The Ohio Department of Transportation
Office of Research & Development
Executive Summary Report

High-Accuracy Direct Aerial Platform Orientation with Tightly Coupled GPS/INS System

Start Date: March 2001

Duration: 20 + 24 months (extension)

Completion Date: November 2004

Report Date: September 2004

State Job Number: 14781 (0)

Report Number:
FHWA/OH-2004/014

Funding:
$279,082

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Problem

Obtaining sensor orientation by direct measurements is a rapidly emerging mapping technology. Modern GPS and INS systems allow for the direct determination of platform position and orientation at an unprecedented accuracy. In airborne surveying, aircraft trajectory and platform orientation can be determined at the level of few cm and 20-30 arcsec, respectively at an almost continuous time scale. The use of such integrated GPS/INS systems offers immediate benefits for large-format camera-based airborne surveying by substantially reducing the need for ground control and by basically eliminating aerial-triangulation, except for system calibration. For emerging sensors such as LIDAR, RADAR, multi-/hyperspectral imagers, however, the use of the direct orientation systems is mandatory since indirect methods such as control point-based aerial-triangulation are not feasible. ODOT Aerial Engineering has been operating an airplane with a large-format Zeiss Jena LMK2000 camera. The introduction of a modern GPS/INS-based direct orientation system was not only highly desirable for economic reasons, but also mandatory if ODOT wanted to keep up with technological developments. Since ODOT predominantly performs corridor surveys over the highway infrastructure, the use of direct orientation makes it even more attractive in this case, since the savings due to the elimination of control points are quite substantial. By establishing a GPS/INS-based direct orientation technology for ODOT aerial operations, the foundations was given for future imaging sensor extensions such as the introduction of LIDAR systems or the like.

Objectives

- To augment the existing airplane sensor configurations with a commercially available GPS/INS system (Applanix POS/AV),
- To carry out test flights to benchmark the performance of the POS system against AIMS GPS/INS,
- To perform the extended quality assurance analysis based on the above mentioned airborne test with multiple sensors,
- To consult ODOT personnel in GPS/INS technology/data acquisition and processing,
- To consult ODOT personnel on future developments such as the introduction of high-resolution digital cameras and LIDAR systems.

Description

The extensive system calibration and performance validation were carried out based on two test flights performed by Aerial Engineering Office. The data were processed and analyzed at OSU, and the detailed description of the results is provided in the final report. In particular, lever arm calibration, boresight calibration and navigation module quality check were performed. In addition, multiple CORS reference stations were used in the solution. Detailed analyses of the quality of the GPS and GPS/INS solutions were performed.

Conclusions & Recommendations

Since the only way to test the performance is thorough independent georeferencing method, such as aerotriangulation (AT) based on control points, which for practical reasons is not performed, except for the system calibration, the following test procedures are suggested: (1) closely monitor the QA/QC (quality assurance/quality control) parameters during the navigation solution, as detailed in the final report; and (2) run an automated AT (with no control) seeded by the GPS/INS solution that provides the image orientation refinement. Based on the extensive testing and system calibration, as described in the final report it can be concluded that the Applanix system meets the performance specifications, as described by the manufacturer. Especially the recent update of the GPS/INS processing engine provides more robust georeferencing solution, and supports better user interface.

Implementation Potential

The OSU staff worked in close collaboration with ODOT OAE personnel to assure that all functional aspects of the system's operation are followed during the field procedure. This included test flights, calibration and training seminars for the OAE staff. The system is fully implemented and installed in the OAE airplane, and has been operational since fall 2002.