An Introduction to the Global Positioning System

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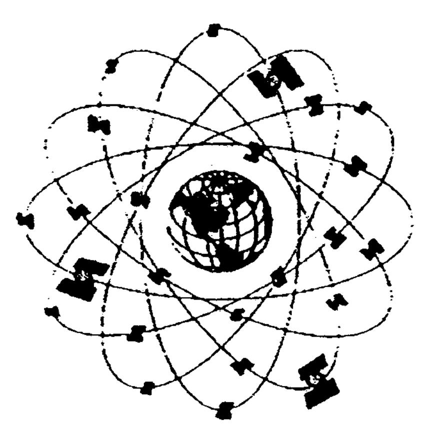
Introduction

The global positioning system–GPS for short–is changing the face of every location-based undertaking from commercial air transportation to pizza delivery. Buying a new car? How about a snappy new BMW, complete with a GPS-based guidance outfit? Prefer the bus? If it's a bus in Baltimore, Denver, or Milwaukee, chances are it is monitored by a GPS-based tracking system. Maybe you're planning to sail around the world–or just across the bay. In either case, don't forget your hand-held, GPS-oriented compass.

The wide variety of these applications makes clear why, in the best estimate of the National Academy of Public Administration, the worldwide GPS market will grow from about two billion dollars today to roughly thirty billion dollars ten years from now. Since GPS hardware prices continue to fall in a manner typical for high technology products, such an increase would represent a spectacular step-up in the role GPS plays in our everyday dealings. Indeed, global positioning may well lay at the root of the fastest growing technology of the coming decade.

I. What is the Global Positioning System?

The global positioning system was developed in the 1970s by the Department of Defense to provide reliable data on three information commodities that the military values highly: position, velocity, and time. The basic working unit of GPS is the time-and-space address. At any stated time, any object or feature on or around the earth has a precise, three-dimensional locus described by its longitude, latitude, and altitude. GPS pinpoints and describes this locus at the pertinent instant.

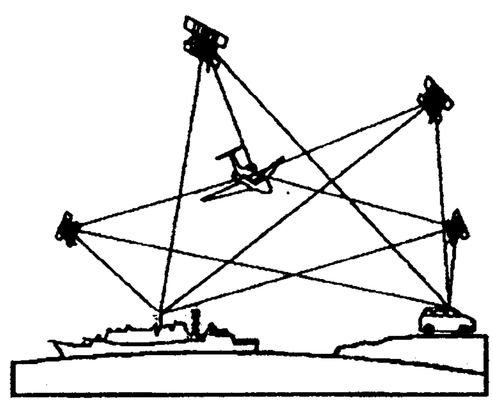


Twenty-four Navstar satellites form the backbone of the global positioning system. (Diagram courtesy of Peter H. Dana, The Geographer's Craft Project, Department of Geography, The University of Texas at Austin.)

Global positioning is made possible by a system of twenty-four Navstar satellites maintained by the federal government. These satellites orbit the earth twice daily at an altitude of roughly 11,000 miles. As currently deployed, the Navstar satellite network enables GPS users to determine a time-and-space address for any point at any time, twenty-four hours each day.

II. How Does GPS Work–and How Well?

At the most basic level, GPS technology uses two elements: a radio transmitter and a radio receiver. Each of the system's Navstar satellites is a transmitter. These transmitters continuously send out time-tagged data bits in precise, thirty-second increments at the direction of an internal atomic clock. Earth-based GPS receiving units pick up these signals from several transmitting satellites at once and, by determining the time from transmission to reception, calculate the distance to the transmitting satellites. The earth-based receiver then compares these distances and triangulates its position in longitude, latitude, and altitude. The result is a unique, time-specific address in all three dimensions that amounts to what one commentator has called the "ultimate zip code."



GPS works by comparing the distances from an identified point to a series of transmitting satellites. (Diagram courtesy of Peter H. Dana, The Geographer's Craft Project, Department of Geography, The University of Texas at Austin.)

The accuracy of GPS-based calculations is astonishing. A stand-alone receiver can calculate its position at any point on the earth, in the earth's atmosphere, or in the earth's lower orbit to within twenty-five meters. Two receivers together (the first placed at a known location and the second continuously comparing its location to the known reference point represented by the first, a technique known as "differential positioning" or DGPS) can calculate a position with a maximum margin of error of between two and five meters. Further, as state and local governments and commercial entities begin to sponsor and operate ground-based networks of reference stations linked to GPS, margins of less than one centimeter should become common.

The accuracy of GPS-based locating depends largely on two variables. The first variable, atmospheric condition, occurs naturally. Ionospheric conditions, for example, can distort the satellite signals that GPS equipment relies on, causing spatial errors in calculation. The other variable is man-made, and belies GPS's origin in the national defense program. By activating a system in the Navstar satellite network called Selective Availability (SA), the Department of Defense can degrade the accuracy of a stand-alone GPS receiver from twenty-five meters, as noted above, to as much as three hundred meters. Classified decoding devices correct this degradation for military uses. In nonmilitary applications, differential GPS techniques generally suffice to assure accuracy in the two to five meter range.

