Mobile GIS Best Practices

GICC Technical Advisory Committee

Document Overview

With the growth of mobile in GIS, the North Carolina Geographic Information Coordinating Council (GICC) asked the GIS Technical Advisory Committee (TAC) to create a best practice document for GIS professionals that are considering deploying mobile GIS applications.

While mobile GIS applications may be developed simply for viewing information in the field, they are most typically developed to facilitate field data collection with a map-centric context. This document focuses primarily on that collection aspect of mobile GIS.

Table of Contents

Overview

A large percentage of government workers and utility companies perform daily work tasks away from their office. Historically, mobile technology was limited in capability, expensive, and cumbersome to maintain, so it was only implemented where absolutely necessary and usually involved tedious or convoluted processes. Today, mobile technology is inexpensive and easier to implement and maintain, so organizations recognizing the value are eager to move GIS-related activities to the field. Moving GIS information and tasks to the field can improve processes, streamline field operations, optimize resources, reduce paperwork, and reduce waste.

Advantages of GIS Mobile Technology

Data Awareness versus Data Collection

Data Awareness

Mobile GIS can offer the end-user the ability to explore their surroundings in a platform and place of their choosing. This can empower the end-user with the ability and freedoms to make real-time decisions based on the quality and quantity of spatial data presented before them in an easy to use interface of their choosing. Users can plan trips to destinations whether far or near, make livable decisions or decide where to participate in common outdoor activities.

Data Collection

Newer technologies whether open-sourced or proprietary have allowed for the more accurate collection of data that allows data collectors the ability to participate in the data upload revolution. Mobile GIS Data Collection allows for the office to now become anywhere a mobile device can be used. Thus, opening the world of data collection to more than just the highly trained, but ranges from the novice to the professional. This makes more usable services, data and maps, which directly improves the satisfaction of end-users and their ability to navigate their surroundings.

Components and Considerations

GIS mobile solutions generally consist of the same building blocks; however, the actual components implemented and their configuration can vary depending on the requirements of the problem you are solving and the limitations of each component. The following is a list of common GIS mobile solution components and some considerations when evaluating the components against your problem requirements.

Mobile Device

A mobile device is the hardware that users in the field use to collect and/or view GIS data. Today, the most commonly used mobile devices are smartphones and tablets. Other devices used in the field include laptops and GPS units. Which mobile device is implemented will depend on what the organization has on-hand, what field staff need to accomplish, and what else the mobile device needs to support.

When evaluating GIS Mobile devices, consider:

Operating system

There are many reasons to choose one operating system over another – what are users familiar with, what non-GIS applications need to run, etc. Unfortunately, not every GIS mobile application runs on every operating system. For example, ESRI's Collector does not run on Windows OS and ArcPad does not run on iOS or Android. The challenge is to find the best mobile application for the operating system you have to use.

Mobile Device Specifications

When evaluating a mobile device, consider all characteristics of the device including:

- Weight – is it too heavy to carry all day, especially with a protective case?
- Is the screen size adequate for all users and uses?
- OS and OS version
- Is the Internal storage space adequate?
- Can it connect to peripheral devices (scanner, GNSS receivers, camera)?
- Does it have internal camera?
- Can it use SD or microSD cards?
- Is it ruggedized?
- Does it use a long-lasting, removable, or a backup battery?
- Its internal GPS and its accuracy
- Wireless connectivity (Wi-Fi, 4G)

Editing versus Viewing

When selecting GIS mobile solution components consider if users are just viewing data or editing data. There are applications and configurations that do either or both well. Editing solutions are going to be more complicated, so if users are simply viewing GIS data, just focus on that.

If users are just viewing GIS data in the field, consider:

- Using a Commercial-off-the-shelf (COTS) application such as Esri's Explorer for ArcGIS.
- Focus on the data hosting component and less on the application and mobile device.
- Look for applications that can run on most any mobile device or operating system rather than a special configuration.
- Develop simple user guides and other supporting documentation to assist users through self-help.

Most of this document focuses on mobile data collection and editing.

