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WINNING INNOVATION

The American Global Positioning System (GPS) is the world's first global satellite radio navigation system. It enables anyone with a smartphone to pinpoint exactly where they are on Earth along with the precise time. GPS is used in applications that range from aviation safety, banking and rescuing ships in distress to locating taxis on Earth and spacecraft in outer parts of our Solar System.

GPS uses a constellation of orbiting satellites, ground stations (that operate and manage the spacecraft) and a receiving device. A satellite broadcasts a radio signal containing information about its location and the time from an extremely accurate onboard atomic clock. This precision timing, accurate to within billionths of a second, is critical for financial transactions, cellular networks and power grids.

GPS provides location data for Google Maps, Waze and SatNav users and can be applied to everything from precision farming with GPS-guided tractors and open pit mining trucks, to the guidance of humanitarian supplies into war drop zones. GPS has transformed navigation and precision timing and is essential for today's transportation services, smartphones, food production, banking and science. High precision GPS can determine a location to within a millimetre. Surveys and mapping using GPS, for example, can track the movement of glaciers, detect whether tectonic plates are shifting apart and observe the build-up of stresses that lead to earthquakes.

Originally developed for military applications for Position, Navigation and Timing services, civilian GPS is now freely available for peaceful, commercial and scientific use. Billions of people around the world rely on this huge engineering infrastructure that extends across our planet and into space and, in 2011, the International Astronautical Federation selected GPS as the revolutionary space system that most benefited humanity during the first 60 years of human spaceflight.

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Technology background

The Global Positioning System consists of a satellite constellation, a ground control network and user equipment or receivers. It can support a network of 31 operational satellites flying in Medium Earth Orbit at around 20,200 km (12,550 miles) above the planet's surface. The baseline number of satellites used, however, is 24 - 12 in each half of the globe. Each satellite makes a near circular orbit around the globe twice a day, equally spaced around the equator. This allows users from virtually any place on Earth to access the system.

Signals from at least four satellites, using a process called trilateration, are required for latitude, longitude, altitude and time. Each satellite broadcasts on the same signal frequency and carries extremely accurate atomic clocks. It transmits both the spacecraft's position and its time signal. Satellite radio signals are weaker than those from a light bulb and travel by line of sight. They can pass through clouds, glass and plastic but are blocked by solid objects such as mountains or buildings. When a GPS receiver on the ground picks up these radio signals and the exact time that the signal was broadcast, it can measure the time delay. Since radio waves travel at the speed of light, it can then determine the receiver's distance from the satellite and location on Earth to within two metres, for civilian use, and - if on a moving vehicle - velocity.

The US Air Force (USAF) manages the constellation and each satellite is in one of six orbits in order to provide continuous worldwide coverage. Twenty-four satellites were launched between 1978 and 1994 and, because the satellites have a lifespan of 7.5-11 years, next generation satellites began launching from 2005 onwards.

The satellites are tracked by six USAF monitor stations around the world and there are two caesium atomic clocks in each station, referenced to GPS system time. GPS provides a Standard Positioning Service (SPS) for civilian use and a Precise Positioning Service (PPS) primarily for military use.