# UPDATING A UTILITY GIS TO DEPICT NEW CONSTRUCTION – A CASE STUDY

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**Abstract**

One of the more important issues for utilities with established GIS systems is to keep the GIS current and representative of real-world features. A timely and efficient approach is to equip field personnel to collect that data as construction occurs. With sub-meter GPS and ArcPad, field personnel can collect data and upload into the existing GIS system. Concurrently, field personnel can use the GIS in the field to assist with many day-to-day operations. This paper will describe a case study of a utility that has undertaken this project and will detail the steps along the way.

## Introduction

Martin County Utilities (MCU) is a growing South Florida water and wastewater utility with 26,000 connections and serving a population of over 60,000. Martin County is currently experiencing substantial growth, and this is expected to continue for some time. With rapid additions and changes to utility assets, it is increasingly important to keep the geographic information system (GIS) maintained and up-to-date with the most current information. In 1996, MCU decided to begin development of a GIS to help accomplish many tasks more efficiently. Each year MCU takes on several new challenges to enhance the GIS. One of the challenges for fiscal year 2003-2004 was to determine if it was efficient to collect GIS data in the field during construction. It was decided that a pilot project could assist in making that determination.

Currently, the process for updating and maintaining the utility GIS is based on digitizing asset information from record drawings or converting AutoCAD drawing files to GIS format. On a bimonthly basis, record drawings for new construction are input into the GIS utility system. These utilities are then on-screen digitized from record drawings. The features are digitized into a geodatabase with location and attribute data captured from the record drawings. The new method utilizes newer sub-meter global positioning system (GPS) technology, which is made available to field personnel to collect GIS data. Using the agency's existing GIS standards, the data can be collected in the field as construction occurs. Using this method, GIS data can be submitted to MCU's GIS in relatively short order. MCU also has the opportunity to collect more comprehensive data. Perhaps most importantly, it provides MCU field personnel a tool to help them catch potential problems or conflicts in the field before they arise.

The first step in the project was to acquire a sub-meter GPS device that would enable field personnel to gather data in an efficient and accurate manner. An accurate and efficient data collection tool was essential for success. The data collection device had to be fairly simple to use. The field personnel who would be responsible for data collection are not surveyors and have little or no experience with GPS, so learning how to use the device had to be somewhat simple and intuitive. After researching several units, the Leica GS20 GPS / GIS Data Collector was chosen based on several factors including ease of use, reliability, and technical support availability.

After the proper GPS equipment was selected for the project, MCU's utility GIS standards had to be followed to create a master code list for the GPS system. This code list would contain all potential utility features one might encounter in the field or find on record drawings. Using the existing personal geodatabase, a master code list was constructed. Attributes were added to these codes, so field personnel can input the data directly on site. The code list was developed utilizing drop down menus with default attributes that could be selected to minimize human error in attribute input.

Finally, field personnel had to be trained to use the Leica GS20 unit. The basic operation for data collection is fairly simple. The menus of the sub-meter unit are easy to follow and understand. All the major set up operations on the GPS unit are performed ahead of time, enabling field personnel to focus on data collection efforts. Once the unit is set up properly, the field data collection process consists of a few basic steps to input features and their attributes.

There are many benefits to utilizing this method for updating the utility GIS system. This Leica GS20 sub-meter unit allows for an efficient way to capture utility data in the field and utilize it directly in a GIS environment. Once the data is collected, raw data is extracted from the unit and can be directly converted to shapefile format using the GISDataPRO software provided by Leica. This process takes virtually seconds via wireless Bluetooth connections, and the data is ready for input into the master GIS utility file. This process eliminates heavy data input or conversion method that was implemented prior to this technology. It minimizes the need to perform on-screen digitizing of the utilities from record drawings and manual input of the attribute data. Now, all information is collected in the field during the utility installation process and simply converted and added to the master GIS database.

This method of on-site GIS data collection by field personnel allows for greater control and accuracy of the GIS system by MCU. Since MCU field personnel perform routine checks and provide overall maintenance of the utility system, they have great knowledge of existing and newly constructed utility features. Datasets from nearby existing utilities can be loaded into the project allowing for field personnel to perform QA/QC on existing utilities in the area as well as locate potential conflicts during the construction process.

The County has a central GIS operation in the Information Technology Services (ITS) department. This department coordinates user access on a countywide basis, and access for the public. It was critical for MCU to coordinate with the ITS department to ensure there was no duplications of effort and to ensure seamless operation. In order for the utility data to fit in with the County GIS, available guidelines were followed as needed.

