CHAPTER 7: GLOBAL POSITIONING SYSTEM (GPS)

To be useful in management systems, data collected by the prototype vehicles' sensors must be spatially referenced; that is, the data must be correlated to specific locations on the earth's surface along the vehicles' routes where the data are collected. Global positioning system (GPS) technology is a worldwide, precision navigation and location tool that uses three-dimensional positioning capabilities to identify spatial references. It is based on triangulation of radio signals from a constellation of 24 satellites orbiting the earth. A local GPS location system receives radio signals from a satellite, calculates the signal's travel time from the satellite to the GPS antenna, and then translates the travel time into distance between the satellite and the GPS antenna. To determine a specific location (for example, the location of a prototype maintenance vehicle) using GPS, an onboard GPS receiver would simultaneously calculate the distance of at least three satellites (synchronized by atomic clocks in the satellites), triangulate the three distances to find their common location on the earth, and record the location in latitude and longitude, along with the GPS time the signals were received.

In Phase II, Rockwell International, Cedar Rapids, Iowa, provided GPS on the prototype vehicles for spatially referencing data collected by the vehicle sensors. Rockwell adapted GPS product lines originally developed for military, transit, agricultural, and commercial vehicle GPS to suit highway maintenance applications.

OBJECTIVE

Conduct proof of concept regarding incorporating GPS technology on winter maintenance vehicles to correlate data collected by other add-on technologies and stored on the PlowMaster with realistic location coordinates, GPS time, and GPS speed.

MEASUREMENT

The GPS antenna will be successfully installed on the prototype vehicle, and the GPS works as expected. Sensor output data (air and pavement temperatures, friction meter readings, etc.) stored on the PlowMaster's removable PCMCIA card have a GPS location stamp (latitude/longitude coordinates) comparing favorably to other GPS latitude/longitude coordinates for the same locations, and a GPS time stamp. Output data also include GPS speed data.

DISCUSSION

Installation

GPS requires a special antenna to receive radio signals from the GPS satellites, and a receiver (engine) to translate the signals into location information. During Phase II, the GPS on the prototype vehicles consisted of (1) an antenna mounted above each prototype vehicle's cab and (2) a receiver (engine) and GPS software located in the PlowMaster's Flexible Interface Adapter in the cab. (The GPS antenna part number is 013-1925-150, and the GPS antenna cable part number is 989-2383-111.)

In areas where full GPS satellite visibility may not always be available, such as urban canyon environments, the PlowMaster system can revert to navigation based on the vehicle's odometer if equipped for this function, using dead-reckoning algorithms and auxiliary sensors. However, the prototype vehicles were not so equipped in Phase II; if conditions temporarily prevented the PlowMaster from acquiring GPS information (location and time) during Phase II, the loss of GPS signals and information was highlighted on the in-cab display as an advisory message.

Installation of the GPS antenna/receiver systems was easily accomplished. The GPS antennae were installed above the cabs without difficulty and posed no significant maintenance problems. The receiver is incorporated in the PlowMaster unit; see Chapter 3 for descriptions of in-cab configurations of the PlowMaster units in the three prototype vehicles. Incorporating the various in-cab technologies made the cabs quite crowded, and the states experimented with various arrangements. In the spring of 1998, Michigan's GPS failed**,** and Rockwell ultimately replaced the GPS unit on Michigan's prototype vehicle. No difficulties were experienced after the unit was replaced.

Performance

During Phase II data capture runs, each prototype vehicle's GPS recorded the location of the vehicle in latitude and longitude every five seconds and sent the location data, along with the GPS time and GPS heading and speed, to the onboard PlowMaster computer processor for recording. Each recording thus provided a GPS location and time stamp that accompanied data being simultaneously collected by vehicle sensors and recorded on the PlowMaster.

GPS time was recorded in Uniform Time Conversion (UTC) time, which is the number of seconds past midnight Sunday at the International Dateline. GPS time synchronized the PlowMaster system with friction and temperature sensor systems. The GPS location information was recorded in latitude and longitude and used to determine heading and speed with respect to the vehicle's prescribed route.

It was important in Phase II to prove that GPS could perform satisfactorily on the prototype vehicles. To confirm that Rockwell's GPS was collecting reasonable data, CTRE compared latitude and longitude data collected at mileposts by the onboard GPS system to known latitude and longitude values for those mileposts supplied by the Iowa DOT. The comparison showed that the two sets of values are not significantly different, confirming that GPS performs as expected and desired on the winter maintenance vehicles.

OBSERVATIONS

Proof of concept was successful; the GPS supplied by Rockwell worked as expected, proving that location information can be collected by technology on winter maintenance vehicles. The systems were easily installed and required little or no maintenance. Milepost comparisons illustrated that the accuracy of location information was within the tolerances expected. GPS is an accurate method of relating prototype vehicles' sensor outputs spatially for analysis and comparison.

For greater location accuracy in Phase III, Rockwell plans to retrofit the prototype vehicles' GPS with differential GPS (DGPS). With DGPS, a local area DGPS base receiver receives signals from satellites and adds a correction factor. The differential corrections provide location data accurate within 16 feet.