Field Guide for the Use of Global Positioning Systems (GPS) and Geographic Information Systems (GIS)

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Office for the Coordination
Of
Humanitarian Affairs

DRAFT

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User notice: While the information within this guidebook is organized in a logical manner, it is suggested that the entire document be reviewed thoroughly before initiating a GPS survey. Not all GPS receivers operate the same, so it is also suggested that the user thoroughly review the user manuals that accompany their GPS device.

Introduction

Humanitarian and relief operations require accurate knowledge of location as a requisite input into the planning and coordination of field operations. The technology of satellite-based navigation, or GPS, and geographic information systems (GIS) combine to give field personnel full command of the locations and distribution of populations, roads, distribution centres, and key facilities for all logistics, analysis, and planning activities. This field guide provides a basic overview of the operations for GPS and the methods for transferring coordinate data into computer mapping systems or GIS.

How to Use this Guide

An overview GPS (from Global Positioning Systems) is provided to introduce the systems components and demystify the functional components of this technology. Field officers will learn some fundamental insights regarding planning for the use of GPS in surveys and methods to handle the data gathered from the field. Using the guide as a reference, the field officer is expected to read the user manual for any specific brand of GPS hardware and become familiar with the custom operations of that hardware. This guide provides a framework for field operations using these technologies with references for further technical assistance.

What is GPS?

Overview

Global Positioning Systems, or GPS, are surveying and navigation systems that allow the user to obtain, view, and store precise information about geographic positions on Earth. Advances in GPS software also allow for precision navigation over roads or off-road terrain.

The main component of any GPS is the network, or constellation, of satellites that orbit the Earth and constantly transmit encoded radio signals that can be detected by user-controlled instruments. The Navigation Satellite Timing and Ranging network (NAVSTAR) is deployed and administered by the U.S. Department of Defense. Construction of a second satellite constellation for GPS is sponsored under the European Galileo system.

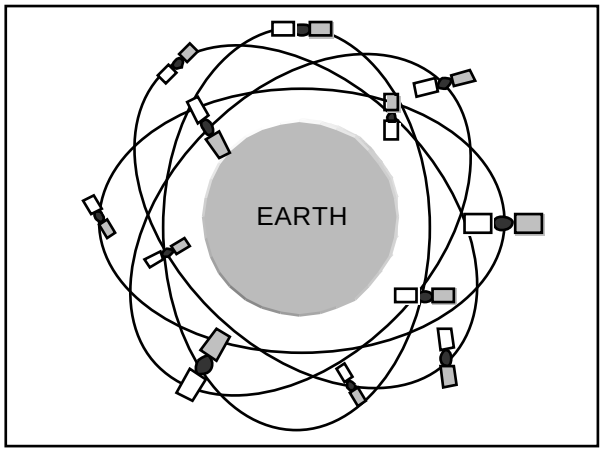


Figure 1: GPS Satellite Constellation

Besides the satellite array, there are several key hardware components in a GPS:

- Receiver
- Antenna
- Data Device
- Power Source

A software program that permits data download, viewing, editing, and exporting usually accompanies these key hardware components. GPS receivers are designed to acquire the radio signals that are transmitted from these satellites and process that data into coordinate values.

The antenna is generally connected to the Receiver and Data Logger via cables, but some antennas are combined in a common housing with the other hardware components. Some modern GPS equipment use wireless technology to connect the main hardware components. A range of GPS receivers from simple handheld units to higher precision backpack units will be encountered in the field.

The Data Device is a small computer-like element that stores and displays the collected data. This device can be an actual computer, but more often is a lightweight, handheld data-logging instrument that includes a digital display screen, keypad functions, and connections to the Receiver component.

Power Sources vary depending upon the type of receiver being used, and the location of use. Many modern GPS receivers use internal batteries that can be easily replaced. Larger receivers may require more substantial batteries that can be recharged, or support direct electrical sources as from vehicle batteries.

These GPS hardware elements are collectively referred to as “the GPS receiver,” are controlled by the user, and are carried together in a housing unit or pack that can be easily carried by an individual.

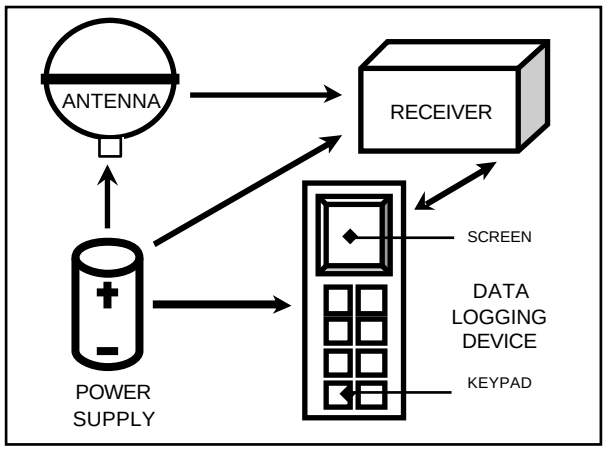


Figure 2: Key Hardware Components of a GPS

***Common Applications*:**

GPS is used for land, sea, and air applications. Depending upon the objectives of the user, GPS can be used to survey and collect data, or to navigate to a predetermined location.

