Appendix B - ArcGIS Mobile features that support GSS mobile needs

The detailed analysis of the requirements for the mobile component of the GSS initiative and recent user experiences point to an implementation based on the ArcGIS Mobile technology. The purpose of this appendix is to provide a quick review of some of the technical solutions and features that support this recommendation. The materials have been assembled from a wide range of promotional literature, workshop materials, brochures, other Esri literature, and conversations with Esri personnel who were contacted as a part of our research effort. As noted in the report, the ArcGIS mobile solution involves a tight coupling of field devices with a server environment. By tightly coupling field data collection with the server side environment it is possible to:

- View and navigate mobile maps to direct field resources and monitor the location of assets. {The essence of the idea – take maps from the desktop/ server and move to the mobile device}
- Collect, edit, and update GIS data in real time and share information with colleagues immediately. {This is the validation and editing environment}
- Search and manage a list of GIS features to perform tasks or plan future work
- Rapidly deploy mobile GIS on Windows Mobile 5.0 devices

The ArcGIS mobile solution includes many capabilities that address issues identified in our needs assessment related to mobile computing and the GSS:

- Access projects remotely either by pushing projects to the device or pulling them from a server over a variety of wireless networks
- Support almost any Windows Mobile platforms (Laptops, Tablets, field based GPS devices)
- Design mobile maps and forms with a set of server manager tools
- Locally cache mobile maps and imagery – stored on the mobile device or flash drives
- Incorporate web mapping and image services
- Collect, inspect, and delete features and associated tabular data
- Provide tight control over security, versioning and synchronization

Regardless of the solution chosen for deployment, there are eight discrete operations to establish a functional field data collection system (Figure 1). In fact, these operations were an integral part of the previous address canvass.

1. Build Mobile DB
2. Author Mobile map
3. Publish Mobile service
4. Secure Service / Transmission / Device Data
5. Design & Build Mobile Application or Extension
6. Build Data Deployment Packages
7. Deploy Mobile Solutions
8. Synchronize Mobile Solution

Figure 1 Eight steps in mobile workflow – (Esri)

The advantage of the ArcGIS Mobile solution is the provision of a set of tools to optimize the eight operations (Figure 2). With proper planning and design, these operations can be used to establish an efficient workflow among the server, mobile devices, and desktops. ArcGIS mobile utilizes the concept of a Mobile Product Center that allows a manager to customize data and tools to load onto the mobile devices. Another set of tools control the synchronization of the data between the device and the server.

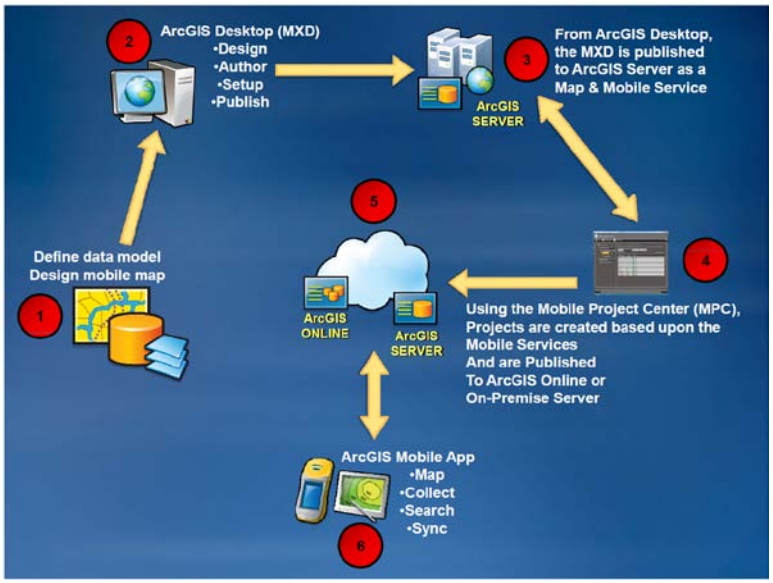

Figure 2 Interaction among components (ESRI)

The logical architecture for this deployment is based on a series of standards that facilitate deployment within an SOA (Service Oriented Architecture) (Figure 3)