Spatial Accuracy & GNSS Receivers

Smartphones and tablets can identify their location through several technologies. The most widely used is through a GPS receiver; either internal or external. GPS is a Global Navigation Satellite System (GNSS) used in the U.S which can be used to determine locations on Earth. GNSS systems provide a level of known accuracy depending on the grade and performance of the GNSS receiver. These levels are:

- Consumer Grade: accurate within 10+ meters
    - These are cellular, tablet, or MiFi devices with built-in GPS and cellular capabilities.
- GIS/Mapping Grade: accurate within 3+ meter
    - These are vendor solicited GPS devices that are sold for the specific purposes of data collection. Many mapping grade GPS can be quite customizable and have a price point

ranging from several hundred to several thousand dollars depending on quality and other customizable options.

- Survey Grade: accurate within 1+ centimeter
    - Usually consist of the use of an external antenna, post-processing software, highly sensitive GPS receiver, and/or usage of Real-Time Kinematic (RTK) technologies. These range in cost but usually start in the thousands of dollars.

Examples of Use - The City of Wilson

Consumer Grade Accuracy

The City of Wilson utilizes ArcGIS Collector on IOS and Android devices for its ease of use and data collection related to smaller projects associated with grants, non-geocentric users, and when the data accuracy is not as valuable as the attributable value of the collected data. Such recent projects include the Choice Neighborhood Improvement Grant opportunity. In which the City partnered with Wilson Housing Authority to map over 2500 structures. The collected data could be viewed in real-time through ArcGIS Online and was collected over a four weeks by a team of ten members.

Mapping Grade Accuracy

The City of Wilson's Wilson Energy (Utility Services) utilizes three-meter accuracy GPS to re-map their existing utility poles inventory. This mapping project helps identify and recuperate lost revenue for uncharged uses of the City's utility infrastructure. The captured coordinates from the mapping project are subsequently fed into a third-party system, which the poles form the basis of another utility smart device mapping project. In discussing the project by in large, utility poles are very visible and the City was able to purchase a higher quantity of the three-meter accuracy GPS' in order to facilitate the project's deadline.

Survey Grade Accuracy

The City of Wilson's Water Resources utilizes GPS that are capable of 1-centimeter accuracy to map its water valves. The City through past experiences understood that because of its aggressive street paving projects and the critical nature of needing to know the exact location of these valves it was necessary to spend the additional resources to properly map them.

If you are collecting data in the field, spatial accuracy is important and may even be critical. However, not all data collection efforts require high level of accuracy. In fact, some accuracy requirements can be met using manual feature placement if using a specific, trusted base map. Further, if a data collection effort is more focused on the attribute data rather than the spatial location, dropping features anywhere close using the device's built-in GPS may be acceptable.

Consider the following when evaluating how to meet your spatial accuracy requirement:

- Is the accuracy provided by the GPS receiver on the device accurate enough? If so, then you don't need to evaluate external GNSS receivers or try finding a mobile device that can connect to one or an application that can use one.
- Can the GIS mobile application use a device's GPS receiver or an external GPS receiver? Most mobile spatial data collection applications will use an internal GPS receiver, but not all will use an external receiver.

- Every GNSS receiver is different. When evaluating, consider how complex it is to use and the post-processing it requires and can support.
- When evaluating the spatial accuracy of devices and external GPS receivers, be sure to test the devices in a variety of situations users will be in – wooded areas, cloudy conditions, among tall buildings, and in urban and rural areas. Evaluate if the accuracy in all situations is acceptable.
- Smartphones and some tablets can identify their location through other technologies, such as assisted and synthetic GPS, Cell ID, Wi-Fi, and inertial sensors. If you will be depending on the internal device location for spatial locations, fully test the device in all conditions where all technologies are being used.

For more information about GNSS in general, refer to Appendix A.

Connectivity & Offline Editing

Connectivity is a device's connection to the internet or network. Through a connection data can be downloaded to the mobile device or uploaded to a central data storage location.

Offline editing is being able to continue editing data when the mobile device is not connected to the internet/network. Offline editing usually involves editing a locally stored copy of the data that is then synchronized with the central data store when reconnected at a later time.

Since mobile GIS data collection is usually destined for a central storage location, internet/network connectivity in the field is important and how an application handles data entry when a user is disconnected from the internet/network is equally important.

Mobile connectivity is, by nature, unreliable, as not every part of the earth is covered by Wi-Fi, cellular networks, or other forms of communication. Some technology is more reliable than others, but often the more reliable an option, the more expensive it is. If constant connectivity is critical to the data collection effort, then evaluate the more expensive options.