GPS receivers are used to support a variety of primary data collection projects and advanced applications. These efforts may include:

- Scientific Sampling (water, soil)
- Public Health and Safety (mine fields, disease vectors, epidemic locations)
- Resource Mapping (water, firewood)
- Survey Monument Recovery
- Property Boundary Surveys
- Aircraft , Ship, and Vehicle Navigation

How does GPS Work?

Overview

GPS data are collected through a relatively simple, but practical manner. The receiving elements of the GPS (see Figure 2) acquire the radio signals from several discrete satellites and through basic geometric principles (triangulation) compute the current location of the GPS antenna.

To complete this calculation, two basic pieces of information are required; the location of the satellites relative to the receiver, and the distance that each satellite is from the receiver.

The radio signals that are sent include information about which satellites are transmitting, and where they are positioned in their orbit. Once the satellites are identified and positions are known, high precision clock data are used to calculate the precise distance between the receiver's antenna and each satellite.

Once the transmissions from three or more satellites are simultaneously acquired by the receiver, a position can be triangulated. Figure 3 depicts the basic communications and calculations required for GPS to operate.

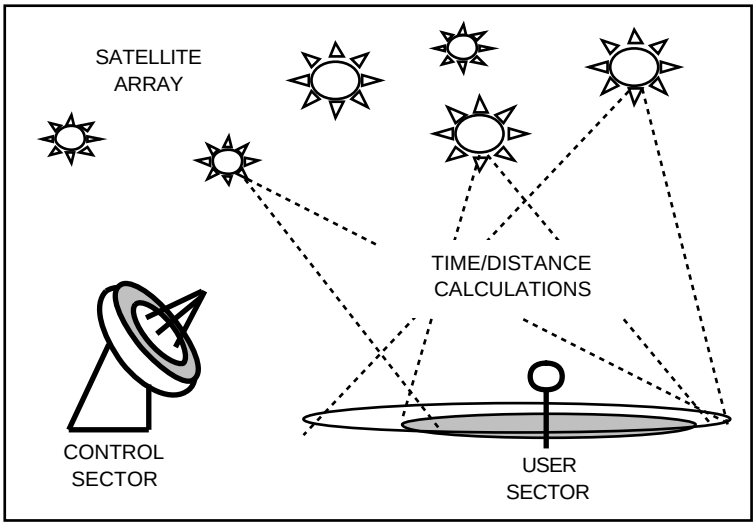


Figure 3: Basic GPS Communications

Signal Acquisition

Most GPS applications require data that provide a basic coordinate position (i.e., X and Y). This requires a minimum of three (3) discrete satellites, plus the receiver. Some GPS applications may also require elevation data (X, Y, and Z), in which case a minimum of four (4) separate satellites are required.

Generally receivers have between six (6) and twelve (12) "channels" which allow them to track and accept signals from numerous satellites at once. It is best to operate the GPS receiver with a minimum of four (4) satellites in view, or line of sight to the receiver.

Once the necessary satellite signals are acquired, which may take a few minutes, the receiver computes the current position (based on the location of the antenna), displays those same coordinates on the screen, and if prompted by the user, stores the data for later use.

Accuracy

The accuracy of a GPS receiver is dependent upon a variety of factors, including the quality and precision of the internal electronics, the combination of satellites that are visible at a given time/location, the presence or absence of a correction signal, and the knowledge/alertness of the user.

Accuracy requirements may vary depending upon the application being addressed. For example, if the features being surveyed are the location of towns that are hundreds of kilometers apart, then the accuracy requirements are different from that for a survey of mine fields outside a city. However, it is strongly recommended that the user

acquire the most accurate data possible. **The determined accuracy and method should always be recorded in the metadata documentation**.

While in autonomous mode (i.e., no correction applied), most modern GPS receivers are capable of calculating positions that are within 5-10 meters of the actual location. With correction applied, these accuracies can improve to less than1-5 meters.

Differential Correction

GPS receivers can operate in autonomous mode, meaning that they run automatically with no adjustments made by the user or inputs from other electronic devices. However, autonomous mode will not produce position data as precise as that generated through signal correction. For general navigation purposes autonomous mode may be sufficient.

Because of some inherent (and some induced) signal corruption, a method has been devised to correct and adjust the position values, resulting in more accurate data for the user. Signal correction may be desired if the application requires very accurate data (<5 meters) or real-time navigation and data recording are needed.

This signal adjustment process is referred to as "differential correction" and can be applied under a real-time or post-processing scenario. Figure 3 depicts the principle of differential correction. Differential correction applications often require some additional planning considerations.

