BIOGRAPHICAL INFORMATION

Mark Hatfield
Executive Consultant
KEMA
101 Inverness Drive East, Suite 140
Englewood, CO 80112
Telephone: (303) 708-9355 Fax: (303) 708-9356

Specific Responsibilities

Joined KEMA in 2002. He has over 9 years experience in the planning, design, integration and implementation of field automation, work management, and geospatial systems for energy utilities. He leads or participates in projects to perform feasibility studies, vendor selections, strategic planning, system design and configuration, project management, business process optimization, and project audits. Mr. Hatfield provides practical knowledge and experience vital to the success of a client's strategic information technology project

Past Experience

From 1995 - 2002, worked at Convergent Group as a senior consultant focusing on the planning, design, integration and implementation of field automation, work management, and geospatial systems for energy utilities.

From 1985 – 1995, served as an officer in the US Air Force introducing commercial GIS, GPS, and remote sensing technologies to various peacetime and wartime applications.

Educational Information

B.S. – Geography, US Air Force Academy
M.A.- Geography University of Illinois

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GPS Applications for Utilities: Challenges to Adoption

ABSTRACT

As a proponent of GPS applications, it is frustrating to see the actual adoption of GPS technology be so slow in utilities. Many utilities use GPS for a limited range of applications, but curiosity far exceeds actual GPS implementations. The basic premise for this paper is that a GPS application must have a valid business case in order for a utility to proceed with implementation. The paper discusses limitations in current geospatial systems and processes that hinder GPS adoption and potential mitigation strategies. This paper identifies the range of GPS applications for utilities. For each application, the potential benefit categories are summarized and the challenges to adoption are discussed. This analysis identifies applications with good potential business cases.

INTRODUCTION

With 14 years of practical GPS experience in the military and civilian sector, it has been fascinating to see the explosion of GPS applications in a wide range of industries for data collection and navigation. The purpose of this paper is not to highlight GPS use in other industries. Rather, it is to discuss why adoption of GPS in the daily operations of utilities is so slow. Given their investment in GIS systems over the last 20 years to spatially manage assets, why aren't more utilities using GPS to locate new assets and navigate to existing assets? There are utilities incorporating GPS into routine operations. However, curiosity in GPS far exceeds actual implementations.

This paper begins with a discussion of issues in current geospatial systems and processes that may hinder GPS adoption. Then the paper identifies a range of GPS applications for utilities. For each application, the potential benefits are summarized and the challenges to adoption are discussed. This analysis identifies applications with good potential business cases.

CHALLENGES TO ADOPTION

GPS applications are affected by the underlying spatial data infrastructure of the utility. The decisions made in building and maintaining this spatial data infrastructure will impact the potential success of GPS applications. Because GPS is a field application, it must also meet the operational needs of field resources to be accepted. Finally, it should improve field and office processes to have a successful business case. Within the context of a utility's spatial data infrastructure, field realities, and the need to have a financially successful application lay a range of potential challenges to GPS adoption at utilities. This section will discuss some of these challenges.

Paradigm of Dimensions vs. Coordinates

If you look at a paper map in a typical utility, I challenge you to find any geographic coordinates displayed on the map. Utilities use dimensions to locate facilities, especially underground facilities, relative to other features the field crews can identify. For example, an underground pipe or conductor may be located "two feet south of the south curb." To a field crew, this relative location is an excellent description of where the facility is located. It doesn't matter if the south curb is located with 6 inches or 60 feet of its actual location on the map. If you can find the "south curb", you can find the facility. To a GPS receiver, "two feet south of the south curb" is unintelligible. GPS lives in the world of absolute location expressed as coordinates. It could be geographic coordinates, state plane, or UTM, but coordinates describe the location of that facility.

This contrast between the relative location of dimensions and the absolute location of coordinates poses a problem for utilities. If you use GPS for navigation, where do you get the coordinate information to enter into the GPS so GPS can guide you to the facility? The paper map doesn't show the coordinates. If you need GIS data in the field to provide the coordinates (using a mobile GIS solution), the cost and complexity of a field GPS solution increases. If you are using GPS to capture the location for a facility and return it to the GIS, how will non-GPS users navigate to the facility if you don't also capture dimensioning data? If you use GPS to capture the location of a facility, can only GPS users locate that facility?

