INTEGRATED MULTISENSOR NAVIGATION SYSTEMS

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BACKGROUND

The multisensor navigation systems research evolved from the availability of several stand-alone navigation systems and the growing concern for aircraft navigation reliability and safety. The intent is to develop a multisensor navigation system during the next decade that will be capable of providing reliable aircraft position data. These data will then be transmitted directly, or by satellite, to surveillance centers to aid the process of air traffic flow control. In order to satisfy the requirements for such a system, the following issues need to be examined:

- Performance
- Coverage
- Reliability
- Availability
- Integrity

The presence of a multisensor navigation system in all aircraft will improve safety for the aviation community and allow for more economical operation.

COMBINED GPS, LORAN-C, AND ALTIMETER

For the development of an integrated multisensor navigation system several navigation sensors were considered including the Long Range Navigation System (Loran-C), the Global Positioning System (GPS), an Inertial Navigation System (INS), and an altimeter. Based on system cost and complexity, signal characteristics and sensor accuracies, the inertial sensors are omitted from the initial design. Although the use of inexpensive inertial sensors can reduce the variance of the position solution error, the overall position accuracy still depends on the absolute position sensors such as Loran-C and GPS.

During last year, a GPS receiver (FAA Experimental Dual Channel GPS Receiver), a Loran-C receiver (Texas Instruments 9900), and an altimeter were installed in the DC-3 research aircraft. Figure 1 shows the functional block diagrams of the equipment. Data from the navigation sensors is stored on magnetic tape for post test analysis. The GPS receiver was initially installed to provide verification data for a codeless GPS tracking scheme developed under the FAA/NASA Joint University Program (JUP) (ref. 1). Loran-C receiver and application technology has been part of the JUP at Ohio University since 1976.

The navigation sensors were flight-tested during June 1986. The flight test results provide novel capabilities for a direct comparison between GPS and Loran-C. Figure 2 shows the ground track results for a typical data collection flight across southern and central Ohio on June 22, 1986. The duration of the flight was 24 minutes and contained two turns at an altitude of 12,000 feet.

Figure 3 shows the navigation solution differences between GPS and Loran-C in the East direction and figure 4 shows the differences in the North direction. The cause of the larger differences during the two turns is illustrated in figure 5. This figure shows the ground tracks for GPS and Loran-C during the second four-minute turn. From this figure it can be concluded that the Loran-C navigation solution lags in time due to a larger time constant used in the navigation filter. Even with the lag in the Loran-C solution, differences between GPS and Loran-C were typically less than 0.15 nmi during the flight. However, the stand-alone use of both systems does not provide optimal navigation and failure detection capabilities.

Original techniques were developed during the last year for a fully integrated GPS/Loran-C navigation system. Loran-C will be used in the ranging mode providing ranging accuracies on the same order of magnitude as GPS range measurements. In addition, the integrated system will have the following advantages compared to a combination of stand-alone GPS and Loran-C:

- Larger coverage area: degraded satellite observability can be compensated for by one or two range measurements to Loran-C stations.

- More measurements are available than necessary for the navigation solution allowing for user autonomous failure detection and system monitoring.

- The integrated system is expected to meet the requirements for sole means random navigation (RNAV) systems and nonprecision approaches.

FUTURE RESEARCH

Next year's multisensor navigation research will be focused on the following areas:

- Realize Loran-C direct ranging.

- Combine receiver clocks for GPS and Loran-C.

- Ground test Loran-C receiver.

- Integration of high-quality altimeter data.

- Computer simulations to predict the performance and coverage of the integrated GPS/Loran-C navigation system.

- Flight experiments with ground-referenced tracking.

The sensors involved in the flight experiments are GPS, Loran-C, and an altimeter. For this experiment, the hyperbolic Loran-C receiver will be replaced by a ranging receiver, most likely the Racal Megapulse Accufix 500.

Aircraft data will be referenced to measured positions obtained using the Ohio University ground tracking system. The data will then be post processed on the ground to prove the multisensor navigation concepts.

Successful flight tests of the integrated GPS, Loran-C, and altimeter system will be used as a basis for further multisensor navigation system research. Algorithms for efficient integrity checking will be developed and implemented. An inertial measurement unit will be added to the system to reduce position noise and also to aid failure detection algorithms.

REFERENCES

1. Laube, J.P.: An Investigative Study of Blind Despreading and Doppler Tracking Using Autocorrelation. Ohio University, Department of Electrical Engineering, Master's Thesis, June 1986.