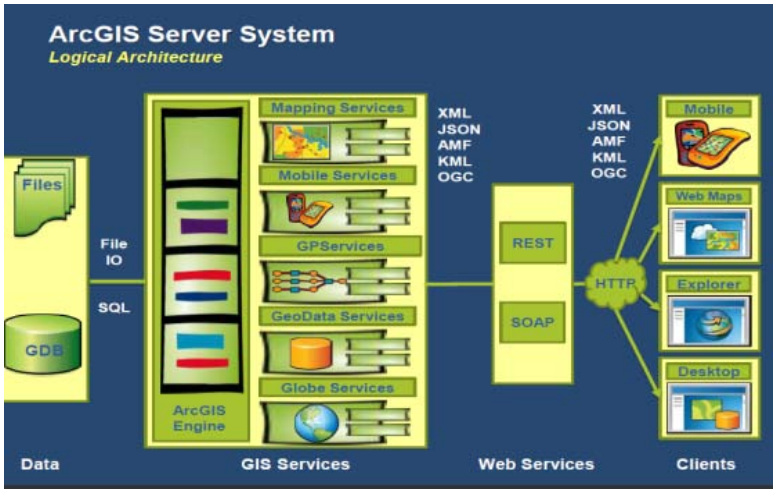

Figure 3 Standards based architecture for server, web and mobile deployment (Esri)

GPS Integration – The ArcGIS mobile solution provides extensive control over the GPS connection (file or serial). This includes constant GPS display for map control. It also supports the National Marine Electronics Association (NMEA) protocol for communication. An important aspect of any GPS oriented field data collection is the ability to monitor the quality of the data. The ArcGIS mobile GPS status page provides information regarding PDOP (Position Dilution of Precision) and HDOP (Horizontal Dilution of Precision).

- GPS Quality Filter. To ensure that the collection of a vertex using GPS is as accurate as possible, ArcGIS Mobile applies a GPS quality filter to evaluate each position that is read from the GPS receiver. If the position read meets the quality filter specified, it will be used in computing the vertex location for the feature being collected. The GPS quality filter is set for each feature type and is based upon 2 key factors: GPS Fix Type and PDOP.
    - The GPS It is also possible to ensure that only differentially corrected GPS locations are used in the averaging process,
    - If the GPS fix type from a receiver is different than the GPS fix type that has been established it may still be able to average GPS positions. This can occur if the fix type you are receiving is of higher quality than what the filter will accept. The hierarchy of fix types is as follows:
        - Real Time Kinematic
        - Float Real Time Kinematic
        - Differential GPS Fix
        - GPS Fix
        - Estimated Fix
    - PDOP - In addition to the fix type, it is also possible to filter positions based upon the geometrical strength of the GPS satellite configuration. PDOP is a numeric value representing the amount of error in the position read. Setting a PDOP value

as a part of the GPS quality filter ensures that only positions with a PDOP equal to or less than the set value will be used to create the average.

Software Development Kit (SDK)

It is a straightforward process to configure and customize maps designed for project deployment based on the feedback of users. In order facilitate this interaction ArcGIS mobile comes with a SDK that includes a number of generic tasks (Figures 4 and 5)

1. View Map
2. Collect Features
3. Search Features
4. View Work List
5. View Field Crew
6. Manage Edits

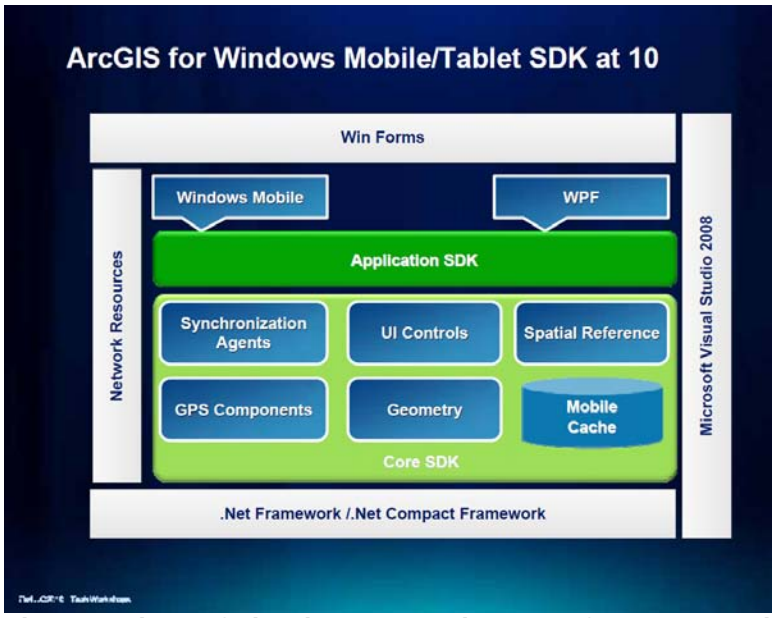

Figure 4 Microsoft development environment for ArcGIS mobile (Esri)

Figure 5 – User interface to main menu on mobile device (Esri)

The following discussion provides a brief description of important features that would support several of the needs of the GSS initiative.