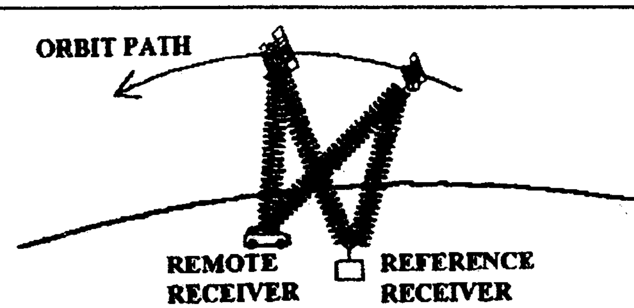
III. GPS and the Dual Use Dilemma

GPS has obvious uses in both the military and civilian arenas. The "smart" weapons deployed in the Persian Gulf conflict used GPS guidance components, as did some five thousand hand-held locating units issued to ground troops in that action. On the civilian side, a British sailor participating in the BOC Challenge around-the-world race in October 1995 was rescued with the help of a GPS device. Construction crews working on the Channel Tunnel from Dover to Calais used GPS receivers to confirm their locations, and hand-held navigation units linked to GPS are now widely available to boaters and hikers. Further, GPS technology is likely to play a prominent role in the National Information Infrastructure (popularly known as the information superhighway) announced by the White House in 1993.

Despite the global availability of GPS data to all users without charge, the Department of Defense retains close control of GPS through the Air Force Space and Missile Center and through its network of ground-based monitoring and control stations. As a result, a principal concern of commercial GPS users is that the system's military managers give due regard to civilian applications. The National Performance Review authored by Vice President Gore strongly endorses the creation of a National Spatial Data Infrastructure to formulate standards for spatial information (including GPS) on the information superhighway, and to oversee management and dissemination of spatial data. In the meantime, GPS users have formed the GPS International Association (206 East College Street, Grapevine, TX 76051) specifically to support and to further the education of GPS users.

IV. GPS in Surveying and Mapping–Its Uses and Benefits

For the real estate lawyer, GPS's surveying and mapping applications are probably the most interesting and surely the most relevant. Generally speaking, GPS surveying methods fall into two categories: static and kinematic. In static GPS surveying, a surveyor uses two GPS units simultaneously. One unit remains fixed at a known point. The other unit is moved from point to point, with readings taken at each stop. Static GPS surveying is the more common of the two methods. It can be used over long distances, without regard to possible overhead obstruction of satellite signals, and in situations where mobility is difficult.



Kinematic GPS surveying allows the surveyor to collect data from a roving receiver. (Diagram courtesy of Peter H. Dana, The Geographer's Craft Project, Department of Geography, The University of Texas at Austin.)

Kinematic GPS surveying also involves multiple receivers, one of which remains fixed at a known point. In the kinematic method, however, one or more other receivers (commonly mounted in a backpack unit) rove from point to point taking readings along the way. This method demands that each roving receiver constantly remain locked on the requisite number of satellites (at least four must be locked in for accurate positioning), thus making the method difficult to use in environments that include tall buildings, overpasses, or other obstructions. Kinematic surveying is superior, though, for mapping large, continuous features such as roads and utility rights-of-way.

With either the static or the kinematic method, data gathered in the field can be downloaded automatically into survey and engineering software back at the surveyor's office to permit expedited processing of maps, drawings, and reports. In addition, Trimble Navigation, one of the leaders in the GPS industry, recently introduced a system permitting "real-time" kinematic surveying. With Trimble's real-time technology, point coordinates are generated and displayed almost immediately.

GPS surveying offers several advantages to surveyors and their customers. Because GPS readings do not require clear sight lines, surveys can be delivered without delays for inclement weather or even, in concept, darkness. Precise leveling of instruments is not necessary either, making GPS ideal for surveying in wet and snowy areas. And the kinematic method is well suited to hydrographic surveying. Most importantly, GPS surveying promises to proceed more quickly and to make more efficient use of manpower, thereby resulting in cost savings. If cost savings do result, GPS surveying will clearly affect real estate conveyancing by making surveys much more common in residential and in smaller commercial transfers.

V. GPS Surveys and the Real Estate Lawyer

Real estate practitioners should keep GPS surveys in mind for every large job, but particularly for the following applications:

- *Control surveys*. Control surveying involves the precise location of surface points to be used as references for later surveying. GPS's ability to create a quick and accurate three-dimensional description for any geodetic feature makes GPS surveying an economical way to produce a control survey.
- *Route surveys*. Surveying routes and rights-of-way (such as for highways, pipelines, and utility easements) requires locating a large number of points spread across long distances. With conventional techniques, these surveys are expensive and quite time-consuming. Kinematic surveying with GPS, however, can produce route surveys very efficiently.
- *Development surveys*. As with route surveys, surveys of large construction projects require the surveyor to establish a large number of points. Using kinematic GPS methods, surveyors on foot can rapidly collect the needed data.
- *Simple contour surveys*. GPS's ability to yield three-dimensional data means that a surveyor using kinematic GPS equipment can produce contour data as quickly as the surveyor can traverse the pertinent surface.

Real estate practitioners should also keep in mind the enormous potential of GPS technology to create geographic information databases. Using GPS locating and input devices, state and local governments can accurately assemble information on vegetation, soils, wildlife, zoning, land use, population density, property values, demographics, and other information useful in municipal planning and governance.