In addition to the GPS receiver and the satellites, differential correction involves the use of another GPS receiver that is fixed at a known location. This GPS receiver is known as the "reference station" or "base station." The exact coordinates and altitude of this base station receiver are precisely measured and recorded. Any differences between the satellite derived positions and the known position of the reference station are then broadcast via radio signals, and also recorded in digital file format.

Real-time differential correction is enabled through the use of a special antenna attached to the roving receiver. These types of receivers are called differential GPS or DGPS. This antenna is capable of acquiring the correction broadcast from the base station and applies this correction factor to the incoming satellite data. This allows the data recording device to automatically display and save the correct positional data. This process is ideal for real-time navigation applications, or for users that do not have access to post-processing utilities.

Post-processing differential correction does not require any special antenna, and is designed to apply the signal correction factor after the data collection is completed. The same principle is used, although data files from the reference station have to be retrieved before post-processing can be performed. This method of correction is often employed when real-time updates are not required, the user has reliable access to Internet-accessible base station data files, and other data processing procedures are planned.

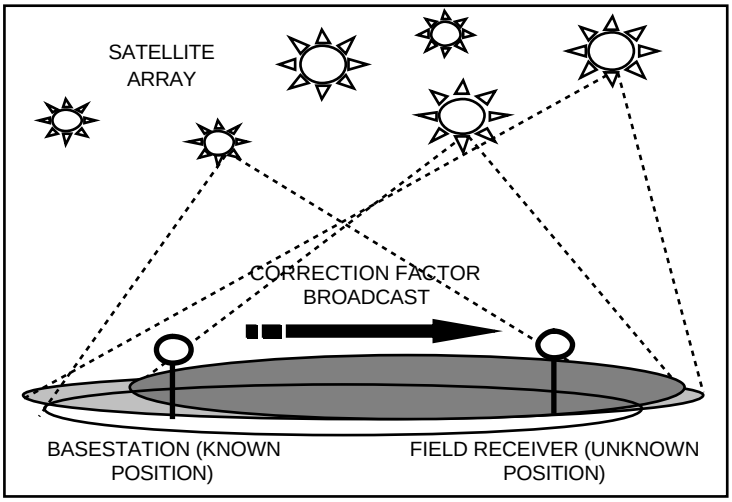


Figure 4: Basic Differential Correction

Modes of Operation

GPS receivers can operate in two basic modes, **survey** or **navigation**. The user can alternate between the two options as needed.

Navigation Mode permits the user to follow a series of on-screen prompts to a predefined location. The on-screen data are continuously updated.

Survey Mode is used to conduct projects when data capture is required. This mode displays the current location of the antenna (and presumably of the user), and allows the user to save the coordinates of specific features.

Many applications make use of the ability of GPS receivers to toggle between the two modes. For example, if you were conducting a multi-day survey over a large area you might use navigation mode to find your way back to the last point you surveyed the day before, and then continue collecting data after switching to survey mode. These two modes of operation will be described in more detail in the **Basic Operations** section.

Planning a Survey

Overview

Before beginning any project involving GPS technology it is important to thoroughly research and plan out the steps that will be involved in meeting the objectives. A well planned project enables the user to anticipate problems, be more efficient during the data collection phase, maintain better organization, and assesses the progress or success of the effort.

Establishing Objectives

The first step in planning a GPS project is establishing clear objectives. By answering a few simple questions about project elements and limitations the user can define clear, achievable goals that bring value to the project.

The user needs to understand the practical aspects and logistics of the project, and be aware of the tactical considerations – all of which help them with improved decision making.

At minimum the user should be able to answer the following questions about their project:

- Where will the survey be conducted?
- What type of GPS receiver(s) will be used?
- What features/attributes will be collected?
- Where is the nearest reference station, if any exist?
- What supporting resources are available?
- Who is the audience for the final data or how will the data be used?

In addition to the logistical considerations the user should be aware of other aspects. For example, the user should understand the timeframe, resources available, and identify the other personnel (within or outside of the one's organization) that will be involved in the project. Established project planning tools, such as Gant charts should always be employed to display each step in the planning process.

Understanding the flow of data from the initial collection through the final processing and use is critical to project success. Figure 5 depicts the general flow of data in a typical GPS project.