1. View Map There are straight forward tools to configure features, annotation, and raster display. There are tools for designing optimal symbology for representations of features and control of the images (Figure 6). There are commands to zoom in, zoom out, pan, and sketch. A major performance enhancement is the use of mobile service cache and images and features stored in this cache have greatly enhanced display and refresh rates. It is also possible to produce custom map layers and an extremely useful function is the ability to control the "dimming or brightness of different features" (Figure 7).

Figure 6 Example of map display on mobile device with image and symbology (Esri)

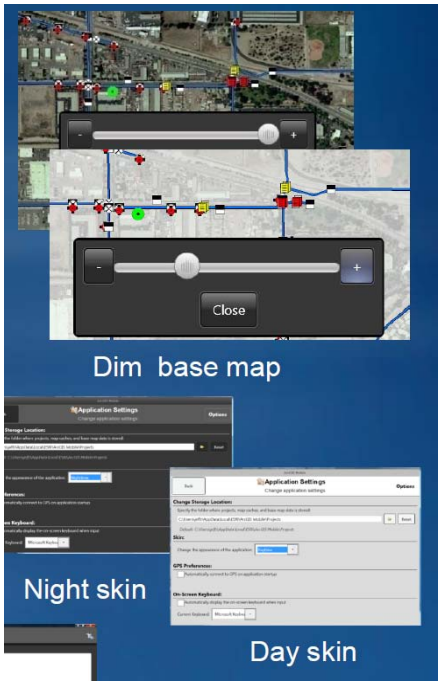

Figure 7 Example of controls over the selective dimming of different features. This facilitates the creation and editing of features. (Esri)

2. Collect Features - ArcGIS mobile provides a set of tools for the collection of both geometry and attributes features. There are four ways to create new points, lines, and polygons (Figure 8). Once a point is correctly located, all information relating to the "containing" face (typically a block) can be joined

Figure 8 User interface to mobile data collection tools on a Trimble Juno (Esri)

(1) GPS averaging

With GPS averaging it is possible to obtain highly accurate positions for point features (Figure 9)

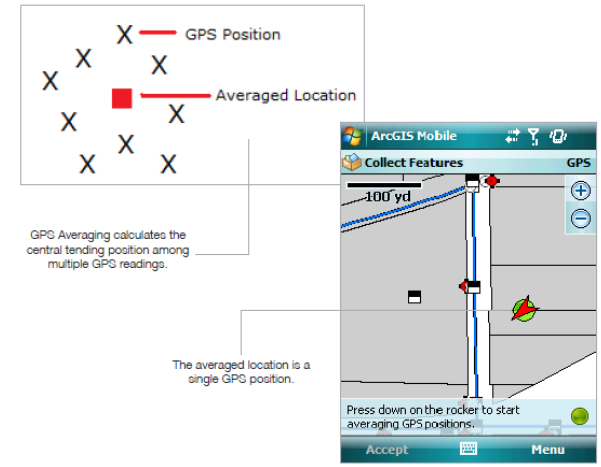

Figure 9- Example of gps averaging for point level features. (Esri)

(2) GPS streaming (line and area features only)

The GPS streaming collection method is used for the creation of line or area features and is useful for GPS-based data collection while in motion (walking, driving). GPS positions that meet the quality filter standard set when authoring the mobile project are used to create vertices of line and area features at a set time or distance interval. Since GPS receivers can acquire a GPS position roughly once per second it is important to filter the number of positions that are used to construct line or area features. Without filtering the shape will be too complex and difficult to manage once synchronized to the server. GPS streaming settings are used to define the method for filtering the number of positions from the receiver. Filters can be based on either a distance or time measurement. As with GPS averaging, the streaming settings are per feature type.

(3) Sketching on the map:

Given the wealth of ancillary or base map information and the difficulty of physically occupying the desired location, the ability of to collect the shape of the new feature using an input device or tapping on the map is critical (Figure 10). The current location of the cursor indicates the location of the vertex that will be collected if you tap on the map. From the map page, it is possible to remove or undo the last location entered on the map or offset the location entered. **Note that within the application settings you can enable snapping**. By default snapping is turned off.

