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Agenda Item 10: HF Data Link

OAKLAND HF DATA LINK TRIAL

Presented by the Federal Aviation Administration

SUMMARY

This paper provides preliminary information regarding an ongoing High Frequency (HF) Data Link trial in the Oakland FIR

1. INTRODUCTION

1.1 Hawaiian Airlines (HAL) operates a fleet of B767 that are equipped with Future Air Navigation System (FANS) but not INMARSAT satellite communications (SATCOM). This configuration (Very High Frequency, VHF, and HF only) presented an opportunity to evaluate HF media message transit delay times that were not "burdened" with initial attempts via SATCOM.

1.2 In June 2008 Oakland ARTCC, Hawaiian Airlines, and ARINC commenced an operational trial of HF Data Link (HFDL). The data gathered during the trial will evaluated against the criteria in RTCA DO-306, SAFETY AND PERFORMANCE STANDARD FOR AIR TRAFFIC DATA LINK SERVICES IN OCEANIC AND REMOTE AIRSPACE, to determine the suitability of the HF media for ATC data link communications.

2. DISCUSSION

2.1 The trial incorporates a three-phase approach in the implementation of HFDL operations. The phased approach was taken to allow for baseline measurements, HF data radio upgrade, early data collection, and aircrew training. While the design of the trial defined three distinct operating environments, each of the phases was not exclusive of previous phases (e.g. phase 2 operations could continue while phase 3 operations were also being conducted).

2.1.1 The primary activities during phase 1 were the upgrade of software on the HF data radios and performance evaluation of Airline Operations Center (AOC) messaging. All of the HFDL equipped aircraft in the HAL fleet had to receive a Honeywell software upgrade prior to participation in the trial. This upgrade addressed a bug in the software that had a direct effect on link reliability. The three metrics evaluated for the AOC data were: First Try Uplink Block Success Rate, Uplink Message Success Rate, and Uplink Transit Delay.

► **First Try Uplink Block Success Rate** measures the HF data radio's ability to receive and properly decode the uplink on the initial broadcast attempt. This metric measures the radio's frequency scanning and signal grading algorithms.

► **Uplink Message Success Rate** measures the ability of the HFDL ground network to delivery the entire ACARS message to the aircraft.

► **Uplink Transit Delay** is a round trip measurement from the first uplink attempt to receiving the acknowledgement (ACK) from the aircraft.

The upgraded software installation began in mid July 2009. The first aircraft to receive the upgraded software was N594HA. Over the next 45 days, the AOC data was collected and compared against the aircraft performance from the previous two months. This was repeated for each aircraft as the upgraded radios were installed. N594HA HFDL AOC performance turned out to be representative of HAL HFDL fleet. The results of the HAL N594HA HFDL AOC message performance are as follows:

- First Try Uplink Block Success Rate

May 08	46.23%
Jun 08	48.02%
Jul 08	54.89%
Aug 08	71.89%

- Overall Uplink Message Success Rate

May 08	91.66%
Jun 08	93.67%
Jul 08	98.27%
Aug 08	98.34%

- Average Uplink Transit Delay

May 08	111 sec
Jun 08	116 sec
Jul 08	96 sec
Aug 08	88 sec

2.1.2 Phase 2 was position reporting via Automatic Dependent Surveillance (ADS) and air traffic control (ATC) communications via HF voice. This phase was included to allow initial data link operations with minimal aircrew training while at the same time providing a large number of measurement points.

Aircraft participating in this phase were given relief from voice reporting requirements. This relief served two purposes; redundant reporting was not necessary in the Ocean 21 system and it minimized the use of HF voice which can impact HFDL due to the single HF antenna that serves both voice and data. Aircrews in aircraft that had upgraded radios were to log on to the Oakland ground system and then select ATC COMM OFF after the automatic Controller Pilot Data Link Communications (CPDLC) connection sequence was completed. While the operations during this phase did provide the large number of data points as designed, the results were not encouraging. Several issues contributed to poor performance:

- Aircrews had a short time to acclimate to the elimination of voice reporting on waypoint crossing. Since HF Voice pre-empts HF Data transmissions, voice retarding the data deliveries still existed.