A similar problem impacts underground transmission facilities. Transmission applications typically rely on stationing from a known starting point. You know that you have a weld or a splice 1,000 feet from a known starting point. But what are the GPS coordinates of that weld/splice?

Just as GIS has evolved to include both absolute and relative location descriptions, until all field users have GPS, GPS field applications must support absolute and relative location descriptions.

Horizontal Accuracy of the Underlying GIS

The horizontal accuracy of the underlying GIS data does not prevent a utility from using GPS. However, the horizontal accuracy should temper expectations of what GPS can do. Later in this paper, we will divide GPS applications into two broad categories:

- Navigation – using GPS to get to a geographic coordinate.
- Data collection – using GPS to capture the coordinates for a facility.

Navigation applications are impacted the most by the horizontal accuracy of the GIS. If the expectation is to navigate to within one meter of an underground facility, it is difficult to meet this expectation if your GIS has a horizontal accuracy of ± 40 feet. A GPS receiver using real-time, high-quality DGPS corrections, can get you within one meter of the coordinate you enter. However, the actual facility could be anywhere within a 40 feet radius of that point. 40 feet of error in the underlying GIS data could put you on the wrong side of the street. Certainly the horizontal accuracy of the GIS data will impact the confidence field users have in navigating to the actual facility of interest.

Regardless of the horizontal accuracy of the GIS, you can use GPS for data collection and capture the features at whatever accuracy you desire. The difference will only be apparent when the GPS data is displayed against the existing GIS data. If the underground facility is actually two feet south of the south curb, but it displays it in the middle of street, users will have difficulty using the new data. A solution is to carry two sets of coordinates for all facilities in your GPS. One set is the actual GPS coordinate; the other set is the coordinate for where it looks "pretty" in the display. With this approach current users of the GIS display are satisfied and future navigation applications have a set of coordinates to use.

Standard vs. Custom GIS/CAD coordinate systems

One of the Murphy's Laws of mapping is that any area you are interested in will straddle at least two map sheets. A corollary to this law is that a utility's facilities will straddle one or more state plane or UTM zones. Some of the earlier adopters of GIS solved this problem by creating their own custom coordinate system to locate all their facilities. Creating a custom coordinate system rarely impacted anyone outside the mapping department. However, using custom coordinates can make the adoption of GPS more complex.

First, not all GPS receivers can display custom coordinate systems. If you have a custom coordinate system, make sure the GPS vendor can support the translation between real world coordinates and your system. Second, translating between your custom coordinate system and real world coordinates assumes you know how the two relate. If you can clearly state the relationship, usually in the form of a mathematical conversion factor, and you select a GPS receiver that can do the translation, the impact on GPS adoption should be minimal. The price you pay is a reduced set of GPS receivers and/or processing software to choose from and possibly a higher cost for the additional functionality.

If you are one of the utilities with custom coordinate systems that cannot translate to a real-world coordinate system, the challenges to using GPS exceed the scope of this paper.

Cost of GPS equipment

Two important questions you must consider when implementing GPS:

- How accurate does your GPS information need to be?

- Do you need real-time accurate information in the field?

The answers to these questions will have a significant impact on determining the cost of the GPS equipment you will need and therefore on your business case.

If you expect a user to navigate within one meter of a location, you need high quality, differential GPS (DGPS) equipment with access to a real-time DGPS source. This equipment costs $3,000-$6,000. If you expect users to collect facility locations within one meter of the actual location, the price range is the same. If you want to navigate to within 8-12 meters of a location, the price will be in the range of $300-$1,000. Obviously, the business case to justify $300 equipment is very different from a business case for $6,000 equipment for the same number of crews.

<u>Where is the Business Case?</u>

The premise of this paper is that a utility must have a business case to justify implementing a specific GPS application. If a regulatory change required precise location of new facilities or precise navigation, then GPS would be easier to justify. However, without the regulatory requirement, utilities must justify the cost of GPS equipment and processes through savings – increased productivity, reduced duplicate data entry, reduced damage to buried facilities, etc.