But, like most data collectors, assume there will be gaps in connectivity and plan ahead for them accordingly.

The following are considerations when evaluating internet/network connectivity in a mobile data collection solution:

- Sometimes it's easiest to implement a manual alternative for collecting data when a mobile device becomes disconnected.
- If users are only viewing data in the field, decide if you really need to plan for disconnected viewing.
- Not all mobile GIS applications support offline viewing and editing. If offline editing is critical, focus only on applications that support it. Remember that not all applications support offline editing the same way.
- Offline editing usually means storing large amounts of data on the mobile device. Make sure your mobile devices can support the appropriate amount of data.

- Since preparing for offline data collection and viewing usually requires setup tasks while connected, evaluate an application's setup process against your existing and new workflows and needed user training.
- Depending on how the central data is hosted and maintained, evaluate the post-processing required of data collected offline. Some applications and data hosting configurations can require a lot of manual processing; others make it easy.

Mobile Device & GPS Connectivity

Besides knowing your device's connectivity to the internet, it is important to understand how the mobile device is connected to GPS. The device is usually connected in the following ways:

- Built-in GPS
    - These devices typically come with the GPS built inside the actual device and is intended for the collection of data utilizing the device. Data is synchronized to the backend device using a serial connection, USB connection, or Bluetooth connection.
- Universal Serial Bus (USB)
    - Typically, a GPS device can connect to an existing piece of hardware (laptop or tablet). The USB port allows for the transmission of data to and from the transmitting and receiving device. The USB port also allows for the synchronization of collected data into the GIS or geospatial application for integration into existing or enterprise data.
- Serial Port
    - Many Automatic Vehicle Location (AVL) devices use serial connections in which the data is passed to the com port of a computer and read by a native application. This application can then manipulate and push the data to various storage locations for use in a wide variety of applications.
- Bluetooth
    - A wireless form of connectivity in which devices are able to synchronize data between a separate GPS transmitting device and a receiver. Typically, the receiver is a tablet (iOS, Android, or a Windows-based device). Connectivity between the transmitter and receiver can be maintained well over 30 meters on many devices. In some cases, newer technologies can allow up to 2500 feet in range before connection is lost.

Data Storage/Hosting

The goal of any GIS field data collection effort is to collect data in the field by many users and transfer it to a central location.

Whether or not you are developing a solution for GIS data viewers or field data collection, how your data is stored, hosted, and made available to mobile users will influence the mobile device, application, and workflow decisions.

Data Storage

Data can be stored in a variety of formats, such as databases and on local file systems. While this topic is too big in general for this document, considerations when determining where and in what format to store your data for mobile use include:

- Do you plan to implement QC controls through something like Esri's database versioning? If so, some hosting options are better suited than others, and not all mobile applications support versioning.
- Local files (such as Esri file geodatabases) are not well suited for multi-user editing scenarios. Pre-processing and post-processing workflows often require a lot of overhead to use and process data stored in that format.
- Evaluate your data storage and configuration options against your hosting scenarios and against the capabilities of the mobile devices and applications. For example, hosting data through geospatial web services has a different setup and configuration than copying data locally.
- When designing the data location and configuration, consider if you will want a public version of the data and how that public version will be used. For example, data hosted through ArcGIS Online and locally are more limiting and may require manual processes whereas, data hosted through SDE is more flexible, especially when replication can be used.

Hosting

Hosting is making the data available to end users – whether they are viewers or editors. The two common scenarios for hosting data are:

Geospatial web services

A geospatial web service is a service that provides access to geospatial data through the internet. Edits to data are automatically passed from the application through the service and to the source data. Depending on the mobile application used, edits can be stored on the mobile device until the user requests a data store synchronization.

Examples of geospatial web services include:

- Esri's dynamic map services, feature services, geoprocessing services, image services, etc.
- Open source formats such as WMS (web map service) and WFS (web feature service) and many others.

Geospatial web services can be created from scratch, but many organizations use a product/platform that makes it easy to create, maintain, and deliver geospatial web services. Commonly used products include:

- Esri's ArcGIS Server – a server-based product for hosting and managing geospatial content, such as geospatial web services. The product and hosted content is deployed on the organization's internal or cloud servers. From a mobile perspective, content can be configured to support mobile data editing and viewing.