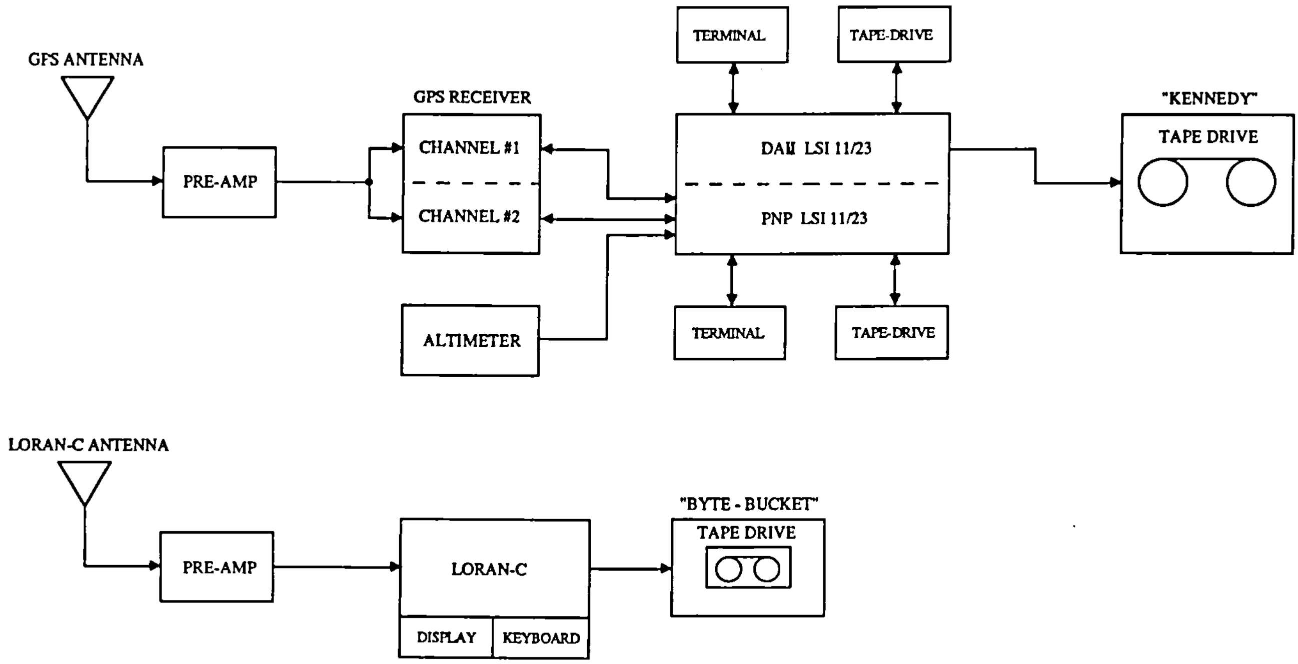

Figure 1. Functional block diagram of the navigation test bed in the Ohio University DC-3 research aircraft N7AP. The equipment consists of a dual channel GPS receiver, a Loran-C receiver, and an altimeter.

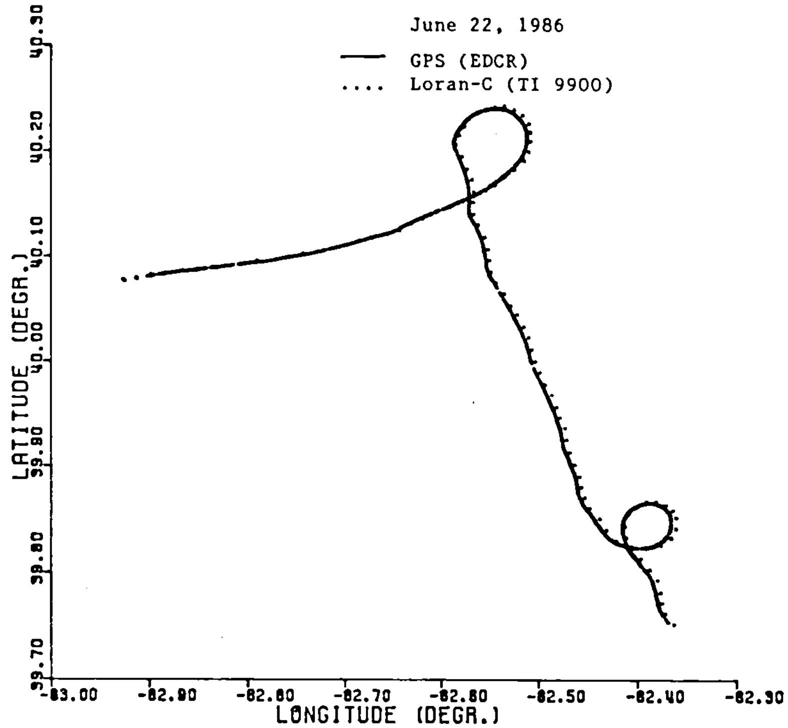

Figure 2. GPS and Loran-C ground tracks for a 24 minutes flight across southern and central Ohio on June 22, 1986.