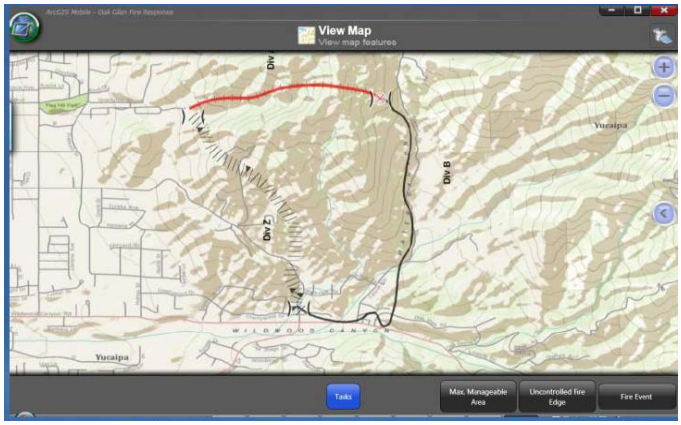

Figure 10 Example of sketching of a road feature on mobile device with cached image base map. (Esri)

(4) Using x, y coordinates

It is also possible to directly enter an x, y location for a point. This is useful when the GPS receiver is not connected to the handheld device. Most of these receivers have their own display and can represent location in decimal degrees. The coordinates could also be read from a GeoPDF map. These coordinates are stored in WGS84 format. Coordinate types include decimal degrees using the WGS84 transformation or decimal degrees using the transformation applied to the map. By default, the longitude and latitude values that are displayed in the dialog box represent the location at the center of the map display.

Controlling for offsets - In many field situations it is not feasible or it is too dangerous to access a property or to occupy a street intersection. When the feature cannot be accurately sketched from reference materials it is critical to be able to calculate the desired location from the current location and the distance and bearing to the feature. Many users (e.g. San Juan NM) are utilizing a laser range finder to calculate these distances and bearings. A popular choice is the devices manufactured by Laser Technology (Figures 11 and 12) that can be directly connected to a field data computer such as a Trimble Juno or Yuma. (It should noted that the iPhone Theodolite application will also estimate these measurements) Furthermore, the direct recording of the coordinates will eliminate the need to store an offset distance relative to a feature (i.e. 200 feet from a road) ArcGIS mobile provides functions to directly incorporate these data into the field observations (Figure 13)

Figure 11 Illustration of the view through the Laser Tech range finder with the parameters of a feature. (Laser Technology)

Measurement Range:	Typical max range to non-reflective targets: 1,000 m (3,280 ft)
	Typical max range to reflective targets: 2,000 m (6,560 ft)
	Inclination range: ± 90 deg
	Azimuth*: 0 to 359.9 deg
Accuracy:	Distance accuracy—short range/light colored/large target: ± 30 cm (1 ft)
	Distance accuracy—long range/dark Colored/small target: ± 0.3 to 1 m (1 to 3 ft)
	Inclination accuracy: ± 0.25 deg; typical
	Azimuth*: ± 1 deg
	**TruPulse 360 and 360 B models only.*

Figure 12 – Specifications for Laser Technology TruPulse 360 laser range finder (~$1,600) (Laser Technology)

Figure 13 Interface to the range finder status and illustration of a Laser Technology laser range finder (Esri)

It is also possible for a user to directly enter distances and bearings (Figure 14). In many cases this approach would provide an acceptable way for a trained operator to obtain a coordiante point for a structure.

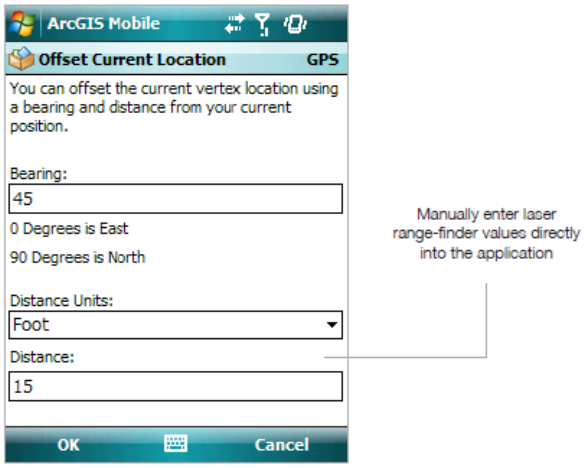

Figure 14 User interface for manually entering distance and bearing information to calculate the coordinates for an offset location. (ESRI)

Collection of Attributes – ArcGIS mobile provides an extensive set of tools to customize the entry of attributes for features (Figures 15 and 16)

Figure 15 Example of an ArcGIS mobile form to enter attributes (Esri)

Figure 16 Example of virtual keyboard for attribute data entry (Esri)

3. Search and identify features - It is critical to be able to quickly search and locate specific features either through attribute or location based searches (Figure 17). Within the ArcGIS mobile environment this is aided by a dictionary of feature types and a series of tools to build spatial and attribute queries.

