VDL Mode 3 Digital Voice Operation

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ABSTRACT

VHF Data Link (VDL) Mode 3 is a digital TDMA communications system developed by the FAA and Industry partners as a replacement for the existing 25 kHz analog AM systems currently used for VHF aeronautical communications. VDL Mode 3 provides increased channel capacity and security for both voice and data link communications.

This paper provides a report on the first Supplemental Type Certification recently issued for production-ready and FAA Technical Standard Order (TSO) approved VDL Mode 3 avionics.

INTRODUCTION

To solve frequency congestion issues, a replacement is needed for the current 25 kHz analog AM VHF aeronautical communications system. VDL Mode 3 is one of several systems being considered by the Future Communications System study group [1] as a global standard for a new aeronautical communications system.

VDL Mode 3 is a digital TDMA system that operates on 25 kHz channels [2]. Because of the 25 kHz spectrum compatibility, it can be integrated within the existing 25 kHz based analog AM communications infrastructure.

VDL Mode 3 will support aeronautical mobile voice and data link communications with a range of over 200 nmi. For each 25 kHz channel, VDL Mode 3 provides four independent digital circuits that can be used for any combination of voice or digital data.

For data link operation, such as with Controller Pilot Data Link Communications (CPDLC), VDL Mode 3 provides a deterministic, low latency data link needed for time-critical Air Traffic Control messages.

Table 1. Mode 3 Functions

VDL Mode 3 Function	Service Levels of Digital Voice	Description
Transmit Status Indicator	Basic & Enhanced	Provides an aural warning to the flight crew when transmissions are disabled
Anti-Blocking	Basic & Enhanced	Prevents other transmitters from interrupting transmissions
Controller Override	Basic & Enhanced	Provides ATC a method to interrupt any transmissions and clear the channel
Next Channel Uplink	Enhanced	Provides ATC a method to send the next frequency to the VHF
Urgent Downlink Request	Enhanced	Provides the flight crew with a method to notify ATC when they need to communicate
Service Level Status	Basic & Enhanced	Provides flight crew with info on Mode 3 functionality

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Mode 3 Voice Features and Benefits

Besides the obvious benefit of increased capacity with digital clarity and data link there are added features that VDL Mode 3 provides. These are summarized in Table 1.

The Transmit Status Indicator function informs the flight crew, via a tone in the headset that the Mode 3 channel is blocked and the VHF is not allowed to transmit.

The Anti-Blocking feature works in conjunction with the Transmit Status Indicator. If the VHF is currently transmitting then other users who attempt to transmit will be prevented from doing so. This results in a one transmitter at a time system.

The Controller Override function allows the Air Traffic Controller to grab control of the channel and prevent any other users from communicating; even those currently transmitting.

The Next Channel Uplink function provides a means for the Air Traffic Controller to inform an aircraft of the next communications channel without having to verbally relay the information. The new frequency is sent over the Mode 3 channel and is displayed on the tuning head. The flight crew can then simply select the new frequency and be tuned to the next controlled airspace.

The Urgent Downlink Request function provides a means for the flight crew to notify Air Traffic Control that there is an urgent need for communications. It is not intended as an emergency indicator. Current emergency procedures on 121.500 MHz still apply.

The Service Level Status feature provides the flight crew with a visual indication of the high level state of the Mode 3 system. If the VHF is tuned to a Mode 3 frequency which has a configuration that is not supported, the flight crew will be informed that it is an invalid frequency. If no Urgent Downlink Request capability is available the tuning head will provide a visual indication that the feature is not available.

HISTORY OF VDL MODE 3 DEVELOPMENT

VDL Mode 3 development began in 1995 within SC-172 of RTCA. Over a period of 10 years, the committee (composed of governmental and industry experts) defined and developed the system including the 31.5 kb/sec D8PSK waveform and the 4.8 kb/sec VOCODER used for digital voice operation.

This outcome of the committee was the publication of DO-224 Systems Specification (MASPS) and DO-271 Minimum Operational Performance Specification (MOPS) that defined the VDL Mode 3 system. DO-224 was utilized by the FAA as part of the requirements for the new TSO C-163 for VDL Mode 3 operation.

DEVELOPMENT OF PRODUCTION-READY VDL MODE 3 AVIONICS

In September 2001, Rockwell Collins entered a Government-Industry Agreement with the United States Federal Aviation Administration (FAA) to develop a production-ready multimode VHF Communications Transceiver providing 8.33/25 kHz analog AM, VDL Mode A, VDL Mode 2, and VDL Mode 3 capabilities. The goal of this program was to demonstrate to industry the production readiness of VDL Mode 3 by making available "off the shelf" multi-mode VHF communications equipment by September 2004.

This development program successfully resulted in the TSO approval of the new Rockwell Collins VHF-2100 product (Figure 1). This product is ARINC 750 compliant, allowing retrofit with existing VHF Communications transceivers. It provides operation on 8.33 kHz/25 kHz analog AM, VDL Mode A and VDL Mode 2 as well as voice and data link operation on all VDL Mode 3 channels.