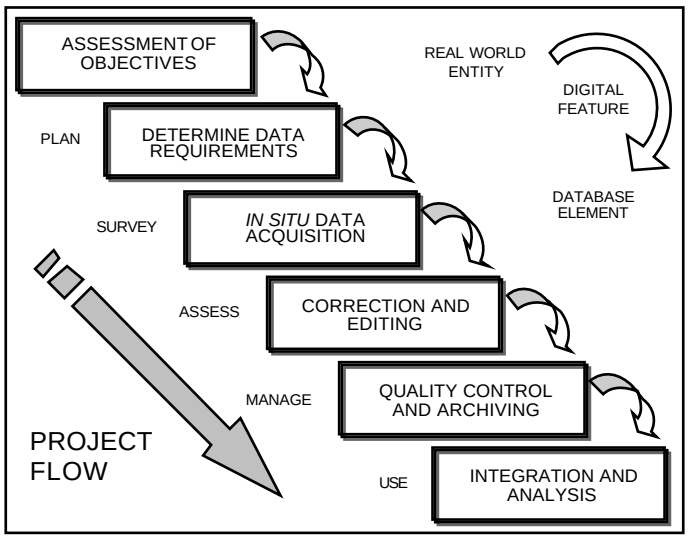


Figure 5: Flow of Data in a GPS Application

Mission Planning

Depending upon what type of GPS hardware is being used, the accompanying software may permit the viewing of pre-survey data that can improve efficiency. This process is referred to as "mission planning" and enables the user to view the optimal times and locations for GPS data collection. Check the user manual that accompanies the GPS receiver to see whether mission planning software is provided.

As part of its signal, each satellite transmits almanac information about where it will be located any given time. When analyzed in the appropriate software, this almanac

information allows the GPS receiver to determine the optimal times for data collection in a given area.

Usually the mission planning software will provide data showing the number of satellites in view at a given time and place, the predicted precision of a specific configuration of satellites, and provide "sky plots" showing the orbital path of the satellites.

Ideally, the user can use this information to plan the time and location for specific GPS projects. By identifying the optimal times for data collection the user minimizes the amount of time spent waiting for adequate signals, and can recognize when there are inherent degradations in the signal quality.

Data Dictionaries

Most GPS receivers will allow the user to input some brief descriptive information about a feature that is being recorded. These "attributes" are important elements of any GPS survey and can be recorded internally on the GPS itself or through a combination of collection methods as part of the metadata.

Attributes are descriptive terms or values that are associated with a specific feature. Attributes help to annotate maps, and allow data users who were not directly involved with the GPS survey to understand the composition of the survey area.

If you were conducting a GPS project that was designed to record the location of remote villages it would also be worthwhile to record some descriptive information about each place. For example, you might choose to include information about the number of people living there, how many buildings the village has, and any general comments.

If the GPS data is being used to support the development of a geographic database, or will be analyzed later it is strongly recommended that the user consider using a data dictionary. Figure 6 shows an example of a data dictionary. It should be noted that a data dictionary can be recorded through a variety of methods, including voice recordings, field notebooks, or other digital recording devices. Therefore, even GPS receivers that do not support internal data dictionary modules can be combined with other collection methods.

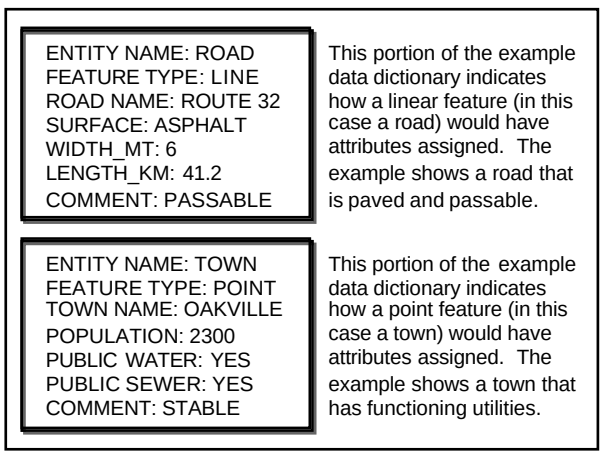


Figure 6: Data Dictionary Example

Key Instrument Settings

There are several key instruments settings that may be available to the user, depending upon the receiver being used. These parameters are usually adjustable through the internal software interface that comes with GPS receivers.

While this document is not designed to provide explicit instructions on every aspect of GPS operations, it is worthwhile to mention several of the critical settings that can have an impact on the quality and accuracy of the data being collected.

Many of these system settings are dynamic and can be adjusted by the user while still in the field. It is strongly recommended that the user become familiar with the function of all of the primary settings and how to adjust them before undertaking a formal GPS survey or attempting to navigate with the GPS.

Some of the key settings that a GPS user may encounter are: PDOP (positional dilution of precision), SNR (signal to noise ratio), horizon mask, update rate, altitude/elevation, and display units and coordinates. Being aware of these settings and how they function can make a significant difference in the success of a project.

Most GPS receivers allow the user to collect numerous "positions" for a given location, and then average these points before recording the data. If time and conditions permit this averaging function to be used, it is generally considered to be a more accurate method of data collection.

Depending upon which GPS receiver is being used, there may be additional system settings that can be defined before data collection begins. Consult the operations manual that is provided by the GPS manufacturer for more details.

Map Display Coordinates and Units

GPS receivers display and record data using sets of coordinates that correspond to some place on (or above) the surface of the earth. These coordinates can be related to numerous map projections. Projections are representations of the 3-D Earth's surface on a 2-D grid. Projections vary depending upon the needs of the user and may be influenced by the international history of cartographers in a country. Datums refer to the established point of origin for a particular grid.