You could conclude that because curiosity in GPS has not translated into a large number of GPS implementations, that the business case for GPS must not be very good. I am not saying I agree with this conclusion, but it does make for interesting conversation. Some of the utility applications proposed for GPS sound good, but it is difficult to identify the benefits to justify the costs. Other applications have definite benefits; the question is whether the utility is willing to acknowledge those benefits to justify the project.

An overall benefit of GPS that is fascinating to debate is whether there is a quantitative, financial benefit to improved positional accuracy. Is there a quantitative benefit to having facilities located at an absolute horizontal accuracy of ± 1 meter versus ± 40 feet? You can argue there is a benefit. Improved horizontal accuracy should result in a reduction of dig-ins and damaged facilities. Improved horizontal accuracy should increase user confidence in mapping data and result in decreased search time in the field and fewer calls to the office for information. Increased horizontal accuracy may reduce costs related to excavation, paving, and landscaping. The potential savings will vary among utilities and will depend on how the improved horizontal data is used in the field. A utility's willingness to embrace the benefits of improved horizontal accuracy will have a large impact on the potential business case of GPS applications.

GPS APPLICATIONS FOR UTILITIES

The remainder of this paper focuses on GPS applications for utilities. I divide GPS application into two categories:

- Navigation – using GPS to get to a geographic coordinate.

- Data collection – using GPS to capture the coordinate(s) for a facility

Within each category, I identify a variety of GPS applications for utilities. For each application, I provide a description of the application, a discussion of the potential benefits, and potential challenges that may limit a utility's ability to realize the benefits.

Navigation Applications

The following navigation applications are discussed in this section:

- Navigation
- Locates/one call
- Automated Vehicle Locating (AVL)

Navigation

The general concept of navigation is using GPS to guide a user to a point of interest. The simplest application requires a user to manually enter the coordinates of a facility into the GPS. The basic GPS functionality will give the user an "as the crow flies" distance and bearing to that facility. It is up to the user to figure out how to get there. A more eloquent implementation is to combine GPS with a mobile mapping application. The user selects the facility of interest and sees its location on the map. With the current location of the user also displayed on the map, the user can determine how to navigate to the facility. Additional functionality would give the user driving directions to the facility using the intelligent landbase in the mobile mapping application, similar to Mapquest.

Potential Benefits

The potential benefits for navigation include:

- Reduced search time. The time spent looking on paper maps, calling dispatchers for directions, etc. is a direct benefit for this application. This can be primarily taken for service technicians as they search for a meter/service, and trouble and maintenance crews looking for a specific facility. The time office personnel spend supporting field queries should also be considered.
- Increased autonomy for contractors and/or foreign crews. If non-company crews have the tools to find facilities on their own and navigate in unknown areas, the productivity of these crews would increase. Also fewer company resources would be required to support these crews.

Potential Challenges

The ability to realize these benefits depends on the degree GPS is integrated with a mobile mapping solution. If the user has to enter the coordinates manually and rely on distance and bearing to navigate to a facility, what is GPS doing for them? They have to find the coordinates for the facilities (see the discussion of dimensions vs. coordinates above). Then they have to enter two, 8-11 digit coordinates into the GPS manually with no errors just to get a distance and bearing. Where are the timesavings? Where is the reduced search time?

GPS integrated with a mobile mapping solution does have the potential to reduce search time and help contractors/foreign crews because the user interface is easier to use and more useable information provided to the user.

One Call/Locates

Using GPS to help with one call/locate orders is an extension of navigation. However, GPS must get the user close enough to the facility to assist in the locating process.

Potential Benefits

The primary benefits of GPS for one call/locate orders are summarized below:

- Reduced search time. GPS should get the locator to the area quicker and closer therefore reducing their time spent searching for facilities.
- Reduction in damaged facilities. Getting the locator closer to the correct facility to begin with should increase the accuracy of the locators and reduce the instances/severity of damage facilities.
- Replacing locating equipment. There is the possibility, if the GPS and GIS data are accurate enough, to have GPS replace one of the locating devices locators must carry. This would be a cost savings for the repair and replacement of equipment.

