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This paper describes a study, recommended in the Report of the Joint DOD/DOT Task Force, The Global Positioning System: Management and Operation of a Dual Use System, to develop a recommendation for an optimum integrated system to provide GPS augmented services to the Federal government. Additionally the study will recommend a transition plan to implement such a system. The conclusions and recommendations of the study will provide an independent expert opinion to DOT to assist in its determination of which GPS augmentation(s) it should continue to support and implement.

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AUGMENTED GPS:
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BIOGRAPHICAL SKETCH

James Arnold is an Electronics Engineer with the Federal Highway Administration, Intelligent Vehicle/Highway Systems (IVHS) Research Division. He received his BEE from the University of Delaware in 1985 and his MSEE from the Florida Institute of Technology in 1990. His experience includes development of military communication systems, commercial communication systems related to IVHS, and technical evaluation of GPS systems.

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ABSTRACT

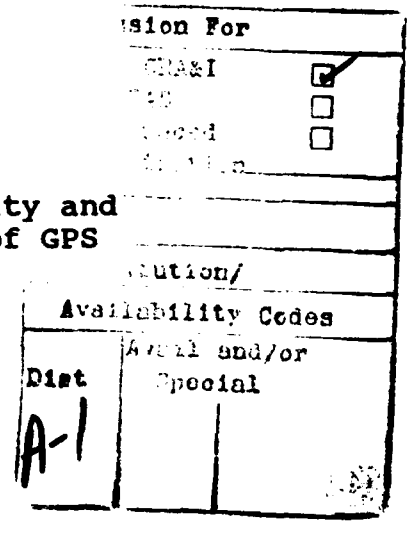
This paper describes a study, recommended in the Report of the Joint DOD/DOT Task Force, The Global Positioning System: Management and Operation of a Dual Use System, to develop a recommendation for an optimum integrated system to provide GPS augmented services to the Federal government. Additionally the study will recommend a transition plan to implement such a system. The conclusions and recommendations of the study will provide an independent expert opinion to DOT to assist in its determination of which GPS augmentation(s) it should continue to support and implement. Factors bearing on the determination of which GPS augmentation(s) to be supported and implemented are: ability to meet user requirements and needs of the operating administrations and other users; cost of Federal development and deployment; user cost; effect on proliferation of government funded GPS augmentation(s); and the ability to satisfy the national security requirements regarding hostile exploitation of augmentation services. This study may also be used to provide guidance and recommendations, where appropriate, to other Federal agencies which are investigating the use of, or are operating, GPS augmentations.

BACKGROUND

The study described in this paper is based on a recommendation in the Report of the Joint DOD/DOT Task Force, The Global Positioning System: Management and Operation of a Dual Use System. The task force report made recommendations in seven fundamental areas of GPS operation and management:

- Management
- Funding
- Accuracy
- Integrity and Availability
- Regulation of GPS Augmentation
- International Acceptance
- Spoofing and Jamming

The study addresses the areas of Accuracy, Integrity and Availability, and to a lesser extent, Regulation of GPS Augmentation.



GOALS AND OBJECTIVES

The primary goal of this study is to provide, through an independent evaluation, a GPS augmentation architecture that will meet the needs and requirements of most, if not all, federal users with a primary goal of meeting transportation requirements. A GPS Augmentation can consist of a number of different applications including, but not limited to wide area/local area differential GPS, subcarriers, triangulation, dead reckoning, and map matching. For the purposes of this study, this also includes distribution of integrity information and increased availability of navigation information.

OVERSIGHT

Oversight of the study is provided by a Study Review Board (SRB), a SRB Working Group (SRBWG), and a Contracting Officer's Technical Representative (COTR). The SRB consists of top level officials from the Department of Transportation (DOT), Department of Defense (DOD), and the National Oceanic and Atmospheric Administration (NOAA). The study is being managed by the Federal Highway Administration (FHWA) through an Inter-Agency Agreement with the Institute for Telecommunications Sciences (ITS) of the National Telecommunications and Information Administration.

The SRB, Chaired by Mr. Joseph Canny, Deputy Assistant Secretary of Transportation, Policy, comprises principles from the primary organizations involved with GPS. These include the Department of Defense: Mr. Richard G. Howe; Federal Aviation Administration (FAA): Mr. Dick Arnold; FHWA: Mr. Dennis Judicky; the Research and Special Programs Administrations: Dr. Rocky Shih; the U.S. Coast Guard (USCG): Adm. William J. Ecker; and NOAA: Adm. Austin Yeager. SRB oversees the study and acts on policy issues as necessary. They are provided bi-monthly updates on the study's progress and other updates as critical tasks are completed.

SRBWG addresses technical issues from the study and provides clarification on a more routine basis. SRBWG is chaired by Mr. Peter Serini, Office of the Secretary of Transportation, Policy. Members are appointed by SRB to represent their interest.

Contract monitoring and technical oversight is provided by FHWA through their COTR. The Contract Manager works in the Intelligent Vehicle/Highway Systems (IVHS) Research Division of FHWA. Since most of the work is being done within the Government through Inter-Agency Agreements, the title COTR is a misnomer. Unfortunately, no other phrase is as descriptive of the position.

TEAM

The team assembled to perform the study consists of the Institute for Telecommunication Sciences (ITS), the U.S. Army Corps of Engineers, Topographic Engineering Center (TEC), Volpe National

Transportation Systems Center (VNTSC), and support provided by Overlook Systems Technologies, Inc. (OSTI).

