

Putting Your System on the Map

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Are you new to GIS, GPS and mapping? Would you like to learn what it is all about and learn how to create your own maps? If so, stay tuned to this article as well as the two following magazine articles. In this article, I will be answering some of the questions a person who is new to GIS/GPS may have. GIS mapping will provide the water/wastewater operator and their councils or boards with valuable information needed in long term planning by allowing a quick, easy to read over view of the water system. This will show the line sizes, zoning, flow characteristics, expected peak demands and it will also show where your systems shortcomings and needed improvements are. A GIS mapping system will show you where your system appurtenances are located and allow you to pick and choose what you are looking at on the map by having separate layers for main lines, laterals, valves, hydrants, service connections, reservoirs, past leak repairs, etc. or show all attributes at once.

Let's start with a brief explanation of the fundamentals of GIS.

The term "geographic information systems", comprises of computer hardware and software used for the systematic storage, processing and retrieval of geographically referenced spatial data and the corresponding attribute data. The important functions of the GIS are the technique known as "overlying" which is the capability of combining different maps irrespective of scale/information to create new maps, and the capability of the data being automatically updated when the spatial data is modified.

In essence, GIS is a data base management system (DBMS) specifically designed for simultaneous processing of spatial and related attribute data. A DBMS generally provides a language for analyzing data, which allows a user to describe to the system what he, or she wants to know with little or no attention to the mechanics or methods used by the system. A DBMS must also contain procedures for checking consistency of the data and maintaining their integrity.

In addition to DBMS, GIS also has many capabilities similar to automated map computer graphics systems. However, as well as having a

powerful capability for processing graphics, GIS must also be able to process non-graphic attributes, such as statistical data, in conjunction with the spatial data to which they are related. For example, if the user modifies the spatial data the GIS will make the necessary modifications in the related statistical database automatically. This link between the two types of data must be present if a system is to be considered a true GIS.

Although GIS differs from other tools, such as alphanumeric data base management systems, computer graphics, and automated map making, each of these other systems is, in fact, a component of GIS. What GIS does is make it possible to integrate all of these other systems in one operation.

One of the primary sources of geographic data used in GIS is the information about the earth that is obtained through remote sensing. Remote sensing data are usually acquired as digitized satellite imagery or as aerial photographs. After the digitized satellite data are checked, geocoded, enhanced and analyzed (in an operation known as "image processing"), or alternatively the aerial photographs are interpreted, the results can be fed into the GIS and integrated with other geographic and non-spatial databases.

Essentially, a GIS provides a means of taking many different kinds of information, processing it into compatible data sets, combining it and displaying the results on a map, some standard GIS capabilities include:

- Integrating maps made at different scales, different projects, or different legends;
- Overlying different types of maps of a particular area to make a new map that combines the attributes of the individual maps. For example, a vegetation map could be overlaid on a soil map. This in turn could be overlaid on a map showing length of growing season, thereby producing a land-suitability map for a given crop;
- Generating buffer or proximity zones around lines or polygons on a map. This technique is used to find areas within a given distance from roads, rivers, etc., or from certain thematic conditions. These buffer zones can in turn be used as another layer in overlay operations, for appreciating the disturbance

scale of the ecosystem or the resource management strategy from such areas.

- Changes of scale, projections, legend, lettering, etc. on maps.

Geographic Information Systems are comprised of three major components:

Hardware, The hardware components of a GIS include several which are common to any computerized database management system, such as a central processing unit (CPU), a disk storage unit for storing data and programs, a tape drive used to store additional data, and a visual display unit, as well as other general purpose computer peripherals.

The GIS has, in addition, several specialized hardware components, including; a digitizer or scanner, which is used to convert the Geographic details into digital form and send it to the computer; a plotter, which prints out the maps and other graphic outputs of the system; and a visual color graphics display unit (workstation) on which spatial data editing and display can be performed by the user.

Software, The main GIS software components are designed to perform the following functions:

- Data input (digitizing);
- Data storage and data base management;
- Interaction with the user (graphics/map editing); and
- Data output and presentation (plotting)

Human resources and management, when describing GIS one tends to think in terms of hardware and software, which overlooks the most important component, the people needed to make it work.

As in any computer application, the results are only as good as the information put in. As in any map-making project, data collection and data input operations require high standards of training and frequent monitoring for quality control.

Another essential element of good GIS operation is the close interaction between the computer specialist and the application specialist (forest, agriculture, etc.

GIS application is the use of GIS lies in its capability to construct models of the real world from digital databases. These models can be used to simulate the effect specific activities over a period of time. Modeling is a powerful tool for analyzing trends and identifying factors that affect them on displaying consequences of decisions (or lack of it) regarding use of resources.

Most of us are familiar with GPS in the sportsman's applications. On your hand held GPS receivers, you plot a specific coordinate where you will meet up with the rest of your hunting party at a designated time... each one of you knowing that this will **NEVER** happen. The question is; what can GPS do for you in your professional lives.

GPS determines location by computing the difference between the time that a signal is sent and the time it is received. GPS satellites carry atomic clocks that provide extremely accurate time. The time information is placed in the codes broadcast by the satellite so that a receiver can continuously determine the time the signal was broadcast. The signal contains data that a receiver uses to compute the locations of the satellites and to make other adjustments needed for accurate positioning. The receiver uses the time difference between the time of signal reception and the broadcast time to compute the distance, or range, from the receiver to the satellite. The receiver must account for propagation delays, or decreases in the signal's speed caused by the ionosphere and the troposphere. With information about the ranges to three satellites and the location of the satellite when the signal was sent, the receiver can compute its own three-dimensional position.

GPS is available in two basic forms: the standard positioning service (SPS) and the precise positioning service (PPS). SPS provides a horizontal position that is accurate to about 100 m (about 330 ft); PPS is accurate to about 20 m (about 70 ft). For authorized users—normally the United States military and its allies—PPS also provides greater resistance to jamming and immunity to deceptive signals.

Enhanced techniques such as differential GPS (DGPS) and the use of a carrier frequency processing have been developed for GPS. DGPS employs fixed stations on the earth as well as

satellites and provides a horizontal position accurate to about 3 m (about 10 ft). Surveyors pioneered the use of a carrier frequency processing to compute positions to within about 1 cm (about 0.4 in). SPS, DGPS, and carrier techniques are accessible to all users.

The number and integrity of the satellites in orbit currently limit the availability of GPS. Outages due to failed satellites still occur and affect many users simultaneously. Failures can be detected immediately and users can be notified within seconds or minutes depending on the user's specific situation. Most repairs are accomplished within one hour. As GPS becomes integrated into critical operations such as traffic control in the national airspace system, techniques for monitoring the integrity of GPS on-board and for rapid notification of failures are being developed and implemented.

Now that we are armed with a basic knowledge of what GIS and GPS are, we can concentrate on the next step, which is putting the knowledge to work for us. In the next two magazines, I will give a basic outline of how to do this in both a city and a rural water system application. I will also go over some of the tools and the costs involved in *putting you system on the map*.