Data from the GPS satellites is designed to deliver coordinate data relative to the World Geodetic Survey of 1984 (WGS-84). During the process that exports data from GPS unit to a computer, the user can convert from this default datum to a wide range of projections and datums. This is often necessary to accommodate integration of new GPS data with existing map data. It is suggested that the user become familiar with the common map projections/datums used in the area and note these in a field log before starting a GPS project.

Map display units are used to inform the user about their relative position at a given time and place. This is of particular interest if the GPS is being used in navigation mode, so that the user can judge how far to travel to reach the destination. The most common units are meters or feet.

Most GPS receivers allow the user to adjust the map display units (i.e., meters, feet), projection and datum. It is important to remember that these parameters are only for the display, the actual data is being recorded within the GPS computer in WGS-84 meters.

It is important to know fully aware of what datum, projection, and map units are being displayed on the GPS screen. This helps the user to integrate that information with other supporting documents, such as paper maps, field notes, or geographic database elements. Many mistakes have been made in the field through lack of attention to the units be used by specific equipment.

Supporting Information and Tools

Although a reliable instrument and a knowledgeable user can make a GPS receiver a valuable tool, it is always recommended that the user complement the GPS with other navigation and mapping tools.

Paper maps, a field notebook, a reliable compass, knowledge of the work area, and a communication device (e.g., cellular phone) provide the user with additional resources to help support a safe and effective GPS project.

The knowledge that the user has about the area being surveyed or navigated can be crucial to project success. If the user has never been in the region before, they can use existing maps, aerial photographs (refer to Remote Sensing Field Guide), and written descriptions to provide them with some basic information. Knowing the degree of topographic relief and land cover types that will be encountered in the project area can help prepare the user for a more effective survey.

Equipment Considerations

Along with the physical characteristics of the land, such as topography and dominant land cover it is useful to know the common weather patterns and conditions in the study area. This can help the GPS user better prepare for time in the field, especially with regard to protecting their GPS.

The GPS manufacturer should supply specifications regarding the environmental conditions (i.e., level of moisture, temperature) that the equipment can endure. The user should be familiar with these limits so that the equipment is protected from damaging conditions.

Safety should be the paramount concern when conducting any type of field work. For example, if your GPS has an external antenna mounted on a range pole then you should not be using it during an electrical storm. Also, while navigating, be aware that the shortest route between two points may not be the safest or even feasible. Again knowledge of the terrain and communication with other organizations in the field is important to conducting a safe survey.

Other equipment considerations include planning for a reliable source of power (e.g., spare batteries), ensuring the security of the equipment, and locating a nearby reference station. Remember to maintain an inventory and bring along supporting hardware accessories such as data transfer cables or battery recharging devices. Missing gear, especially those easily stolen small items, can thwart the best planned field missions.

GPS Basic Operations

Overview

This section of the guidebook will provide some insight regarding the basic operations of GPS receivers. Note that not all receivers operate in the same manner, so care should be taken to review the documentation from the manufacturer.

Navigation Mode

The ability to accurately navigate to a known point is dependent upon several parameters, including the internal accuracy of the GPS receiver, the absence or presence of a differential correction signal, and practical aspects such as the ability to cross over certain terrain. Navigation can be very valuable in assisting the user while returning to a previous location, or retracing a specific route.

GPS receivers use coordinate pairs referred to as "waypoints" to guide the navigation process. These waypoints are uploaded to the GPS data recording device and can be accessed through key driven commands. Waypoints can be entered before or during a navigation session.

Through the navigation menu on the screen, the user selects the waypoint of interest. Since the GPS receiver knows its current location, and it knows the location of the selected waypoint it displays information on the screen that indicates the distance and direction required to reach the desired waypoint. Be certain that you know which units of measurement are being displayed, and how to interpret the compass bearing before attempting to navigate in the field. Compass bearings shift and drift.

As long as the GPS is receiving satellite information it can update the current position and subsequently display the "distance to go" before reaching the desired location. You may set up a series of waypoints to establish a route of travel that describes the most effective course with convenient safety check points.

Again, while navigating it is critical to be aware of your surroundings and have some knowledge of the terrain. Using an existing topographic map or aerial photograph can help you avoid obstacles such as impassable terrain, or restricted areas.

Survey Mode

The survey (or data collection) mode that GPS units can enter is very important for projects that require the acquisition of data in the field. These data can then be analyzed in digital geographic information systems (GIS) to provide decision support.

Some GPS units only support the capture of waypoints and one simple descriptive attribute. For example, a pair of coordinates (X,Y) and the attribute "Village 123" might be recorded (see Geo-Codes Field Guide). Other GPS units are capable of storing multiple attributes, in addition to 3-D coordinate information (X,Y,Z). These more advanced units generally support the use of data dictionaries (described in Planning a Survey section).

The majority of GPS units permit the user to select survey mode through the main menu of the internal software. The user can then begin collecting data, assuming that sufficient and current satellite signals are being received.

Data Collection

Data collection is relatively simple using GPS, but there are some basic considerations to remember.