- Some aircraft that had not yet received upgraded radios were participating in the trial.

- An automatic AOC position report (which includes required Fuel-on-Board reporting) trigger in the Flight management Computer (FMC) had to be halted as it was competing with the automatic ADS waypoint point reports for immediate delivery in the CMU.

- After logon to Oakland, some aircrews were not selecting ATC COMM OFF on the display panel, leading to confusion between controllers and aircrews on how ATC communications were to be handled: voice or data.

- Inter-media (VHF/HF) handoff issues at coverage boundaries surfaced. The majority of HAL flights enter the Oakland Flight Information Region (FIR) from an area covered by VHF; however, the areas where aircraft were typically logging on are at the fringes of the VHF range. This resulted in longer transit times associated with media transitions similar to those observed in VHF/SAT transitions but with added delays related to the time division protocol of the HF media.

Most of these problems resulted in a large number of warnings and messages to be sent to the controller's sector queue and this quickly became a workload issue. A decision was made to terminate phase 2 operations but continue the trial with phase 3 flights: full data link. The logic behind this decision was that there would be significantly fewer flights involved since very few crews were trained on the use of CPDLC, and by eliminating nearly all use of HF voice the issue of voice transmissions pre-empting data transmissions would be minimized.

2.1.3 HFDL in Phase 3 included both ADS and CPDLC with HF voice reserved for non-routine use, such as MEDLINK. We observed much better performance than found in

Phase 2. The reduced data flow has allowed for a more detailed evaluation of any lengthy transit delays. Some observations from this phase:

- A number of messages during the logon sequence were timing out for lack of a technical acknowledgement. The cause of this is related to the way that the Oakland automation system responds to a valid FN_CON message. Approximately 10 seconds after receiving the FN_CON Ocean 21 transmits an FN_ACK followed in rapid succession by an ADS contract request and a CPDLC CR1. To partially mitigate this problem an adapted timeout value was increased from 120 to 175 seconds.

- On some flights while in VHF range, the aircraft will downlink using VHF but the DSP routes the uplink via HF. This can be overcome if the aircrew takes steps to select the VHF services of an alternate DSP. However, for commercial reasons this is not a desirable solution.

- CPDLC performance is better than that of ADS. We are investigating the reasons for this disparity.

  One possibility involves the issue of VHF/HF transition and the performance measurement points. On a typical flight, there are three ADS messages downlinked while the aircraft is in the transition area: the periodic report that is part of the contract request acknowledgement, the waypoint change report at the FIR entry fix, and the waypoint change report at the FIR exit fix. CPDLC performance measurements on the other hand are made only on “intervention” type transactions (e.g., climb clearance, weather deviation). These types of messages are not typically used until the aircraft is well established in the en-route environment and in HF-only coverage.

  Another thought is that the disparity is related to the single antenna for both voice and data configuration. While the crews have complete control over when CPDLC messages are queued up for transmission this is not true for ADS messages. This makes it more likely that the use of HF voice will interrupt an ADS message than a CPDLC message.

- It was discovered that the flight planning system that HAL uses was uplinking duplicate AOC messages in some instances. A software change was made on 18 February to correct this problem.

2.2 Beginning 1 April 2009, HAL crews using FANS terminated the ADS contracts after initial logon and operated CPDLC only using the CPDLC position report rather than ADS to meet reporting requirements. This temporary change to the operating environment of the trial was made for two reasons. The first was to generate more CPDLC downlinks so that we can have greater confidence in the results we have seen so far. The second reason was to evaluate what may very well be the initial post-trial HFDL operating environment: CPDLC only.

2.3 Data collection for the trial was temporarily halted due to the discovery of an error in the program that extracts the CPDLC data from our recordings. This program has since been repaired and data collection has resumed. Overall performance since December 2009 shows a slight degradation from previous reports, and HFDL is no longer meeting the requirements for RCP400. We look forward to working with Hawaiian Airlines and ARINC to investigate the cause of the degradation. We will keep the group informed of future progress and provide a detailed report of the final results of the trial.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

a) Note the interim findings of the HFDL trial being conducted in the Oakland oceanic FIR.