**Equipment**

The Leica GS20 sub-meter GPS consists of two main components. The hand-held unit which replaces the cumbersome backpack with antenna is small and light weight. The antenna is located in the actual hand-held unit that acts as the GPS receiver, antenna and data collector. The second part of the GPS system is the belt that contains the communication hub for the system, a battery pack for the power supply, and the beacon receiver for the differential correction source. Figure 1 illustrates the basic components of the Leica GS20 data collector.


*Figure 1.*

The entire system is wireless and is based on the Bluetooth communication hub located on the belt. This enables the unit to receive and transmit information to and from the data collector/receiver to the belt, as well as, back and forth from your desktop computer to the GPS unit. Code lists can be created and edited on the GPS unit itself or on your desktop or laptop computer utilizing the GISDataPRO software provided with the unit. This software can be installed on a desktop computer and enables the user to create code lists, set-up projects, import/export and convert raw data, and acts as a viewer. This viewer allows a user to see the raw data, insert aerials and other GIS background information, and perform edits on the raw dataset.

Another useful addition to this set-up is the integration of ArcPad software. ArcPad cannot run directly on the Leica GS20 by itself, but with the addition of a PDA, it can be integrated with the GPS system. It requires linking cables and adapters to hook up the PDA with ArcPad to the GPS receiver. The user can then use the ArcPad interface instead of the hand held GS20 receiver/data collector to input information. Also, with the use of ArcPad, a user can load graphics such as pre-construction plans, base maps, or aerials directly into the PDA. The user can view their location on these base layers as data is collected. This provides an extra dimension to the GPS and enables the user to incorporate a background base map layer to use for extra guidance and support.

**Project Set-up**

There are some steps to set-up the Leica GS20 data collector before the unit is ready for field use. Initial set-up consists of settings for time, date, location, units of measurement, and type of differential correction source being used. Once these basic setting are in place, the system stores this information internally, and there is no need to perform the set-up again. On initial use, the GPS will download an almanac for the satellites. This almanac directs the unit to the proper locations of the satellites and provides information regarding the availability of them. Prior to the unit being put to work, a project and corresponding code list must be created for the project.

The first step to project set-up is the creation of the code list. Each code would represent a feature class in the master geodatabase. The code list was based on the existing MCU utility GIS. The codes along with their corresponding attributes were created based on the geodatabase already established. This would enable for seamless integration with the existing GIS data. The codes were created using the GISDataPRO software. Each code was created and its corresponding attributes to match the format and structure of existing data. Figure 2 shows a piece of the code list within the GISDataPRO software.