Plan the survey to maximize data collection time. Acquiring the position of features is the single most important and valuable piece of information that can be recorded. Using mission planning, or designing a survey route that minimizes backtracking can improve the efficiency of the project.

It is important to understand that the data being collected will eventually be used in a GIS database or for some mapping application. By their very nature maps are graphic representations of reality. This simplification of reality requires the use of appropriate symbology (i.e., map graphics).

There are three basic formats that can be used to depict real world features on maps: points, lines, and polygons. Through a combination of these three basic data types any features can be depicted on a map. For example, a point can represent the center of a village, a well, or a building location. Similarly, a line can represent a road, a river, or a property boundary. A polygon is used to represent area features such as a lake, or a minefield.

Fundamentally, all GPS receivers collect data as points (i.e., coordinate pairs). Many GPS units are capable of collecting features as lines or polygons (areas) also. Essentially, these data are collected as points that are automatically connected by the GPS as the user walks or traverses the feature.

It is also important to record any attributes that are associated with a feature at the time of the initial GPS collection. If your GPS unit supports digital collection then these attributes can be entered while the coordinate data is being collected. Alternately, you can provide a description in a field notebook and append this information to the coordinate data after the data is downloaded. If you choose this latter method you must use some reliable method of maintaining the association between the digital coordinates and the written attributes.

Data Transfer

Data transfer refers to the process of retrieving from or providing data to the GPS. This process enables the user to ultimately use and analyze the data in other formats, subsequently realizing the value of the data that has been collected for mapping, planning, and reporting.

Such transfers are usually accomplished by means of a data transfer cable connected to the device ports and facilitated by the user through a software interface.

Data upload refers to the transfer of digital data from a source computer or device to the GPS data recording device. Transferring waypoints or basic background map data to the GPS are examples of uploading.

Data download refers to the transfer of digital data from the GPS unit to a receiving computer or device. Transferring point, line, or polygon features are examples of data download.

Refer to the software manual provided by the GPS manufacturer to ensure that the data transfer process is properly executed. Improper hardware or software setup can lead to the loss of very valuable data. After a data download it is essential to copy the data and store this backup in a safe and secure place.

Data Processing

After data is downloaded from a GPS unit the file(s) may be subjected to several processing routines, including post-processing differential correction, attribute editing, and reformatting. At this point it is critical to stay cognizant of data management and file organization (see Data Management section, below).

Post-processing has already been described in How Does GIS Work section. Most GPS software applications will permit the user to edit feature attributes, delete or add points as needed, and reformat the raw data so that it can be used in standard GIS applications.

GPS software programs allow the user to view data on a computer monitor with a window driven menu and commands. Zoom, pan, and inquiry tools are provided, and some fundamental database editing is permitted. One key aspect of the processing is to export the data in a projection and datum (and in the proper units) to integrate it with existing data.

Data Export

Exporting data in a format that can be used in a GIS is generally the last step in a GPS project. Most GPS software programs provide the user with multiple file format options to choose from during the export routine. Again, it is imperative to know what the incoming map projection, datum, and units are so that the proper conversion factors can be applied (if the user is exporting data in another map projection).

Exporting data from a GPS software application is a critical step in realizing the value of the information that has been collected. Therefore, it is important to maintain excellent data management practices when performing this routine. Refer to the software manual provided by the manufacturer to become familiar with the exact export routine commands.

GPS Data Management

Overview

Besides determining very accurate position data, one of the greatest advantages of the GPS is that it records data in digital format. This saves precious time normally required to manually enter field notes into a digital database. However, this value ability also requires that the user understand some basic data management principles.

Organizing Data

Any successful GPS project employs reliable and sustainable data management practices. Digital data management can be made very easy with the tools available in most standard file management systems, but a well planned and executed set of procedures is essential to keeping the process efficient and error free. The GPS user should be directly involved in the data organization process. It is best to prepare a file directory structure before beginning any data collection project. This will help the project personnel to "visualize" the data process and save time after the data has been collected.

Basic data management principles should be observed when organizing any digital data files. The directory structure and file folder naming conventions should be

intuitive and consistent. Data should be backed up and archived through set procedures that occur at specified time intervals. Ensuring data security is paramount, so it is recommended that backup copies of all files be created and stored in a separate location.

While exporting data it is important to keep files well organized so that the raw GPS data does not get combined with the processed data. This is easily accomplished by creating separate folders for raw, processed, and exported data formats. A few extra folders take up very little computer memory and can save precious time spent reorganizing mixed data.

Data management responsibilities should be shared by all project participants, and standard practices and procedures should be discussed with all staff, documented and posted for reference. Sound data management may also help the user assess project success or flaws.

Metadata

One other aspect of data management that is critical to the long-term sustainability of a data set is the creation of metadata (see Geo-code Field Guide). Metadata is a text file that contains descriptive information about a data set. This metadata file provides key information about the parent data set, such as when the data was collected, a point of contact for questions, the format of the data, and the purpose of the data.

