

GPS: Modeling the World in Time and Space
Background on the
Global Positioning System
and Trimble GPS Solutions

GPS: MODELING THE WORLD IN TIME AND SPACE

In the early 1970's, the U.S. Department of Defense began developing a satellite system to provide precise, three-dimensional position, velocity and time information. This system, now known as the Global Positioning System (GPS), is a constellation of 24 satellites that orbits the earth 11,000 miles above its surface. Twenty-four hours a day, seven days a week, GPS satellites beam time and location data to earth.

GPS signals blanket the world in a three-dimensional grid of precise time and location data points. Trimble GPS products capture these time-and-space addresses for:

- recording the location of an object, such as a tree, fire hydrant or power pole, by capturing that object's address on that time-and-space grid
- finding an object by navigating to it using its time-and-space address
- tracking an object, such as a car, truck or even an oil slick, as it moves from one place to another by communicating that object's time-and-space address to a central location
- navigating a ship, car, truck, train or airplane by knowing current position relative to a destination location
- synchronizing information, such as film images, and data packets, by stamping them with time data

Trimble is the market-leading provider of GPS products and solutions. The company was founded in 1978 by Charles Trimble to develop LORAN navigation technology that was purchased from Hewlett-Packard. In 1982, Trimble again purchased technology from Hewlett-Packard-this time an early GPS breadboard. That breadboard spawned two GPS products, a timing-and-frequency monitor and a GPS receiver for hydrographic survey. Introduced in 1984, these systems were Trimble's first generation of GPS-based products.

Today, Trimble GPS solutions bring unprecedented precision, productivity and competitiveness to individuals, organizations and companies in virtually every area of life. Like electricity and telecommunications technology, GPS data is becoming a pervasive "information utility" that is changing the world.

Expanding and Enhancing Infrastructures Using GPS Information

Civilization depends on its transportation, communications and broadcast infrastructures to link communities together and move goods, services and information between them. Today, these infrastructures are constrained; radio waves, land, water and airspace are finite resources. The cost of expanding modern infrastructures to provide greater capacity can be prohibitive. GPS information expands the capacity of finite resources by providing accurate, consistent data to guide and schedule the movement of vehicles, people and information over roadways, waterways, airways and airwaves.

Trimble GPS hardware and software is being used to:

- Expand capacity of transportation infrastructures through better management of automobile, boat and aircraft traffic patterns and scheduling using GPS location data.
- Expand capacity of communications infrastructures by precisely timing transfer of information using GPS timing data.
- Increase safety by providing accurate position information for navigation of coastal

waters and small or remote airport runways.

- Increase efficiency of communications and broadcast networks by using timing data to manage routing of cellular telephone calls or timing of television advertisements.

Transportation: Moving Goods and People over Land, Sea and Air

GPS-based information not only helps build transportation infrastructures, it also provides information for moving vehicles, cargo and people. Today, commercial companies use Trimble hardware and software to manage the movement of goods and services from one place to another. In a global economy where cargo moves from truck to train to ship and back to truck, GPS data can be used to schedule track and verify its delivery. GPS data, combined with communications technology, helps vehicle operators navigate shipping routes while keeping in touch with fleet managers.

Public transportation systems use GPS-based fleet tracking systems to provide more efficient transportation. In the near future, consumers will also use GPS technology to navigate through towns, cities and countrysides using Trimble GPS technology. European and Japanese automobile manufacturers already offer in-car navigation systems to consumers.

Trimble GPS hardware and software products are used to:

- Meet shipping schedules by tracking fleets and rerouting them to avoid weather delays and Other transport problems.
- Efficiently manage shipping capacity by dispatching vehicles appropriate to cargo size and shipping route.
- Enable businesses, such as taxi companies and towing services, to provide faster response and better customer service.
- Better manage public transit systems by accurately monitoring fleet locations.
- Provide public transit passengers with accurate vehicle-location information and arrival times. Manage traffic flow through automated toll collection.
- Inventory traffic control signs, pavements markings, striping and curb markings for better management of traffic flows and controls.
- Help automobiles navigate through city streets and highways.

Public Safety: Keeping People out of Harm's Way

Today's public safety agencies have a lot to worry about. As jurisdictions expand and budgets shrink, the costs to provide service are skyrocketing. At the same time, communities are demanding faster response times to 911 calls. Adding resources to improve services is not an option—operating an ambulance, for example, costs \$ 300,000 a year. Instead, emergency service providers are using state-of-the-art automatic vehicle location (AVL) systems to more effectively manage people and fleet resources.

By combining GPS and communications technology, organizations can create powerful tools for improving the quality of public safety. All types of public safety providers, from police to fire fighters to ambulance companies, are able to provide faster, more efficient service by using Trimble's GPS tracking and communications hardware and software. GPS receivers on vehicles collect time and location data and communications technology sends that data to a dispatch center within seconds. The accuracy and integrity of Trimble GPS and communications hardware and software enables public safety services to:

- Save lives through faster response times to accidents.
- Give public safety dispatchers confidence to make split-second, accurate decisions in high-stress dispatch situations.
- Improve the safety of police officers, and public transit drivers and passengers by providing automatic emergency communication to dispatchers.
- Support strategic management of emergency response services by collecting data on emergency calls and their locations for analysis.