Potential Challenges

The potential challenges for one call/locates is very similar to navigation and therefore won't be repeated. One call/locates have the following additional challenges:

- Accuracy of the underlying GIS information. If you have very accurate absolute location information (ideally within one meter), there is the potential for GPS to help you locate underground facilities.
- Can GPS replace any locating equipment? The key is whether this is realistic at your utility. Is it realistic to think GIS information will ever be accurate enough to trust without equipment to verify the location? What will the lawyers and regulators say about this? The answer is the key to whether this benefit is realistic for one call applications.

Automated Vehicle Locating (AVL)

AVL is the periodic radio broadcast of a GPS location from a vehicle to identify its location. This information is displayed to dispatchers so they know the location of all tagged resources. Typically, the frequency of updates can be configured based on time or by distance traveled.

Potential Benefits

There are intuitive advantages to giving crew location information to dispatchers, but some of the benefits may be difficult quantify. The key benefits are summarized below:

- Crew safety. If a field crew hits the emergency button on their radio, dispatchers know that a crew is in trouble. But where are they? With AVL, the dispatcher can quickly see the last known location of the crew or poll the vehicle to identify its current location. Emergency response times are improved.
- Reduced response time. If you know where your crews and equipment are located, you should be able to determine the "best" crew to send to an emergency much faster. Time spent on the radio determining where crews actually are is reduced, if not eliminated. Drive times and mileage may be reduced.
- Increased productivity. The goal is to reduce travel time to increase the amount of time available for real work. AVL provides a tool to track a crew throughout their day. Productivity can be improved by giving supervisors the ability to monitor crews. There is also the potential to monitor driving patterns over extended periods of time to tune assignment algorithms in dispatching systems.

Potential Challenges

The potential challenges for implementing AVL are as follows:

- Big brother. The biggest single challenge is acceptance by the field workforce. The technology raises the issues of spying, trust, and enforcement. If sold for crew safety, these issues are minimized. Used as tool to monitor or enforce productivity, the emotions and resistance are strongest.
- Radio network impacts. One packet of GPS data across the radio network is small. However, as the number of vehicles and the frequency of the AVL updates increases, the potential traffic on the radio network can become overwhelming. Careful consideration must be given to the impact on the radio network as the AVL system is configured.

Data Collection Applications

The following data collection applications are discussed in this section:

- Field inventory
- Job estimating
- As-built collection
- Adding GPS to existing processes

Field Inventory

Field inventory is a one-time project using GPS to capture facility or landbase information for a GIS, mapping system, etc. A field inventory is usually done to capture information that is not available from other map sources and/or to improve the location accuracy of facilities.

Potential Benefits

The primary benefits of field inventory are summarized below:

- Field inventory may be the only means available to capture location, connectivity, or attribute information for a facility. If the GIS applications that need this information are important to the utility or justified by a business case, the field inventory is necessary.
- Field inventory, if done correctly, is one of the most accurate forms of data conversion.

Potential Challenges

The potential challenges of field inventory are as follows:

- As discussed above in the underlying accuracy of the GIS, it is likely that the facilities captured via field inventory will have to be moved to look good against the underlying GIS landbase. Facilities must be on the correct side of the curb. Facilities will have to be moved to improve readability and reduce over plotting.
- You must have solid business processes to ingest, edit, and connect all of the data gathered from the field inventory. The business processes must identify data that needs to be reacquired if the data set does not meet standards.
- Do you have the business processes and technology in place to maintain the quality of information resulting from the field inventory? If you are going to spend the money on a GPS field inventory, you should also decide how you will maintain that same level of accuracy (attribute and/or location) for newly constructed facilities.

Job Estimating

Job estimating integrates GPS into the field design process. When an engineer visits the field to sketch the design, rather than redline existing maps, the sketch is created using GPS and actually walking the design. A basic job estimating application identifies the location of point features (for example, poles or valves) and linear features (for example, the conductor or main). More sophisticated applications will incorporate the utility's compatible units into the design so cost estimates can be created in the field.