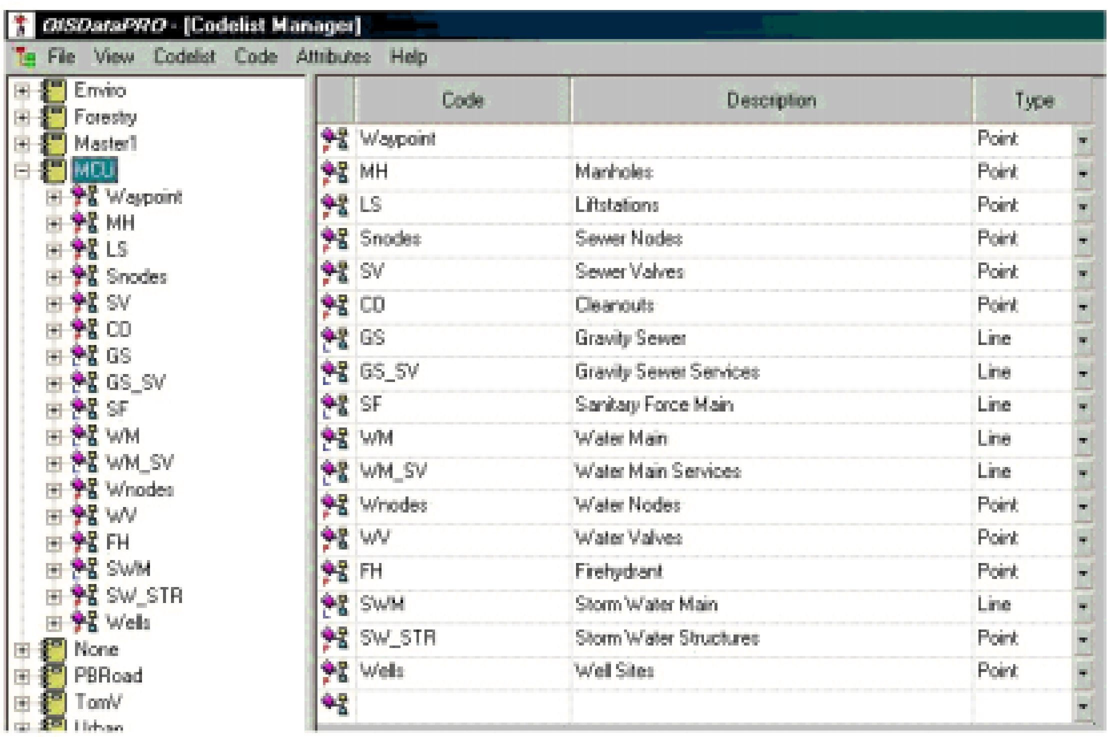


*Figure 2.*

The GIS specialist creating the list controls the format of the features being collected. In the GISDataPRO, the user defines each code's structure creating it as a line, point or polygon. Then, the code's attributes are created. Each will become a field in the final dataset. The field's properties are selected specifying whether it's to be text, a real number, or integer. Also, the attributes can be created with drop down menus that contain value regions and default values, thus minimizing the risk of human error during the process of data collection. Just as in ArcGIS, the GIS specialist can control the database being edited with default values and domains.

Once this code list is created, it can be used for multiple projects and doesn't need to be re-created. It can be exported to the GPS unit were it remains available to use in any project one creates. The code list can be edited to delete or add any additional codes as well as change the format of any existing codes. This is very useful in the initial implementation of the project, for one can adjust codes as testing goes on to fit the needs of the user without having to re-create the entire code list.

Finally after completion of the codes, a project must be created. This project will utilize the code list created and contain such information as the coordinate system of the data and the units in which data should be collected. The project can be created from the main menu of the GISDataPRO by simply choosing from the file menu "new" and filling out the information requested.

The final step in the set-up phase is to transfer the code list and project from the GISDataPRO software to the actual GPS unit itself. This is accomplished by the wireless Bluetooth connections of the Leica device. By utilizing the sensor transfer menu from the software, one can transfer code lists and projects to the Leica GS20 unit in seconds and without wires. Once the code list and project is transferred to the GPS device it is ready to be put to work collecting field data.

## Training

Before the field personnel can go out and start collecting data, training needs to be provided on the basic functions of the data collector. Since initial set-up is complete and the code list and project have been transferred to the GPS device, the field personnel simply need to open up the project, and the unit is ready to collect data. Once the project is open, there are a few basic functions of the data collector that the field personnel need to be aware of. The unit's basic data collection functions are all carried out using the touch pad located on the front of the unit. The pad consists of arrow keys and alphanumeric keys for use in attribute input. The unit face is illustrated in Figure 3.

*Figure 3.*

From the main menu, the user can access all the functions of the GPS system. Once in the data collection mode, the user can scroll through the code list to choose the appropriate feature to capture in the GPS. Then, the menu to collect data is opened which consists of an occupy button and the attributes of that particular code. The occupy button enables the user to take a reading and collect the feature being observed into the GPS. Once the device is finished taking a reading and the data meets the quality standards that were established in the initial set-up, the attributes can be added to the feature. All this is done using the arrow keys along with the alphanumeric keys located on the pad. Finally, the feature can be saved, and the user is ready to move on to the next feature to be collected.

The on screen graphical display provides key information to the user about various processes of the GPS. Located at the very top of the display are the essential status indicators of the device and are key to understanding what's going on with everything from satellites to battery power of the unit. There are a total of six indicators at the top. There is an indicator that displays the battery power, an indicator for how much hard drive space the user has used up and has available to them for data collection, an indicator to show if the unit is receiving the signal from the differential correction source, an indicator to display the number of satellites available and how many are locked in, an indicator to tell the user if it's taking a reading or ready for the next one, and finally an indicator to show the horizontal and vertical accuracies the unit is obtaining at the moment.

Training consisted of a couple hours of hands-on demonstrations and field data collection exercises provided to field personnel by the GIS specialist. The data collection menus are intuitive and the field personnel were quick to pick up on how to read the digital displays, collect data, and input attribute information. Also, some basic problem solving techniques were provided as the demonstrations went along and questions or concerns arose.  Overall, the field personnel found the unit to be small, lightweight and very user-friendly.

