Most of the nation's infrastructure – our transportation, utility, energy, and communications systems – depends on the teamwork provided by GPS, GIS, and the National Spatial Reference System.

Transportation

New-age geodesy is helping many U.S. transportation sectors to simultaneously reduce their operational costs and increase their safety and reliability. For example, this trio of tools:

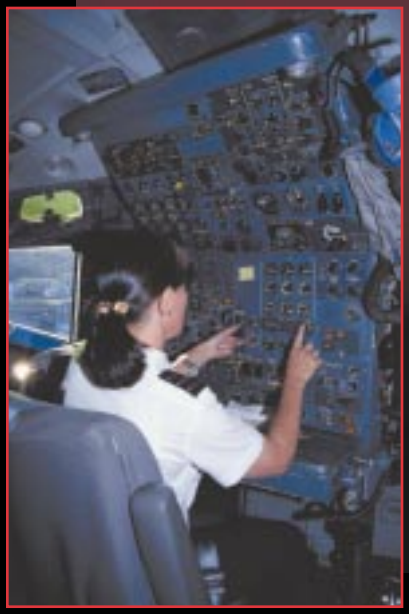
- Provides the essential foundation for our air navigation and traffic management systems, reduces fuel consumption by shortening flight paths, and ensures smooth, safe take-offs and landings.
- Serves as a common reference between a ship's electronic chart and the real-time position of its keel in relation to the bottom of the channel, thus promoting safe navigation and reducing the idle time ships spend outside ports waiting for ideal conditions.
- Allows railroads to route cars seamlessly and accurately in crowded shipping yards and to maintain a safe distance between trains on the same track.
- Helps companies calculate the most direct routes to their destinations for just-in-time delivery.

Receivers connected to electronic map displays are available to new car buyers today, and some rental car companies are offering this technology to their customers. In the not-too-distant future, GIS will be a standard feature in automobiles.

Utilities and Energy Systems

Utility companies are using geodetic coordinates to compile maintenance data bases on ser-

"If you can dream it, you can do it."
– Walt Disney



ABOVE: The National Spatial Reference System and GPS have made possible the development of an improved air traffic control system. Work is under way on developing highly accurate zero-visibility landing systems.

RIGHT: Some vessels today draw up to 60 feet of water – the equivalent of a five-story building plunging toward the ocean floor. Accurate spatial data can alert ships' captains to shoals or other obstructions they may find in their course. *(Photo: American Petroleum Institute)*

vice equipment, such as underground pipes and manholes. When a piece of equipment needs service, maintenance personnel can return to its exact location, even if it's below the street or obscured by ground cover. If equipment is changed or moved, its new location can be easily updated in a GIS.

GPS, GIS, and the National Spatial Reference System team up in all phases of coal, oil, and gas exploration, extraction, and delivery. This trio of tools is indispensable in designing, constructing, and mapping pipelines and utility lines – especially gas lines, which can save lives as well as millions of dollars.

In earth moving, mineral extraction, and construction projects, these tools help to simultaneously dispatch and route vehicles and to excavate according to precise specifications and environmental regulations. They also aid in documenting the land's condition and topography before excavation begins, so the area may be restored as naturally as possible.

As groundwater is withdrawn from below the Earth's surface, the ground above settles. This sinking, known as subsidence, can fracture roads and building foundations and can burst water, sewer, and gas lines. Through partnerships with local agencies, NOAA is using GPS to measure subsidence at a fraction of the cost of traditional surveying methods.

Communications Systems

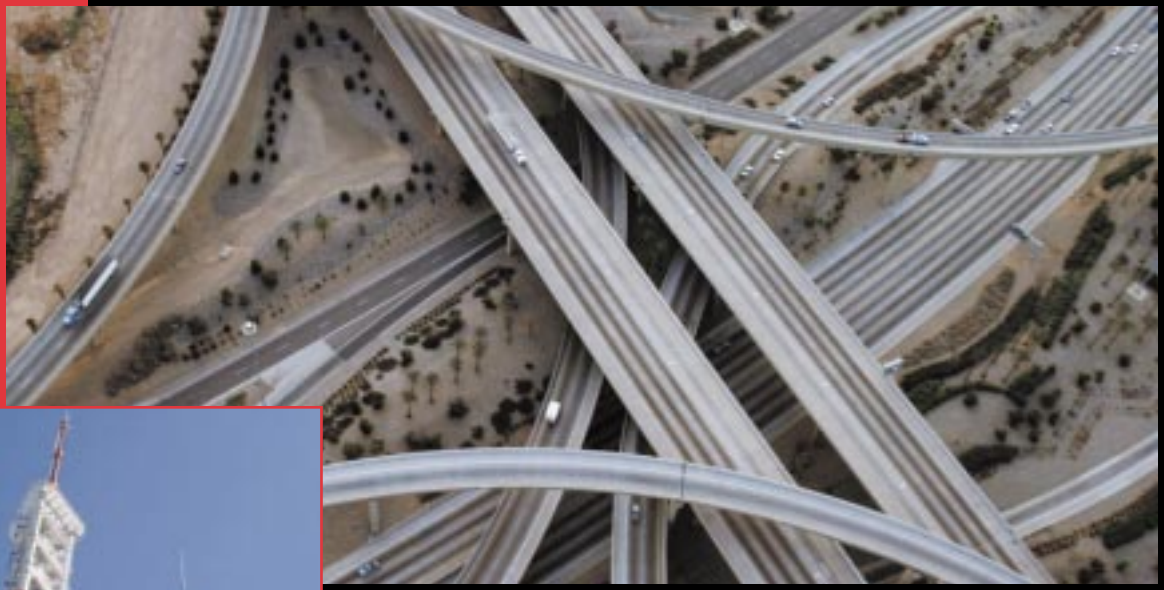
Automated teller machine (ATM) banking and other financial transactions, voice communication, high-speed computing, and the Internet all depend on precise timing.

Without the extremely accurate clocks within the GPS satellites, the Internet would have gridlocked years ago and would never have achieved anywhere near the utility it has today. The GPS clocks, in turn, depend on the precise positioning derived from NOAA's National Spatial Reference System.

Although GPS satellites broadcast correct timing information, the signal becomes susceptible to errors during the eight-hundredths of a second it takes to travel up to 15,000 miles to the receiver. Any error in the position of the receiver causes errors in timing.

A packet of information on a fiber-optic cable or a radio transmission will travel one foot in a nanosecond, or a billionth of a second. Every foot of error in the positions of the electronic message transmission and receiving sites equals one nanosecond of error in timing, increasing the probability of collision and jamming.

As our communications become more sophisticated and the use of new technologies grows exponentially, nanosecond – even subnanosecond – timing dependent upon accurate positioning becomes ever more critical.



ABOVE: The cost of transporting goods across state lines would increase significantly without the quality control inherent in NOAA's National Spatial Reference System. Because reliable maps wouldn't exist, truckers couldn't determine the shortest route to their destination – or worse, would frequently get lost.

LEFT: Using the tools provided by GPS, GIS, and NOAA's National Spatial Reference System, utility companies can pinpoint the location of every piece of service equipment in an area, even if it's below the street or obscured by ground cover.

RIGHT: Real-time GPS, an on-board GIS, and positions referenced to the National Spatial Reference System enhance the efficiency of heavy equipment and provide enormous savings in time and money in many applications in mining, construction, forestry, agriculture, and public services.