ArcCatalog -** User interface built into ArcGIS Pro that manages data, maps, geodatabases, and other geospatial information within your projects.
- **ArcScene -** Esri's 3D geospatial mapping software for local environments.
- **ArcGlobe -** Esri's 3D geospatial mapping platform for global scale projects.

An ArcGIS Desktop license also includes an ArcGIS Online organization subscription.

ArcGIS Online (is a SaaS) that is hosted by Esri in the cloud, and allows users from around the globe to create and share mapping applications, data, and other geospatial content within their organization or out to the public.

ArcGIS Online Pros:
- Fast/Easy deployment
- Little maintenance of hardware/IT equipment
  - ArcGIS Online is hosted on Esri servers and is maintained, updated, and managed by Esri
- Scalable with as organization grows its GIS infrastructure/data
- Abundance of available spatial data and maps from across the globe
  - Through Open Data and Esri's Living Atlas

ArcGIS Enterprise Architecture

The ArcGIS Enterprise suite is a software that is installed on infrastructure that is owned and maintained by your Organization. It differs from the ArcGIS Desktop (with ArcGIS Online) system above mainly in that the Enterprise GIS components are stored on-premise (either on internal servers or in the cloud (Amazon Web Services (AWS), Microsoft Azure)). This offers greater control and security of your GIS, and integration with existing databases that your Organization uses. Enterprise also has a web gis component called ArcGIS Portal.

ArcGIS Enterprise Base software:

- ArcGIS Desktop - ArcGIS Pro, ArcMap, ArcCatalog, ArcScene, ArcGlobe
- ArcGIS Server - The core web services component for making maps and performing analysis.
- Portal for ArcGIS - Web platform for sharing maps, applications, and other geographic information with other people in your organization or the public
- ArcGIS Data Store - Allows you to configure data storage for hosting and federated servers used with your deployment.
- ArcGIS Web Adaptor - Allows you to integrate your ArcGIS Server and Portal for ArcGIS with your existing web server and your organization's security mechanisms.

**ArcGIS Enterprise can also be integrated with ArcGIS Online.

Pros:
- ● Highly Customizable
- ● Integration with existing database infrastructure
- ● Security of data
- ● Supports multiple GIS editors (versioning)
- ● Accessible by all devices connected to the Organization's network
- ● ArcGIS Portal allows for sharing of content within Organization and to public
- ● Integration with ArcGIS Online

ESRI Cost Bundles for Local Government
ESRI Enterprise Bundle for Local Government

GIS Collaboration

Appendix D

GIS Guide for Local Government - Implementation

Path to GIS – Geospatial Strategic Planning:

1. **Develop a GIS planning Team & Team Leader**
   a. Process begins with an individual (GIS Champion) taking lead and setting the initiative for an better integrated GIS
2. **Determine the existing and/or expected vision of GIS within your organization.**
   a. What are the goals, objectives, and benefits of introducing/improving your GIS?
3. **Market the importance of GIS throughout your organization.**
   a. Highlight the potential applications of GIS in your organization, and how it could be integrated into workflows to improve efficiency and enhance planning.
   b. Could be through a presentation, meetings, conversations, email, etc..
   c. Understand the current GIS implementation within your organization
      i. *What are the shortcomings of it?*
4. **Develop a Needs Assessment (or Needs Analysis)**
   a. Identify overall goal of GIS within your organization
   b. Identify Users/Scenarios
      i. *Who will be directly and indirectly using GIS? Who currently uses GIS?*
      ii. *How will these users be utilizing GIS?*
         1. **Provide example scenarios**
   c. Identify existing & potential applications of GIS across departments, as well at the entire County-level
   d. Existing GIS infrastructure:
      1. **Data**
         a. **What spatial data is available in the organization?**
         b. **Where does the current database for the County/municipalities exist?**
         c. **What spatial data is currently used? (Infrastructure data, public health data, emergency management data, etc..)**
      2. **GIS Applications**
         a. **Online maps or geospatial applications**
      3. **Software**
         a. **GIS software currently used (Esri ArcGIS Pro Desktop, Web Mapping platforms, etc..)**
         b. **Current Licensing for GIS data**
         c. **IT resources**
      4. **Hardware**
         a. **Computers, data servers, internet connectivity, etc..**
      5. **Personnel**
         a. **Staff that are trained in GIS**
         b. **Staff that may be allocated to assist with the planning/ development of a GIS**
      6. **Budget**
         a. **Financial resources available to support this GIS technology advancement project**

    e.   Develop a questionnaire/survey to send out to GIS Users to gather input of how familiar they are with GIS, and ways that they would like to see it integrated into their workflows.

    f.   Set up interviews with GIS Users to gain additional detail about their GIS use.

    g.   Create a GIS Needs Assessment report that summarizes the findings

5. **Develop and design a GIS architecture that will best fit the needs of your organization (as defined in the Needs Assessment).**

    a.   Free and Open Source (FOSS) vs Proprietary GIS Software

    b.   Reach out to GIS consultants or Esri for support in determining the best GIS solutions

    c.   Consider hiring specialized GIS personnel to maintain your geospatial infrastructure

    d.   Consider integration with current software, data, and applications

    e.   An ArcGIS Enterprise vs. ArcGIS Online/Desktop

    f.   Must account for any other geospatial software or applications currently in use, and also plan on migrating all existing spatial data into this enterprise geodatabase.

6. **Produce a Project Charter for implementing your new and improved GIS. This could contain the following elements:**

    a.   Project Description/Purpose

    b.   Set Goals & Objectives

    c.   Project Team Structure

    d.   Set Measurable Benchmarks

    e.   Constraints/Risks

    f.   Project Budget

    g.   ProjectTimeline

7. **Consider setting up a GIS User Group within your Organization, which meets regularly to discuss data, software, and project updates.**

**Diagrams and charts help to visualize and understand complex geospatial design structures and workflows.