## Data Collection Process

After training, the field personnel were ready to go to the site and collect GIS data.   With the project open, the user must use the digital display to observe the status of the satellites and differential correction signals to make sure they are obtaining the proper signals for data collection.  Once the unit has picked up a minimum of four satellites and a correction signal from the coast guard tower is achieved, the GPS can start collecting sub-meter data.

The project is opened up and the codes are displayed.  The use of pre-construction plans has shown to be beneficial in figuring out the general location of the new utilities and provide for an overall view of the project site.  The user simply walks over to the feature to be captured, scrolls to the appropriate code in the list, and selects it for data capture. Then, the user simply stands over the feature holding the GPS slightly away from their body so not to obstruct the signal during data capture.  The user checks over their display at the top to ensure that the unit is receiving the correct number of satellites and a differential correction.  Finally, with the units head directly over the top of the object, the user can select the occupy button to record positional data on that feature.  Once the positional data is recorded, the field personnel can continue on to the attribute data. Selecting from the various drop down menus the user defines the attributes and finally saves the feature into the database.

The user can collect points, lines, and polygons.  The method of data collection is primarily the same for each, except that when collecting lines and polygons, the user has more options as to how to collect that data.  Line and polygon data may be collected by either streaming mode or by node.  In the node-to-node collection mode, the user occupies one point at a time as with collecting simple point data.  Then the GPS automatically draws a line connecting those points to construct the line or polygon.   With the streaming option activated, the GPS data collector records readings at pre-defined intervals as the user walks along the path.  The line is constructed in this manner and may be useful if collecting a line segment with many nodes.

## Data Conversion

When the data collection process is complete, the raw data needs to exported from the GPS to the desktop and converted to shapefiles.  This process is made simple with the use of Bluetooth technology and the GISDataPRO's quick conversion utility.  With the GISDataPRO software open to the sensor transfer mode and the GS20 on and relatively nearby, the transfer of raw data takes merely a few seconds.  Then, the user needs to exit out of the sensor transfer mode to the main menu of the software and open up the project created and import the raw data.  From this screen, the GIS specialist can view the data collected and perform some basic QA/QC.

The GIS specialist can check to see if all features are present by comparing the raw data to the pre-construction plans. This is the best time to catch any mistakes for items that may have been omitted from the pre-construction plans. It is also an opportune time to add any additional features found while performing on-site data collection with the GPS. Edits can be made at this phase if errors are discovered. For example, if an object was collected under the wrong code, the GIS specialist can switch the code to the correct one. Features can be deleted or moved and positional accuracy can be verified.

Once the GIS specialist is satisfied with the raw dataset, they can then simply export the data to shapefiles. The software automatically generates shapefiles from the raw dataset, and the data is ready to use in the GIS system. There, additional QA/QC should be performed on the attribute data in ArcGIS prior to integration into the master geodatabase. Integration into the master geodatabase in ArcGIS is shown in Figure 4.