Metadata standards have been established for nearly a decade and should be considered part of a data set. GPS data files that do not have accompanying metadata should be considered incomplete and untrustworthy. Metadata helps others that are unfamiliar with a data set to quickly understand the content and purpose of the parent data set, and serves as a reliable source of documentation regarding the origin and originator of the positional datasets. The only way to maintain and communicate the quality or fitness of a dataset is with metadata. Properly applied, metadata for a coordinate survey can enable the data widespread use among many organizations for literally decades.

GIS Overview and Location Applications

Introduction

Geographic information systems (GIS) have evolved over the past 30 years to a point where they dominate all other command and control systems for accurate display and management of the landscape and activities upon the landscape. While GIS come in a variety of guises, their capabilities to generate maps, reports and provide practical analytical products for planning and assessment scenarios have earned GIS strong and loyal following throughout the humanitarian and tactical communities.

Fundamentally, GIS allow for the collection, encoding, management, analysis, and display of spatial information. Spatial or geographic information covers most every element of humanitarian applications. GIS have evolved to user-friendly windows-style user interface software, which allows field personnel using laptop computers to call up various views of the mission terrain, query the database contents for key features or status, and to build a knowledge base about the spatial relationships (distance, proximity, connectedness) of all elements in the field.

Basic Applications

There are myriad GIS applications and the areas of adoption are still increasing. Primary among the applications for GIS is the ability to render a view of the mission environment. Common applications include environmental assessments, public health analyses, transportation and utility mapping, and land or facility management, (see Figure 7). Based on the creation and availability of a foundation or basic area database (refer to UNHQ OCHA or HIC representative for details) the field officer can expect to easily locate and display views of an area and select the features of interest. Field maps can then be instantly printed and available for a day's activities.

Mission environments can be better understood, for example, using satellite imagery as the backdrop, using the GIS to display overlays of roads, key distribution facilities, schools and hospitals, known hazardous areas, et cetera. Survey points can be readily viewed with perspective on the relationship of the surveyed points or navigational tracks to other existing features.

By linking an organization's database of weekly or period incidences of disease outbreaks, violence, or activities into the GIS, the field officer can quickly display the locations of these activities and conduct spatial analysis as to relationships, causes, and devise response or remediation strategies. Spatial analysis is the process of querying a spatial database to highlight patterns or anomalies, or performing specialized operations with spatial data to derive new information for decision-making. The sharing of databases among agencies quickly creates an exponential increase in the spatial analytical capacity for any field agent.

Perhaps one of the key benefits of GIS is the in the application of GIS as a communication vehicle. Using the multiple ranges of "mapping" outputs of a GIS, a field officer can more effectively communicate with local residents as well as with cooperating humanitarian organizations.