- Esri's ArcGIS Online – a cloud-based platform for hosting geospatial content, such as geospatial web services. From a mobile perspective, it provides the tools and storage to support mobile spatial data editing and viewing.

Advantages:

- The data location, configuration, and some access is hidden by the web service. Data can be in any format and stored in any database or file server and users do not need to know the details to use it.
- Since web services hide the data component from end users, data can be moved to new locations and converted into new formats without changes to editing applications.
- Because geospatial web services use internet protocols, it is sometimes easier to secure access to the services than the back end data. Applications and users do not need to connect directly to the data source.
- Since multiple editing and viewing applications (mobile and desktop) can use geospatial web services, the same service can be used in multiple solutions. As a result, users view and edit the same data no matter which tool they use.
- The data is live. Changes by one user can be seen immediately by another user.
- If an application takes advantage of Esri's SDE versioning (such as Collector), then SDE QC workflows can be implemented.
- Many GIS mobile applications use geospatial web services, including: Esri Explorer for ArcGIS Mobile, Esri Collector, Esri ArcPad, and Survey123. Choosing one today does not preclude you from using others in the future.
- Because many GIS applications support geospatial web services, they are well suited for editing solutions that must support different editing scenarios.

Disadvantages:

- Since geospatial web services use the internet to provide access to users, users must be connected to the internet to use the services. When in the field, users don't always have an internet connection.

However, this can be remedied by choosing a mobile application that supports offline editing, which is the ability to copy data to the device, edit locally, and automatically synchronize with the geospatial web service when connected.

Local Data

Local data is a snapshot copy of GIS-based base maps, reference data, and editable data on the mobile device. Data edits are stored on the mobile device.

This is not the same thing as using a mobile application's (e.g. Esri's Collector) capability to create, manage, and synchronize an offline copy of the data.

Advantages:

- The user's mobile device does not need a connection to the internet in order for the user to add and change data.

Disadvantages:

- Often the source data cannot be automatically updated by the application on the mobile device. Instead, a manual process must be implemented for updates.
- Manual QC processes are usually required.
- The data on the device is a snapshot of the data. Changes made by other users are not reflected in the data.
- Usually, a manual process is required to copy the appropriate data to the mobile device and to keep track of who has what.

Application Considerations

There are many mobile applications available for geospatial data collection and viewing and, as you would expect, all have their pros and cons.

When evaluating applications consider:

- Evaluate the application against more than just the end user experience. Consider what might be required to prepare the mobile device for a day of editing and what is involved in merging the edited data with the source data when the time comes to do so.
- While most popular and more modern mobile devices typically run iOS, Android, or Windows 8/10, not all GIS mobile applications will run on all operating systems. Weigh the pros and cons of the mobile device and application against requirements to find a good match. For example:
    - Esri's Collector runs on Windows 10, iOS, and Android devices, but not Windows 8.

Focus on GIS Mobile Applications

The following is a description of several commonly used GIS mobile applications. These descriptions are based on the products as of the date on this document. Most of these products are regularly updated by the vender and features and capabilities often change. Additionally, some features described may require specific versions of supporting products (e.g. Esri's ArcGIS Server, Esri's SDE).

Application: Esri Explorer for ArcGIS Mobile

<u>What Is It?</u>

Esri Explorer for ArcGIS mobile is an Android and iOS (and Windows in the future) standalone application that provides viewing access to web maps hosted in ArcGIS Online. The web maps can contain most any type of geospatial web service. The application is available through the device's mobile app store.

Basic Requirements

- ArcGIS Online or Portal for ArcGIS web maps – either hosted by the organization or through Esri's portal
- ArcGIS Online organization subscription or Portal for ArcGIS is only needed if you want to provide access to your own data
- You do not need an ArcGIS Online account to use the application
- A mobile device that uses iOS or Android. Windows support should be available in a future release.