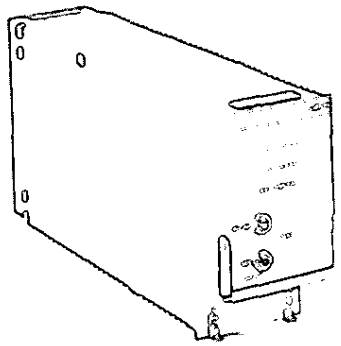


Fig. 1. Rockwell Collins VHF-2100 Multi-Mode VHF Communications Transceiver

In this development program, Rockwell Collins also partnered with Gables Engineering in their development of the G-7424 multi-mode Radio Tuning Panel (RTP) (Figure 2) that provides selection of 8.33/25 kHz analog and new VDL Mode 3 channels.

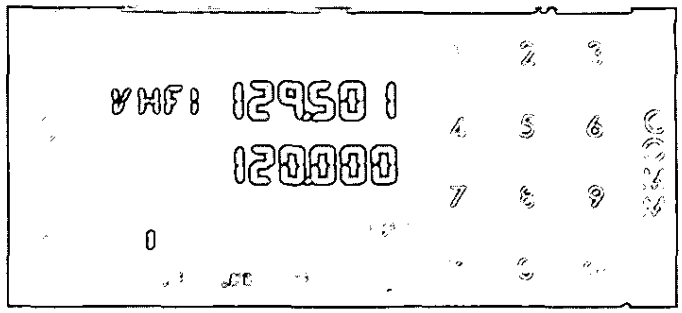


Fig. 2. Gables Engineering G-7424

The final Rockwell Collins milestone in the FAA program was to achieve a supplemental type acceptance (STC) certification for use of the VDL mode 3 equipment on a commercial Air Transport type aircraft. This STC would certify analog voice and VDL Mode 3 operation using the new VHF-2100 VHF communications transceiver and Gables G-7424 RTP.

To achieve this goal, early in the program, Rockwell Collins reached an agreement with Delta Air Lines to perform the STC on a Delta 737-800.

STC ACTIVITY

Rockwell Collins and Delta Airlines participated in Supplemental Type Certification on October 16 and 17 2004. The STC flight took place on a Delta Boeing 737-800. The aircraft was retrofitted with 3 Rockwell Collins VHF-2100 Communications Radios and 3 Gables G-7424 Radio Tuning Panels.

The test flight departed from Atlanta, Georgia and terminated in Atlantic City, New Jersey at the FAA Technical Center. See Appendix A for the flight profile.

The Delta Boeing 737-800 was modified in accordance with FAA DAS procedures which included Conformity plan and inspection, ground testing, flight testing and a Fault Hazard Assessment.

The STC consisted of two parts: ground tests in Atlanta and Atlantic City, and a flight test between Atlanta and Atlantic City. The ground tests verified that the wiring and installation was performed correctly and that the newly-installed equipment did not interfere with or cause problems with other avionics. All three VHF communications transceivers were checked with each of the three Radio Tuning Panels. Voice

