

## **A Low Cost GPS/Inertial Mapping (GIM) System**

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### **BIOGRAPHIES**

#### **TIMOTHY ASH**

Timothy Ash is a Systems Engineer at Navsys Corporation. He has over five years of experience in the design, development, and testing of complex hardware and software systems. Mr. Ash received his Masters in Electrical Engineering from San Diego State University.

#### **JOSEF COETSEE**

Dr. Coetsee is a Systems Engineer at NAVSYS Corporation. He has several years experience in control, estimation, and system modeling. His current interest is in the development of integrated inertial and GPS navigation systems. Dr. Coetsee completed his graduate education at MIT where he received Masters and PhD degrees. He is a member of Sigma Xi.

#### **RANDY SILVA**

Mr. Silva is a Software Engineer at NAVSYS Corporation. He has worked for the last several years developing software for many GPS applications. Mr. Silva has received his Bachelors Degree from the University of Colorado.

#### **ALISON BROWN**

Alison Brown is the President of NAVSYS Corporation, which specializes in developing GPS customized products and services. Dr. Brown has over 15 years

experience in GPS receiver design and has seven GPS related patents. She has published numerous papers on GPS applications and is on the editorial board for GPS World and GIS World magazines. She is currently the Space Representative for the ION Council. Dr. Brown received her BA in Engineering from Cambridge University, a MS from MIT, and a PhD from UCLA.

### **ABSTRACT**

Geographic Information Systems (GIS) constitute a multi-billion dollar market for geographic data, and GPS offers a quick and accurate method to meet the demand for this data. A significant and costly problem in the gathering of mapping information using GPS is the voids in the map data base caused by satellite shadowing, which may not be discovered until after the survey is complete. To address this problem a low-cost, miniaturized GPS/Inertial Mapping (GIM) system has been developed that can deliver 1-3 meter accuracies in real time even in the event of temporary GPS signal loss. This paper describes the NAVSYS GIM system, and the results obtained with the system during recent road mapping sessions.

The NAVSYS GIM system incorporates an innovative optimal processing algorithm that enhances the performance of the inertial/GPS system enabling a low

cost Inertial Measurement Unit (IMU) to be employed in combination with a GPS receiver, and a differential GPS correction system to provide an accurate, real time position and attitude reference. The overall process is controlled by an intelligent data management system capable of recording feature and attribute information in real time with associated time tagging for exact location. The GIM system is packaged into a portable, modular architecture that is suited for various vehicles such as cars, four wheel drives, watercraft, or railroad cars, allowing quick and accurate surveys to be performed in a wide variety of geographies.

Recent results obtained from roadway surveys demonstrate that the system is capable of maintaining 1-3 meter accuracy while driving over a wide variety of terrain and while operating at highway speeds.

## INTRODUCTION

A large emphasis has been placed recently on GPS as an aid to collecting data for Geographic Information Systems (GIS). Using GPS it is possible to automatically "tag" locations of interest during the survey process for generating a map. The use of GPS becomes especially advantageous for cases where data is collected in digital form. The cases include mapping of roadways with vehicles, digitizing the path of a pipeline or utility transmission line from helicopters, collecting a video database of road features and utilities, and mapping environmental areas such as forests or supersite boundaries.

GPS systems have already been

developed for many of these applications. These systems can generally be divided into two functional classes: real-time differential GPS (DGPS) systems and post-processing kinematic survey systems. Differential GPS systems provide an accuracy of 1-2 meters by using DGPS corrections broadcast from a central reference station that correct for systematic GPS errors. Kinematic GPS systems process the GPS carrier phase data to derive a more precise solution (<10 cm) of the vehicle's location relative to the reference station.

Both DGPS and kinematic GPS techniques require at least four satellites to be in view of the receiver to achieve full precision. This is a significant problem when collecting data from a ground vehicle, as the satellite visibility is often obstructed by buildings and trees. To a lesser extent, this problem also exists when collecting data from an aircraft, as the satellite visibility can be temporarily obstructed during maneuvers. To solve this problem, an inertial navigation system (INS) can be used to provide a "dead-reckoning" capability during the periods of satellite shadowing.

The performance accuracy required during these dropout periods has previously been available only with very expensive INS systems. Recently results have been published describing an optimal processing algorithm that allows the use of a low cost IMU to be used for GPS/Inertial navigation<sup>1, 2</sup>. This paper reports how this algorithm has been employed by NAVSYS into a modular, real time GPS/Inertial mapping (GIM) system capable of delivering accuracies of 1 to 3 meters in position and 0.5 degrees in attitude, even in regions of