RESULTS OF PRELIMINARY FLIGHT EVALUATIONS COMPARING THE PERFORMANCE OF H-FIELD AND E-FIELD LORAN-C ANTENNAS IN THE PRESENCE OF PRECIPITATION STATIC

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BIOGRAPHY

Jamie Edwards received an A.S.E.E. from Lima Technical College in 1983 and a B.S.E.E. from Ohio University in 1986. For the past 15 years Jamie has been performing research with the Avionics Engineering Center at Ohio University. During that time Jamie has worked on a variety of aircraft navigation systems including ILS, VOR and Loran-C. Jamie uses computer modeling in his work with the Instrument Landing System (ILS) and serves as pilot and panel operator on ILS data collection missions. As a student intern at the center, Jamie aided in the design and implementation of a Loran-C ground-based monitoring system. Jamie holds a commercial pilot certificate with instrument privileges for single and multi-engine aircraft.

ABSTRACT

The susceptibility of Loran-C receivers to precipitation static has been a significant contributor in preventing full utilization of Loran-C for aircraft navigation. Precipitation static is a build-up of electric charge on the aircraft which occurs while flying in precipitation. Typically occurring while flying in light rain or snow, this build-up of electric charge on the aircraft degrades the signal-to-noise ratios (SNR) of the received Loran-C signals. This results in decreased positional accuracy and may even result in a complete loss of Loran-C navigation information.

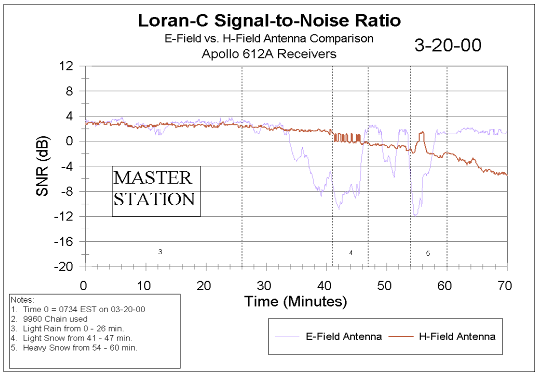
The data presented in this paper were attained to show the improvement factors associated with using a H-field versus an E-field Loran-C antenna in a high precipitation static environment. Included are descriptions of the test aircraft, Loran-C receivers, and antennas used for the testing. Instances of flights encountering precipitation static are presented. These flights show that the SNR's from the receiver using the E-field antenna were significantly degraded while those using the H-field antenna were essentially unaffected.

INTRODUCTION

The susceptibility of Loran-C receivers to precipitation static (p-static) has been a significant contributor in preventing full utilization of Loran-C for aircraft navigation. P-static is a build-up of electric charge on the aircraft which occurs while flying in precipitation. Typically occurring while flying in light rain or snow, this build-up of electric charge on the aircraft degrades the signal-to-noise ratio (SNR) of the received Loran-C signals. This results in decreased positional accuracy and may even result in a complete loss of Loran-C navigation information.

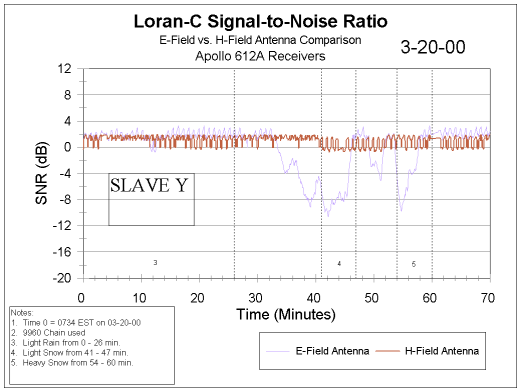
The most common method for reducing Loran-C p-static effects is through the use of static dischargers (wicks) installed on the trailing outboard surfaces of the wings and horizontal/vertical stabilizers. These devices are very effective in lowering the airframe discharge threshold to a value such that the discharges, when they still occur, contain a minimal amount of energy. Unfortunately, the number of static dischargers required on an aircraft are many; and, they can be easily damaged or broken during ground operations. Thus, from a maintenance viewpoint, they are undesirable.

The use of an H-field (loop) Loran-C antenna has long been known to provide better noise immunity over the universally used E-field (monopole) antenna. The difficulty of dealing with the phase reversals associated with loop antennas has been the primary reason that H-field antennas have not been used on aircraft for Loran-C navigation. This may no longer be a problem given that a modern Loran-C receiver design would use digital signal-processing techniques. The data collected and presented in this paper were obtained to demonstrate the improvement factors associated with using an H-field versus E-field Loran-C antenna in a high p-static environment.



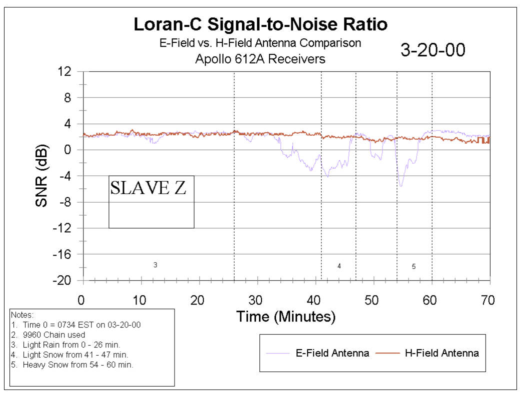
DATA COLLECTION

Airborne measurements were collected in a Beechcraft V35A equipped with two identical Apollo 612A Loran-C receivers. These receivers are approved (TSO'd) for instrument-flight-rule (IFR) operation. One of the receivers used a top-mounted, monopole (E-field) antenna while the other receiver used a modified bottom-mounted, ADF loop (H-field) antenna. The H-field antenna uses a specially designed pre-amplifier/matching network to couple to the receiver. A laptop computer receives the RS-232 output from each receiver and logs the Lat/Lon position of the aircraft and respective receiver SNR values.



RESULTS

Approximately 50 hours of E-field/H-field Loran-C data have been collected during routine transportation missions unrelated to the Loran-C task. Unfortunately, the weather conditions required to produce significant P-static are relatively rare. The only significant p-static encountered during all these flights occurred during a flight from Athens, OH to Ocala, FL on March 20, 2000. Figures 1, 2, and 3 compare the SNRs for the receivers used with the E-field and H-field antennas during this flight.



During the first hour of the flight, light-to-moderate rain and snow conditions were experienced along the route. These plots show that the p-static conditions caused an 8 to 10 dB decrease in the E-field SNR values while the H-field antenna performance remained essentially unaffected during the period of p-static. Although the E-field test receiver never lost track, the pilot's panel-mounted Loran-C receiver failed to provide navigation data for several minutes during the most intense period of snow.

CONCLUSIONS

A prototype H-field Loran-C antenna system was installed on an aircraft and flight tested. Preliminary comparisons have been made with the simultaneous collection of E-field Loran-C antenna data during flights encountering periods of significant p-static. These results show that the H-field antenna provides higher immunity to the p-static noise conditions.

Ohio University plans to continue gathering in-flight data in the p-static environment to further determine the effectiveness of the H-field antenna. Additionally, plans are underway to develop and implement a data collection system to digitally sample and store, for post-processing, the incoming Loran-C RF signals. This data can be used to fully characterize p-static and atmospheric noise effects and develop pulse-tracking routines to deal with the phase shifting associated with the H-field antenna.

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