Figure 17 Example of ability to identify a feature (Esri)

4. View Work List - ArcGIS mobile provides tools for creating queries to find an address, street name or block number. These can be assembled into a stored list of addresses to visit. It is then possible to display a list of features, update their attributes from or delete features. Note that it is also possible to hide the delete tool to prevent a field operator from actually performing a final deletion.

5. View field crew – With proper wireless network connectivity it is possible for members of the field crew to share their positions with each other as well as to report them to a manger in an office

6. Manage Edits - One of the major advantages of the ArcGIS mobile solution is a carefully controlled and customized environment to handle the way that field data is synchronized with server environment (Figure 18)

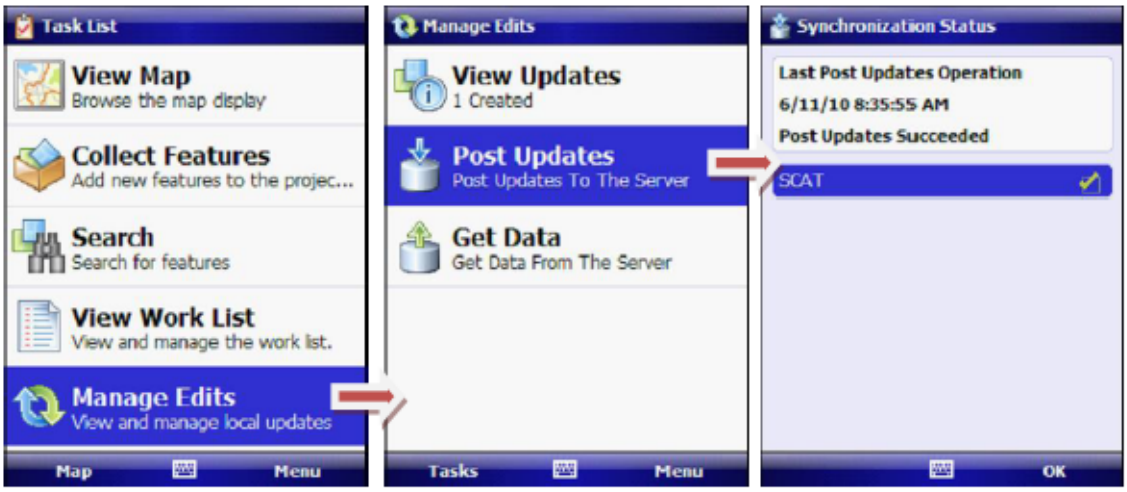

Figure 18 Synchronization data flow (Esri)

Among the important capabilities are the following:

- View edits in cache.
- View sync results.
- Get data from server.
- Post edits to server.

Editing Support

- Edit directly to local cache.
- Edit feature layers only in cache.
- ActiveX Data Objects (ADO) .NET to create, edit, and delete features. { Edit features on the server}

Mobile Service

- Communication component with GIS server
- Ability to get and post data with mobile Web service
- Cache for features, annotation, and rasters

Synchronizing With a Secured Server

- Secure web service access using a login account•
- Secure web service access using tokens
- Authentication can be handled by user name, password and domain.

Information stored recorded as part of synchronization

- Total number of features that were created, updated and deleted on the device since the last time they synchronized
- Date and Time that you last synchronized with the server broken down by posting and receiving requests
- A synchronization log listing all failed posts or "gets" from the server
- Indication of active synchronization that may be in progress on the device
- Access to Current Network Status

Changing Synchronization Settings

- Post Updates Settings
- Web service settings
- Token security settings

Other important functions

Capture photographs - The ArcGIS mobile software supports "geotagging" photographs (Figure 18). For many applications (utilities, building inspection), recording the photographic evidence has become a standard practice and is highly recommended for the GSS initiative. Many devices also allow for the inclusion of a voice memo to accompany the photo.

Figure 19 Example of user interface for adding a "geotagged" photograph (Esri)

Navigation - GPS navigation properties can be used to indicate current heading and speed. These properties may be useful when using GPS for navigation applications using the map. Bearing is based upon the last position received and distance is measured in MPH.