GPS Information: Linking Objects in the Real World to Data

As the cost of GPS technology has decreased, its use has spread to new areas. Businesses and organizations have discovered a multitude of compelling uses for GPS time and location data by combining it with other information, such as the pesticide content of soil, the repair history of a vehicle or the demographics of a local population. Using GPS technology, an object's, or person's, location and features can be stored in a database which is in turn linked to and displayed on digital maps and other information systems. These technologies combine to create Geographic Information Systems (GIS) that transform raw information into knowledge that can be used to support all types of decision making, from public health planning to emergency response to strategic business planning.

Trimble GP5 hardware and software is being used to:

- Integrate accurate location data with other data sets, such as epidemic outbreaks, population densities or tax contributions, to create decision-support systems.
- Support disaster-relief efforts by pinpointing the exact location of damage or emergency situations
- Navigate to a specific object, such as a particular diseased tree in a forest, by using that object's previously recorded time-and-space address.
- Provide accurate and efficient means to manage geographically dispersed resources and assets, such as power poles and fire hydrants.
- Increase public safety by accurately mapping location of hazardous waste or physical dangers, such as abandoned mine shafts.
- Collecting information, such as demographic or traffic pattern data, to help make strategic business decisions, such as the location of a new restaurant franchise or retail outlet.

Global Economic Growth

GPS data provides a common global language for the collection and communication of time-and-space addresses anywhere in the world on a city street, the North Pole or a desert in China. Industrialized and undeveloped countries alike have access to accurate position and location data that can be transformed into information and knowledge to expand economies.

Trimble survey solutions are used all over the world to parcel land, map assets and build roads; create communications, safety and security networks; establish utilities; and more productively and efficiently harvest agricultural and natural resources. To bring greater precision to these operations, Trimble is developing even more precise survey technology called precise positioning. In the future, hazardous and remote work, such as mining and pesticide spraying, will be done by machines that use precise positioning technology. Today, Trimble GPS hardware and software is used to:

- Survey land in rapidly developing communities to create an underlying framework

for infrastructure development, including highway construction, land-use planning and utility expansion.

- Improve safety and productivity and decrease cost of oil exploration seismic survey operations in remote locations, such as the North Pole and the Taklimakan Desert in China.
- Increase agricultural productivity by using GPS location data to precisely apply fertilizer and link specific fields to crop histories, soil chemistry and pest problems.
- Increase efficiency, reduce operational costs and improve quality of natural resource mining operations.

Trimble: 13 Years of GPS Experience

Since 1982, Trimble has been leading the GPS industry with innovative products and solutions. Trimble remains committed to developing leading-edge GPS hardware and software:

- In 1994, Trimble invested \$24.8 million, or 15 percent of total revenues, in research and development.
- Since 1982, Trimble invested \$135 million and more than two million man hours in research and development.
- Trimble's GPS research and development team is the largest in the world.
- Trimble holds 33 GPS patents. (The U.S. Government holds 28.)

Through sales of its GPS solutions, Trimble has captured a significant share of the global market for GPS technology — international sales account for 51 percent of Trimble's 1994 total revenues — and now has 15 international offices, including new locations in Moscow, Beijing and Cairo. Trimble's worldwide sales force is a network of GPS application experts. They combine real-world application experience with a deep knowledge of GPS technology to provide customers with resources and support to get the greatest benefit from Trimble solutions.

A Brief History of Trimble

Trimble has devoted thirteen years of research and development to expanding the capabilities of GPS technology for new applications. Through its own invention, as well as the integration of GPS with other technologies, Trimble has precipitated several breakthroughs in the application and use of GPS technology. The company now offers over 100 different solutions that combine GPS, differential GPS and communications hardware and software.

Trimble's first GPS product offerings, were developed for the scientific research and geodetic survey markets using technology purchased from Hewlett-Packard. From 1984 to 1988, Trimble developed and sold products that brought the unprecedented accuracy and consistency of GPS data to scientific and research applications.

Between 1988 and 1990 Trimble acquired several companies to expand more quickly into new commercial markets. With the acquisition of the Navigation Systems Division of TAU Corporation (Los Gatos, California), Trimble began to develop products for the differential GPS and tracking markets. In 1990, Trimble entered the avionics market with an integrated Omega and GPS product built with Omega technology purchased from Tracor Aerospace (Austin, Texas). Also in 1990, Trimble expanded its offerings to include a variety of surveying and mapping software acquired from Datacom System Research (Christchurch, New Zealand).

Trimble is also heavily invested in development of new GPS technology. The

company created the world's first satellite positioning and mobile communications system by integrating Inmarsat-C satellite communications with GPS receivers. Released in 1992, this system is now used in a multitude of applications on land and sea.

As new markets for GPS products evolve, Trimble has continued to integrate GPS with other technologies. In 1988, Trimble entered the in-car navigation market through a partnership with Pioneer Electronics Company of Japan. Since that time, Trimble has established other partnerships with companies such as Philips and BMW to provide GPS engines for in-car navigation systems. Trimble GPS technology is now fully integrated with PCMCIA technology as well as cellular communications technology.

Trimble became a publicly traded company in July of 1990 and is listed on the NASDAQ exchange NASDAQ:TRMB.