ITS, the research arm of the National Telecommunications and Information Administration of the Department of Commerce, has been designated the Program Manager and is responsible for completion of the study. Their primary role in the study is to provide the communication system analysis and spectrum planning necessary to develop an architecture that is capable of distributing the information to the numerous users. TEC, with their background in GPS reference stations and development of real time centimeter accuracy systems as well as their experience with USCG and NOAA, has several areas of responsibility. These include defining the requirements of USCG and NOAA, acting as liaison with the Federal Geographic Data Committee (FGDC) through the Federal Geodetic Control Subcommittee (FGCS), and working with DOD to define the National Security issues that arise from the utilization of augmented GPS systems.

VNTSC is responsible for analyzing FHWA and FRA requirements. A notable difference in these areas is that the needs and requirements for highway vehicles and railroads have not been previously defined. Another difference is that the agencies, FHWA and FRA, are not the end users of the GPS Augmentation, rather the autos, trucks, other highway vehicles, and the railroad companies will be. VNTSC has the unenviable job of defining needs and requirements where none have been identified previously.

OSTI is responsible for supplying information on FAA's requirements and system descriptions. Since FAA has done considerable work in the area of GPS augmentation, this is a substantial effort and cuts across the five different task areas defined for the study.

TASKS

The scope of work is broken into five main areas or tasks:

Requirement Analysis
System Analysis
Analytic Decision Matrix Development and Application
Evaluation of Augmented GPS Architectures
Final Recommendations

The requirements analysis collects the needs and requirements from the various federal users to determine what the overall needs of the federal users are. This information has been collected through workshops, questionnaires, and interviews with numerous agencies and departments within the government. The list of agencies and departments who have an interest in augmented services is very broad. Responses came back from such

diverse organizations as the Federal Bureau of Investigation and the Department of Agriculture.

The task of system analysis examines architectures for GPS Augmentation systems that are currently available or are under development. This includes systems in the public sector as well as the private sector. Public systems that are being examined include those being deployed by USCG as well as several under development by FAA. It is important to note that this study will include both local and wide area augmentation systems.

The third task is a comparison of requirements/needs to the available or planned systems. The analytic decision matrix is intended to aid in the evaluation of the various systems through a series of absolute must haves to several factors that are weighted in order to determine relative importance of one criteria to another. This matrix is not intended to provide the final decision, but will be used as a tool to sort the tremendous amount of information being collected and analyzed. The weights will be initially proposed by ITS and will be subject to considerable analysis by SRB and SRBWG.

The fourth task within this effort is to use the analytic decision matrix to filter the available or planned augmentation systems to those systems capable of meeting the requirements of the using agencies. Once this has been determined, continued analysis of these systems will include criteria such as cost data and infrastructure establishment. The data formats currently used or planned to be used by DOT to transmit augmented GPS information to users will be evaluated to determine their applicability to the recommended system configuration. This evaluation will consider the use of the available data formats for multiple users, the ability to modify and expand the formats for multiple user applications.

The fifth and final task is to make a recommendation for the optimum integrated system or systems that will meet the needs of the federal users. Included in this is a migration plan to achieve this system in a reasonable amount of time.

EXAMPLE

As a purely hypothetical example of how this may work, consider the application for IVHS where dead reckoning versus map matching are used to augment GPS. The acceptance criteria may include accuracy better than 50 meters with 1 second updates and 99 percent availability. This translates, for a vehicle traveling 90 km/h, to a position fix every 25 meters in 1 second.

To use map matching, this may require map points to be 12.5 meters apart. If each point requires a latitude and longitude then, without any encoding scheme this may require 10 bytes per location then a CD-Rom can store approximately 825,000,000 miles

of roadway. Equipment may include an in-vehicle navigation computer with appropriate display and map-matching software.

To use dead reckoning, an in-vehicle computer system to determine position and from wheel sensors and compass are required.

For this example, both augmentation systems meet the requirements for accuracy and availability. When looking at the cost to the end user, dead reckoning may be less expensive since it does not require the user to periodically update their map database. Dead reckoning may be the favored system.

This example does not include many of the other factors involved in the final determination and is meant only as a hypothetical example.

SCHEDULE

Tasks 1 and 2 are expected to be completed by the end of June 1994 with task 3 and 4 to be completed by the end of July 1994. A draft report will be delivered to SRB by the end of August 1994 with the final to be delivered by 30 September 1994. This is a very ambitious schedule, one which has no slack and places a tremendous responsibility upon the study team. If it were possible to spend more time on the study, we would gladly do so. Many major funding decisions addressing GPS augmentations will be made early in fiscal year 1995. It is critical that these decisions be made with all possible available information. Ideally the recommendation from the study will result in a decrease in the proliferation of federally funded GPS augmentation systems as well as the establishment of an optimal national system which will meet the needs and desires of the numerous user groups around the nation to have an augmented GPS.

IMPACT

While it is still too early to tell precisely what impact this study will have on federal augmentation systems, the desired impact is a reduction and consolidation of the number of different systems currently being implemented with a corresponding saving of expenditures by the Federal government, and ultimately, a cost savings to the using public. As has been pointed out, this effort is good government. We must ensure that we do not impact the end user in this effort by maintaining the appropriate level of service regardless of the final system design.

SUMMARY

We have every confidence in the study team and their ability to meet the schedule and deliver a thorough and well thought out product, one that will meet the needs of the Federal Government and the nation's users.