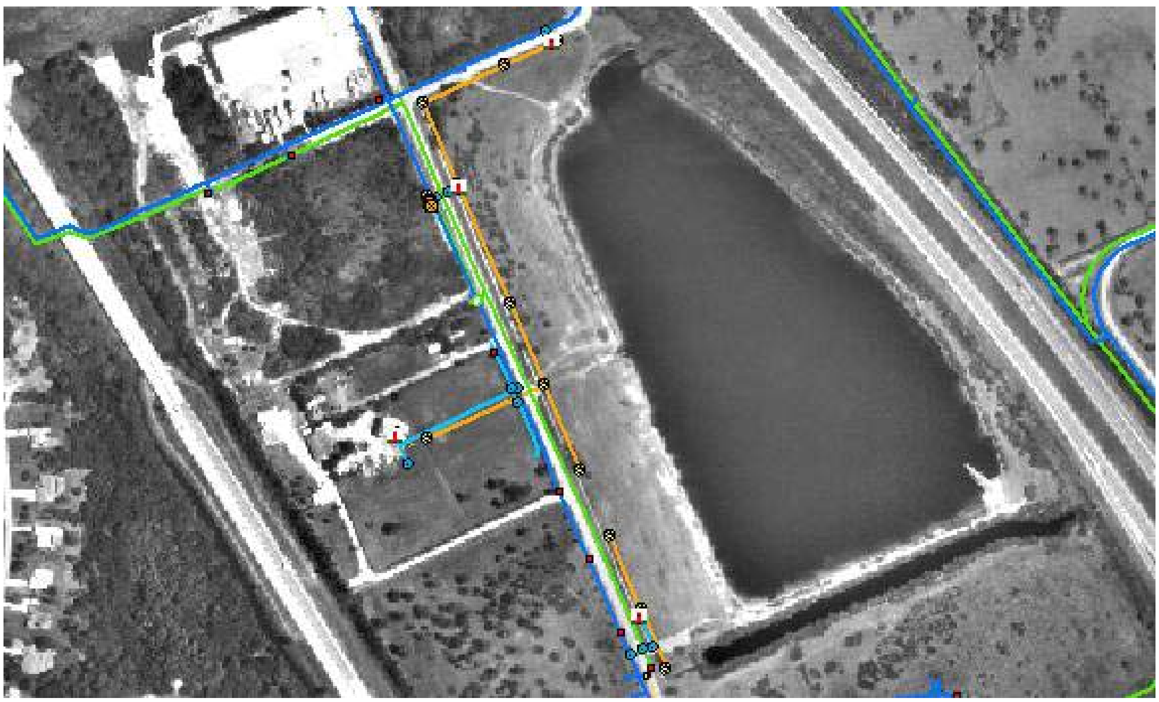

*Figure 4.*

The final step in the conversion process is to import the shapefiles generated by the Leica software to the geodatabase. For this process, ArcCatalog is used. In ArcCatalog, one simply needs to navigate to the desired feature class and right-click. This will open up a menu with an option to load data. From there, it's a matter of following a wizard that guides the user through the process of loading the shapefile into that particular feature class. Once this step is complete, the imported features become part of the master geodatabase, and the conversion process is finished. With the help of Leica's GISDataPro and ESRI's ArcCatalog, the conversion process from raw GPS data to Geodatabase is both quick and easy and provides an end product that is accurate and comprehensive.

## Benefits and Pitfalls

There are many benefits to this method of updating a utility GIS to depict new construction. The field personnel can catch any problems early on in the process and can even locate items not found on plans. There can be a significant reduction in human error with the use of default values and simple and clear drop down menus for attribute input. The data is provided in GIS format and is ready to use in the GIS system immediately. This process eliminates the need for heavy data input or a large data conversion effort that would be required later on. All this makes for a more comprehensive data collection method and in the end adds minimal cost to the project.

Another benefit of this method of GPS data collection is that in the future, once the utilities are covered up, field personnel can use the stored GPS data to navigate back to any utility feature. This enables field personnel to locate underground utilities in the future when designing or constructing new pipes in the same are. The Leica GS20 is not merely a data collector. It can act as a navigation device and utility locator for future projects.

Although this method for updating utility GIS is efficient and accurate, potential problems can exist. Atmospheric and environmental conditions can block signals and otherwise hinder data collection. The equipment can lose its almanac and require extra time to pick up the satellites, or the hub of the unit won't communicate with the GPS receiver momentarily. Although rare, these technical problems can occur. The user should be aware of these potential problems and how to minimize them. This may require the use of more complex field methods such as an offset. Alternatively, the feature may need to be added later using the traditional method of on screen digitizing from a set of record drawings.

Finally, the field personnel using the technology should be eager to work with the new technology. Some field personnel are reluctant to use new technology and may take longer to train. When weighing out all the benefits and problems, that this method for updating utility GIS looks as if it is here to stay. In the future with even better equipment and training, it may become the most ideal method for GIS data collection for new construction.

## Conclusion

Updating new utilities in GIS is as important as ever as people are increasingly relying on GIS in their day-to-day tasks. In an area such as Martin County, Florida where substantial growth is occurring, keeping the GIS current requires continual effort. Martin County Utilities decided to conduct a pilot project to determine if it was efficient to collect GIS data in the field using handheld sub-meter GPS technology as the new construction was occurring. This data was then uploaded into the GIS. The utility found that this was indeed a viable and comprehensive method to collect data and update their GIS quickly. As time goes on, more data collection projects will be conducted in this manner. And as technology becomes even more user friendly and more enhancements are made, projects such as this as should become even more successful.

**Acknowledgements**

Figures 1 and 3 were obtained from Leica located at the following website: http://www.leica-geosystems.com/gpsgis/gs20/index.htm

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