Key Features and Capabilities

- Easy to use by users without GIS experience
- Requires no development or maintenance activities by the organization; individuals manage the application just as they manage any other application on their mobile device
- Application is easy for anyone to obtain
- Esri updates the product regularly and updates are automatically made available to the end user through the appropriate mobile app store
- Only supports ArcGIS Online or Portal for ArcGIS web maps
- Requires a network connection – offline viewing is not supported

Considerations When Evaluating/Implementing

- Explorer for ArcGIS Mobile only sees ArcGIS Online or Portal for ArcGIS web maps. If you want your users to access a geospatial web service or other data, make sure it can be referenced through a web map.
- Since most users will not have an account with your organization they will be looking at content available through Esri's ArcGIS Online portal. If your ArcGIS Online content is shared to "Everyone" users will be able to find it. Ensure your official enterprise web maps are easy to find through searches and are identifiable against the thousands of other items available through Esri's ArcGIS Online portal.

Examples

NCDOT is recommending Esri's Explorer for ArcGIS Mobile to staff around the state to view official data, services, and maps provided through NCDOT's ArcGIS Online portal. The official NCDOT geospatial web services are hosted in ArcGIS Online and on internal ArcGIS Server servers, and the web maps are hosted in ArcGIS Online. NCDOT has developed a "quick start" guide to assist new users with the application.

Application: Esri Collector for ArcGIS

What Is It?

Esri Collector for ArcGIS is an Android, iOS, and Windows 10 standalone application that provides connected and offline editing capabilities of geospatial data through Esri feature services/layers. Esri feature services/layers can be hosted in ArcGIS Online (feature layers), Portal for ArcGIS (feature layers) or on ArcGIS Server (feature services).

The application is available through the mobile device's app store.

Basic Requirements

- A mobile device that uses iOS or Android
- ArcGIS Online or Portal for ArcGIS
- At least one ArcGIS Online or Portal for ArcGIS web map
- ArcGIS Online or Portal for ArcGIS group with services and maps shared to the group
- ArcGIS Online or Portal for ArcGIS user accounts
- Data configured for editing and offline use
- Feature layer/service configured for editing and offline use
- Reference and base map geospatial web services configured for offline use

Key Features and Capabilities

- Supports editing point, line, and polygon features
- Supports attaching images (pictures) to features
- Integrates with the mobile device's camera to take and attach pictures to features
- Supports editing of related records
- Supports SDE versioning
- Attribute data entry is defined through the data schema and web map
- A new product by Esri and is updated regularly
- No application development effort is required by the organization
- Application is easy for anyone to obtain through their device's app store
- Setup in ArcGIS Online or Portal for ArcGIS can be simple
- Uses the device's internal GPS. Can use some external GNSS receivers depending on how they are connected
- When connected, supports feature services/layers, dynamic map services, tiled map services, image services, WMS data, and KML data
- When offline, supports feature services and tiled map services hosted in ArcGIS Online, Portal for ArcGIS, or ArcGIS Server

Considerations When Evaluating/Implementing

- Base maps are often important during data entry. When connected to the internet, Collector can view most any base map. For offline use, Collector provides two ways to load base maps onto the mobile device:

    a) Collector allows users to download base maps and reference data through the application. When a user downloads a map for offline use, the user defines a "work area" which consists of a geographic area and scale. When the map is downloaded the base map, features, and reference data are downloaded for the defined work area. Once the base map is on the device, it can be used by any offline map.

    When evaluating this capability, try downloading a small scale map that includes all features to edit and then several larger scale maps that cover the area in pieces. Delete the larger

scale maps, but save the base maps (you are given the option when you delete an offline map). Then, while editing the small scale map, switch between the saved base maps.

b) Users can load Esri tile package (.tpk) files onto the device. As long as the tile packages are stored on the device in the correct location, Collector will recognize it as a base map and it can be used with any offline map.

- If offline editing capability is needed, ensure that the mobile device you use has the internal storage space necessary to support the base map sizes you will need. Collector requires base map files be stored in a particular location on the mobile device and does not take advantage of external storage devices like SD cards.
- Little GIS technical knowledge or experience is needed to setup and use a simple Collector solution. Therefore, it is a good solution if an organization is interested in putting GIS development and maintenance into the hands of the organization's business units.
- When building your data and services to support editing, consider that fewer types of geospatial web services are supported when using Collector offline.
- There are required settings and configuration in the data, geospatial web services, and in ArcGIS Online/Portal web maps in order to access and edit data through Collector.
- When using offline maps, users must manually execute the syncing operation to upload edits – this is true even if the mobile device is connected. If not using offline maps, edits are automatically and immediately uploaded when the user submits each feature change.
- The feature class schema and web map configuration defines the look and functionality of the attribute entry form. Currently, data validation is defined through attribute domains, allow-nulls setting, and data types in the data.
- Since Collector uses standard geospatial web services and ArcGIS Online/Portal for ArcGIS web maps, the same components can be used by Collector as well as other client application, such as Esri's ArcMap and ArcPad.