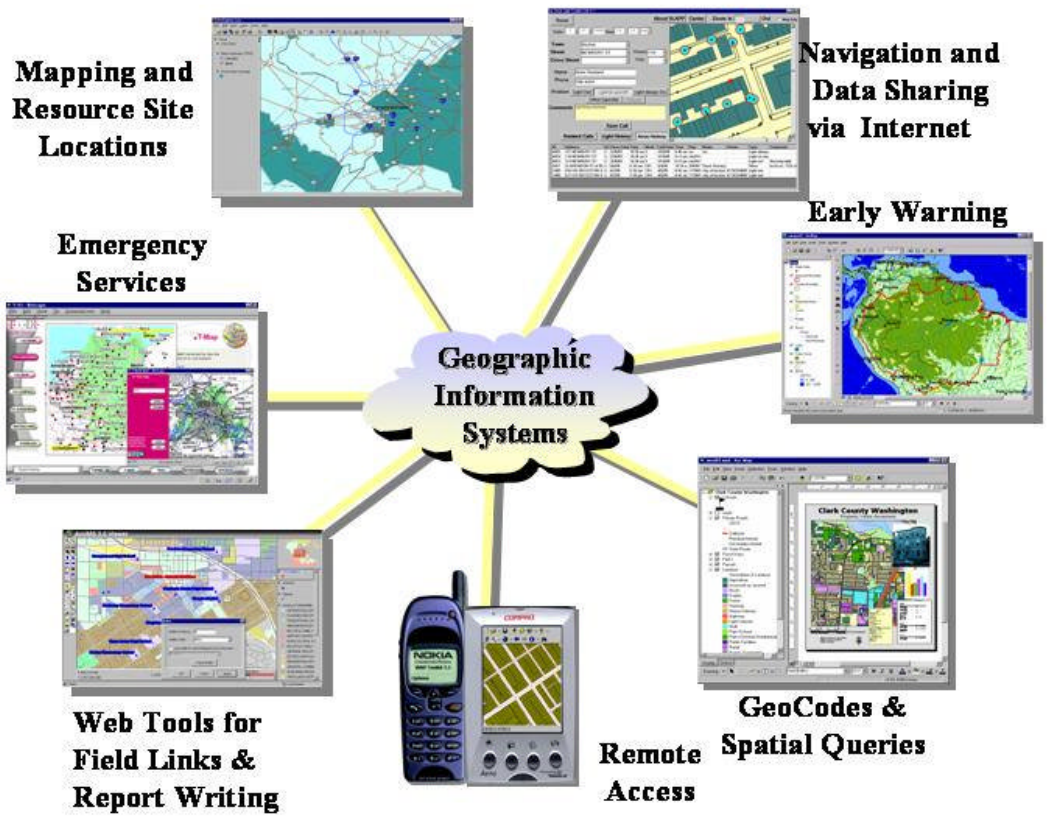


Figure 7: Geographic Information Systems Basic Applications

Advanced Real-Time Applications

Some GPS receivers have display screens and internal software that can support advanced real-time applications. For example, it is possible to connect a laptop computer to a GPS unit to support real-time mapping applications that incorporate background images while walking or touring an assistance zone.

Such applications often require real-time differential correction. The GPS user should be proficient in basic GPS operations and GIS applications before undertaking any advanced applications and caution should be made to ensure backups if life-threatening or other high-risk situations are evident.

GIS Database Structure

A GIS is a relational database management system that maintains an active link between a tabular database and graphic or map features. The tables contain attributes about the features, and the map elements represent discrete real world features.

The relational database structure allows the user to query or extract data from the table or the map to help answer direct questions or reveal geographic patterns. This is referred to as spatial analysis.

GIS Database Elements

One of the advantages of a GIS is the ability to store, retrieve, and manage numerous data formats including imagery, tables, and map features. With regard to GPS data, the key database elements are the tables and map features. The tables contain the x, y, and z numerical coordinates.

Although there are some inherent connections between GPS and GIS it is useful for the GPS user to have, at minimum, a working knowledge of GIS functions and the structure of such systems.

Integration of GPS and GIS

Overview

Generally GPS data is used to create positional accuracy of field features or objects or update locations for field maps as stored in a spatial dataset. The processes required to update databases that is computer maps, requires advanced data formatting and analysis expertise in geographic information system technology.

Over the past few decades GIS has revolutionized the use of geographic or spatial data for a wide variety of user applications. Because of the inherent link (i.e., geography) between the two technologies, GPS is an ideal method of providing locational data about features data (road, bridges, building, minefields, et cetera) for a GIS.

GPS and GIS File Formats

File formats for proprietary GIS applications vary, but some basic aspects remain consistent. GPS data also fundamentally share the same format.

GPS data are stored in binary, simple text format. This enables easy transport between different export platforms, and permits easy editing. In their simplest format, GPS data files include an X and Y coordinate pair, and a text attribute.

GIS data are stored in a variety of formats but adhere to a structure that permits their use in any relational database. GIS files can include links to other files, or applications. Recall that geographic features are represented in mapping environments as a combination of points, lines, and polygons. This requires that all GIS files contain some inherent or associated geographic information.

Importing GPS Data

Assuming that the GPS data export routine was performed properly these files are easily imported by a GIS through a few simple commands. Once the data has been imported it is generally saved in the native file format of the chosen GIS software.

When importing data into an existing GIS database it is again important to know and understand the map projection, datum, and units that are being used. Without this information, data will not overlay properly corrupting relative spatial relationships.

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Acronyms:

DGPS	Differential Global positioning systems
GIS	geographic information systems
GPS	global positioning systems
HIC	Humanitarian Information Center (United Nations)
NAVSTAR	Navigation Satellite Timing and Ranging
OCHA	Office for the Coordination of Humanitarian Affairs United Nations
PDOP	Positional dilution of precision
SNR	Signal to Noise Ratio
UNHQ	United Nations Headquarters
UTM	Universal Transverse Mercator
WGS-84	World Geodetic Survey of 1984

Contacts

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http://www.aero.org/publications/GPSPRIMER/ GPS Primer, downloadable

http://www.trimble.com/gps/ Trimble GPS Tutorial

http://www.gpsy.com/gpsinfo/ The Global Positioning Systems (GPS) Resource Library

http://degaulle.hil.unb.ca/Geodesy/CANSPACE.html CANSPACE. Maintained by Dr. Richard Langley, professor, University of New Brunswick Department of Geodesy and Geomatics Engineering, and contributing editor, GPS World Innovation column:

http://www.topconps.com/Tutorial/index.html GPS Tutorials and Information:

Internet Mapping Programs

http://www.aquarius.geomar.de/omc/omc_intro.html**:** Online Map Creation You may create maps interactively at this site.

http://www.esri.com/base/data/online An extensive online database of geographic data and a mapping engine

http://mapfinder.nos.noaa.gov National Ocean Service MapFinder Home page, provides direct Internet access to primary NOS imagery and data holdings

http://alexandria.sdc.ucsb.edu The Alexandria Digital Library, links to significant collections of geospatially referenced information

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