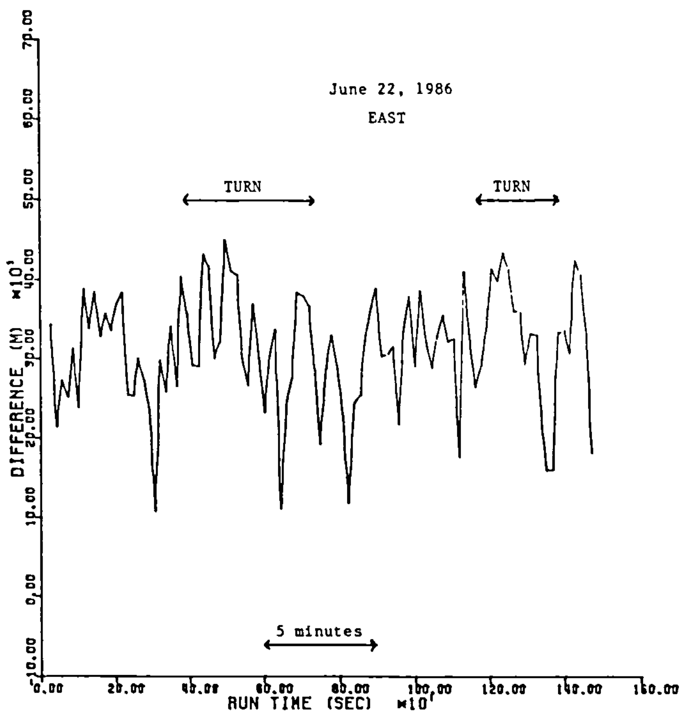

Figure 3. Navigation solution differences between GPS and Loran-C in the EAST direction.

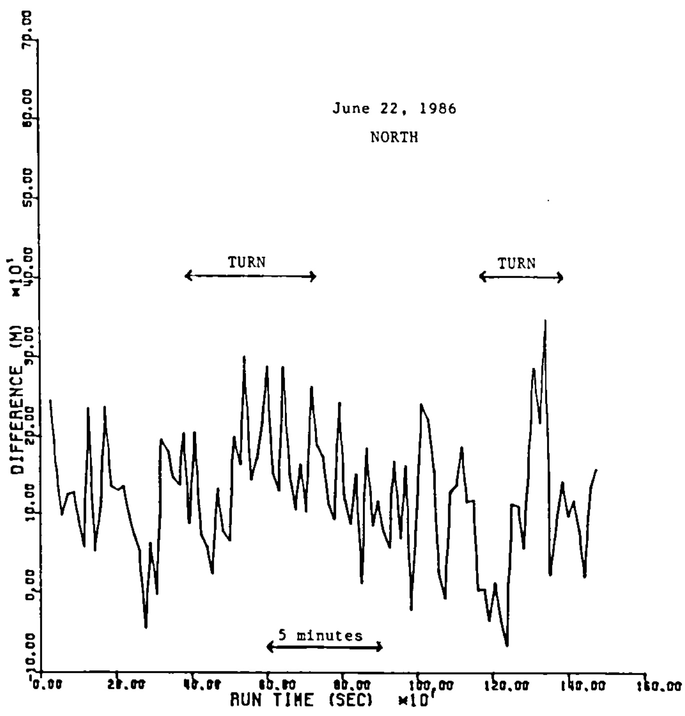

Figure 4. Navigation solution differences between GPS and Loran-C in the NORTH direction.

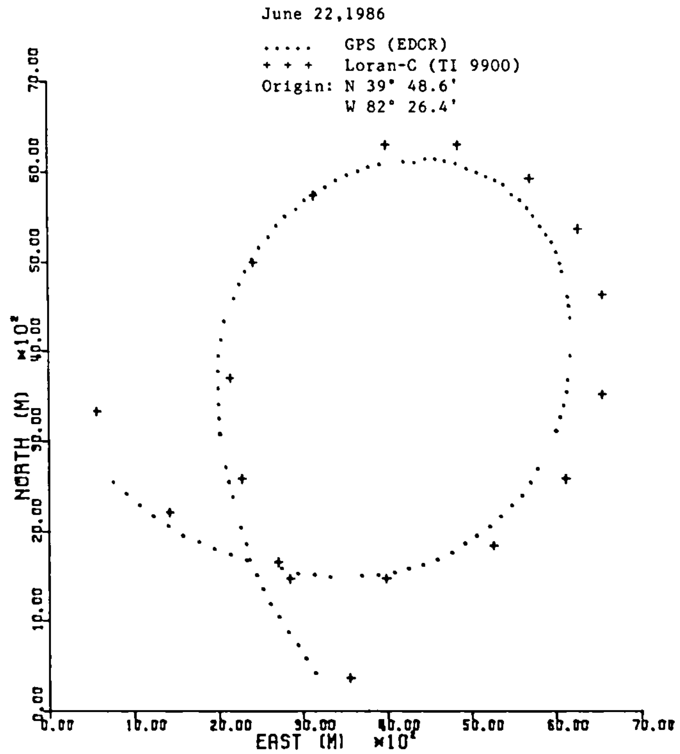

Figure 5. Ground tracks for the GPS and Loran-C navigation solutions during a four-minute turn.