Examples

NCDOT is implementing Collector through ArcGIS Online for small pipe inventory data collection. Collector is a good fit because it runs on iPads, which NCDOT staff already use, supports geospatial web services already published by NCDOT, supports offline editing with base maps, supports authorization and authentication, uses the device's camera, supports feature image attachments, and supports SDE and versioning.

Application: Survey123

What Is It?

Survey123 is a form-centric application for field data collection. It started as an Esri Lab product and is now supported by Esri. The application allows users to capture attribute information for points placed on the map. Configuration is done using the XLSForm standard and the data and form is hosted through ArcGIS Online as a feature layer and form configuration file.

Survey123 consists of two products:

1. Survey123Connect – desktop tool to develop, maintain, and publish Survey123 solutions.
2. Survey123 – mobile application that consumes XLSForm and feature layers created and deployed using Survey123Connect and hosted in ArcGIS Online.

Basic Requirements

- A mobile device that uses iOS, Android, or Windows
- A PC or tablet running desktop versions of Microsoft or Apple OS
- ArcGIS Online subscription
- ArcGIS Online or Portal for ArcGIS user accounts
- Basic knowledge of the XLSForm.org standard
- Microsoft Excel and some experience

Key Features and Capabilities

- Supports creating points
- Form-centric field data collection
- Supports attaching images (pictures) to features
- Integrates with the mobile device's camera to take and attach pictures to points
- Supports signatures
- The attribute data entry form is defined through XLSForm configuration in a MS Excel spreadsheet
- Application is easy for any field staff to obtain through their device's app store.
- Uses the device's internal GPS
- Allows offline editing and syncing when connected

Considerations When Evaluating/Implementing

- Survey123 is a form-centric, survey-type data collection solution. It does not allow users to change point locations or attribute values after the data is submitted to the feature layer.
- It is possible for users to accidentally upload duplicate points. Post-processing may be required to identify and remove duplicates.
- Since this is a form-centric solution that uses Microsoft Excel to configure data, GIS knowledge and experience is not needed. What is required can easily be learned by a technologically capable person.
- This solution is a good fit when:

    a) Spatial accuracy is not important
    b) Attribute validation and configuration is most important
    c) Point data collection is needed
    d) The Survey123 developer is confident using Microsoft Excel and uploading/managing content in ArcGIS Online
    e) The Survey123 developer is not familiar with GIS technology

Example

NCDOT is implementing Survey123 to capture debris collection data in the field. NCDOT is responsible for collecting storm and other debris from road right of way and are reimbursed by the Federal Highway Administration (FHWA) based on the amount collected. It is the responsibility of the debris collection coordinator to gather the debris collection information, consolidate it, and submit a report to FHWA in a timely fashion. Historically, data was captured in multiple spreadsheets and then consolidated. Centralizing the information into a feature layer greatly reduces the time and energy in creating the report. Survey123 is a good fit, because spatial accuracy isn't as important as the attribute information, the data collected has a limited life span, and the debris collection coordinator is very comfortable with Microsoft Excel and has little GIS technical experience.

Application: Esri ArcGIS Online for Organizations

What Is It?

Esri's ArcGIS Online for Organizations is a cloud-based software-as-a-service platform that provides organizations with a set of tools and capabilities to host GIS data and deliver built-in maps and apps to their end users. From a mobile editing standpoint, ArcGIS Online provides a data/service hosting platform with a browser-based map viewer and web map applications with built-in editing functionality.