Potential Benefits

Vendors of these applications advertise savings of up to 20 percent on field designs. These benefits are as follows:

- Reduction in duplicate data entry. The design is created in the field and incorporated into the GIS. The design is not drawn on paper, redrawn in the GIS, and re-entered in the work management system.
- Reduction in paper work. The paper work is included in the field design process.
- Compression of design timelines. Because of the previous benefits, the time to complete a design and communicate with the customer can be significantly reduced.

Potential Challenges

The potential challenges of incorporating GPS into the job estimating process are as follows:

- The benefits assume the normal business process is to send the engineer to the field for the design. If a utility's process does not include this step, it is difficult to realize the benefits.
- You must have solid business processes to ingest, edit, and connect all of the field design data. If the process is too convoluted or results in a backlog of designs to be processed, it becomes difficult to realize the benefits identified above.
- You should have strong integration among the job estimating application, GIS, and to some extent, work management. If one of the primary benefits is reduction in duplicate data entry, then the integration must not require duplicate data entry.

As-Built Collection

This application uses GPS to capture the installed location of new facilities and replaces redlined construction drawings. A more sophisticated as-built collection application includes the work management side of the job completion process (for example, time, materials used, materials returned, etc.)

Potential Benefits

The primary benefits of using GPS in as-built collection fall into two general areas: improving the timeline of as-built posting and improving the positional accuracy of new facilities. The specific benefits are summarized below:

- Reduce duplicate data entry. Using GPS to capture the location and attribute information for the required features and directly ingesting this data into the GIS removes the time spent red-lining construction prints and manually posting this information into the GIS. To the extent work management data is captured by the application, that duplicate data entry can also be reduce or eliminated.
- Reduce as-built backlog. By reducing duplicate data entry, the goal is to significantly reduce the backlog in posting construction information. Therefore, all GIS applications and systems that use GIS information have the most recent network information as quickly as possible.
- Improved positional accuracy of facilities. Incorporating GPS into the construction process enables a utility to maintain the positional accuracy obtained by GPS field

inventory and/or job estimating. For utilities that did not do a GPS field inventory, it begins the process of improving the location information on its assets.

Potential Challenges

The potential challenges of using GPS in the as-built collection process are as follows:

- You must have solid business processes to ingest, edit, and connect all of the as-built information. If the process is too convoluted or results in a backlog of designs to be processed, it becomes difficult to realize the benefits identified above.
- You should have strong integration among the as-built collection application, GIS, and to some extent, work management. If one of the primary benefits is reduction in duplicate data entry, then the integration must not require duplicate data entry.
- Capturing the GPS information should not be extra work. If weak business processes and/or integration are implemented, then GPS just adds work to the field crews rather than reducing the total amount of work.

Adding GPS to existing processes

Once you understand the fundamentals of GPS navigation and data capture, the potential benefits and challenges can be extrapolated to other processes that may benefit from adding GPS. Gas utilities frequently ask about incorporating GPS into applications such as leak survey, and cathodic protection surveys. Electric utilities are interested in incorporating GPS into storm damage assessment and line patrols. The benefits for these applications are very similar to the other data collection applications discussed above. The challenges to realizing the potential benefits focus on good business processes and data integration to speed the ingestion of information and truly make the field technicians' jobs easier.

CONCLUSION

GPS holds great potential to improve the locational accuracy of facility data at utilities. However, whether GPS is feasible at your utility is difficult to generalize. As you begin your investigation, I would recommend reviewing the challenges to adoption section and determine to what extent these challenges exist at your company. Next, identify the application(s) you are interested in and begin to build the business case. The cost of the GPS equipment must be appropriate for the application. You will not get one-meter horizontal accuracy from a $100 consumer grade receiver. Carefully identify the costs of implementation and do not skimp on the business process re-engineering and data integration because they are key to user acceptance and realizing the benefits you are identifying. Be aggressive in identifying potential benefits; be realistic in realizing benefits