Basic Requirements

- Internet connection
- Supported internet browser
- Data configured for editing
- Feature layer/service configured for editing

Key Features and Capabilities

- Supports editing point, line, and polygon features
- Supports attaching images (pictures) to features
- Attribute data entry is defined through the data schema and web map
- ArcGIS Online is updated regularly by Esri
- No application development effort is required by the organization
- Setup in ArcGIS Online can be simple
- Can edit feature layers (hosted in ArcGIS Online) or feature services (hosted in ArcGIS Server)
- Built-in "Web App Builder" to build more focused editing applications

Considerations When Evaluating/Implementing

- Users must be connected to the internet to view and use geospatial web services, web maps, and apps.
- ArcGIS Online accounts are not necessary to edit feature layers/services through ArcGIS Online's applications, but they are needed if you want to secure access to the data and feature services/layers.

- ArcGIS Online does not allow for offline editing. To use the browser-based applications and data, the user must always be connected to the internet.
- Currently, ArcGIS Online does not support editing related records.
- ArcGIS Online map viewer, some map templates, and the web app builder widget support adding attachments to features.
- Collecting features through the mobile device's GPS or external GPS receiver is not supported through the browser-based applications.
- You can edit feature services hosted in ArcGIS Server through the ArcGIS Online map viewer, though there are configuration requirements.

Examples

NCDOT is implementing a solution that uses an ArcGIS Online feature layer, web map, and map viewer for a business unit interested in maintaining GIS data, but with no GIS staff resources, knowledge, or tools. The simple solution makes it easy for the business unit to maintain their own geospatial data.

Appendix A

Automated Vehicle Location (AVL)

A means for automatically determining and transmitting the location of a vehicle using GPS and satellite or terrestrial radio.

Benefits of AVL for field crews

- Improved safety
- Less time spent on radio talking with office
- Boss does not question where you have been
- Not sent to jobs on the other side of town when someone is closer

Benefits of AVL and GIS Integration

- Real-time asset replacement updates
- Dynamic dispatching of the nearest crews
- In-field routing and navigation

Commercial-off-the-shelf (COTS)

COTS software and services are built and delivered from a third party vendor. They are standard manufactured products that can be purchased, licensed, or leased by the general public.

Global Navigation Satellite System (GNSS)

Global Navigation Satellite Systems, or GNSS, is any collection of satellites which can be used to determine a location on the Earth. It encompasses Global Positioning Systems, or GPS, but also includes systems used by other countries. GNSS determines location based on distance trilateration and typically needs 4 satellites for a position. Errors in GNSS are caused by clock differences, atmosphere, multipath, and satellite geometry; however, post processing fixes most of these problems. It is important to understand the different GNSS systems, because all of them have different accuracy levels and other distinguishing properties.

- Global Positioning System
  - Used by the US
  - Full operational constellation of 24 satellites in 1994
  - WGS 1984 Datum
  - 3-4 decommissioned satellites
  - 6 orbit altitude of 12,000 miles
  - 2 frequencies
  - L1-1575.42 MHz (Mapping & Survey grade)
  - L2-1227.60 MHz (Survey grade)
- Global Navigation Satellite System (GNSS)
  - Used by Russia
  - 24 satellites in 1995
  - System declined until early 2000s
  - 19,000 KM orbit
  - 24 active satellites, 3 on-orbit spares, 1 in maintenance, 1 in flight phase

    - 3 satellites in 2013 destroyed in launch crash
    - Future funding in question
    - Signal strength equal to GPS
    - PZ-1990 Datum (16 inches +/- WGS 1984)
- Galileo
    - Used by the European Union (EU)
    - 4 active satellites
    - Full 30 satellite constellation by 2019
    - 24 operational satellites by 2016-not likely
- Compass
    - Used by China, also known as Beidou-2
    - China sponsored military and civilian system
    - 14 satellites in operation
    - 35 satellites upon completion
    - Coverage area limited
    - Same frequencies as Galileo & patent issues with Galileo

These and other GNSS systems provide a level of known accuracy depending on the grade of GNSS receiver used. These levels are as follows:

1. Consumer Grade: accurate within 10 meters
2. GIS/Mapping Grade: accurate within 3 meters
3. Survey Grade: accurate within 1 centimeter

It is unlikely that mobile devices will have better than consumer grade accuracy. This is a key consideration when you picking which device(s) to use when collecting data in a mobile environment.

Real Time Kinematic (RTK)

RTK satellite navigation is a technique used to further improve the precision of data derived from GNSS. It uses measurements of the phase of the signal's carrier wave, instead of the information from the signal, and it relies on a single reference station or interpolated virtual station to provide real-time corrections and up to centimeter level accuracy.