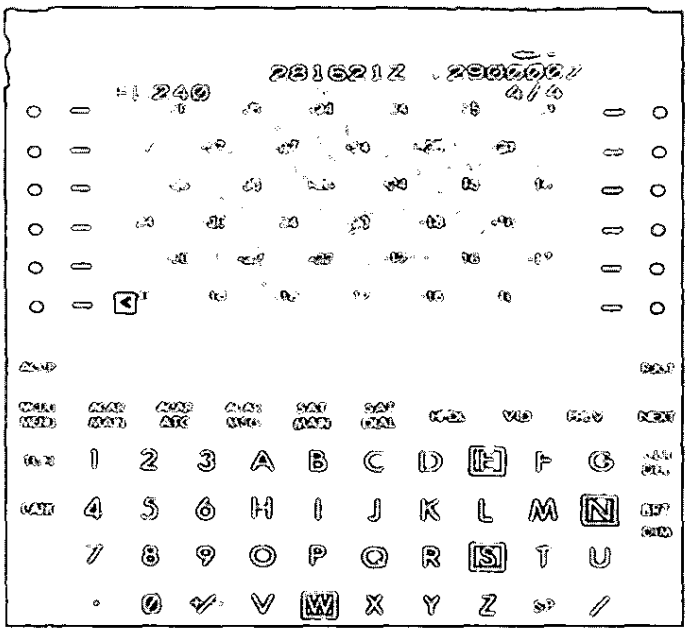
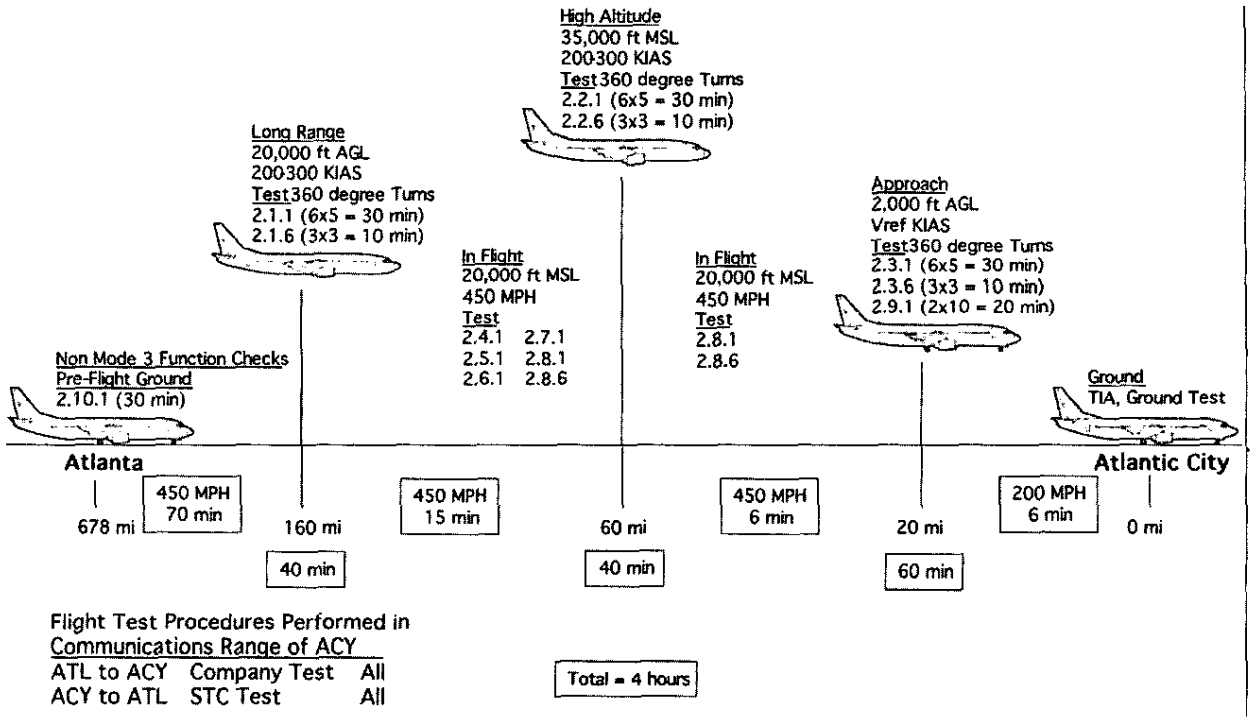


Fig. 3. Weather Display using VDL Mode 3



Company and FAA Flight Test

checks in the current AM analog system and the VDL Mode 3 system were used for verification of operation. 25 kHz analog data operation was also verified on the ground.

Long range (160 nmi) and short range communications in both VDL Mode 3 and analog audio were tested as well as various headsets and microphones including the oxygen mask. High angle communications and communications during approach were all tested in VDL Mode 3. Audio quality was considered excellent in VDL Mode 3 as compared to the Analog audio.

A CD containing samples of audio during the flight test is available upon e-mail request to any of the authors.

Along with voice quality, some interference checks were performed. One VHF comm was tuned to a VDL Mode 3

frequency and logged in to a VDL Mode 3 ground station. A second VHF comm was tuned to a frequency close to the first VHF frequency.

The second VHF comm was monitored to see if automatic poll responses (approximately every 6 seconds) could be heard. No objectionable interference was observed.

ADDITIONAL TESTING OF VDL MODE 3 CAPABILITIES

Although not part of the formal STC process which only certified VDL Mode 3 voice operation, the data link capability of VDL Mode 3 has also been validated.

In testing prior to the STC activities, Rockwell Collins successfully demonstrated data link operation of VDL Mode 3 through the NEXCOM network. The demonstration took place July 15 at the FAA's William J. Hughes Technical Center in Atlantic City, New Jersey. Simultaneous operation of VDL Mode 3 digital voice and data was demonstrated during flight testing using an FAA B727 aircraft. A Rockwell Collins CMU-900 Communications Management Unit along with a Rockwell Collins CDU-2000 display unit were used to provide the data link capabilities.

The data link was used to exchange controller-pilot data link communications (CPDLC) messages using the 2V2D configuration of VDL Mode 3. The 2V2D configuration permits two independent "talk groups" on a 25 kHz channel, with each "talk group" having simultaneous voice and data capabilities.

In other testing during April 2005, NASA Glenn Research Center, the FAA, and Rockwell Collins worked jointly to prototype graphical weather data over the Mode 3 data link. Flight testing was successful in proving the versatility of the Mode 3 system for this application. Figure 3 illustrates the flight deck display showing an uplinked weather map sent by the VDL Mode 3 system.

Rockwell Collins is also currently in the process of developing a Business and Regional Jet version of the VHF-2100 multi-mode VHF Communications transceiver. This radio has a smaller form factor and will undergo TSO and STC verification in the fall of 2006.

CONCLUSION

VDL Mode 3 offers a means of resolving the frequency congestion issues on the current analog voice operations as well as a means of providing a high integrity, high capacity, and low latency voice and CPDLC/data link system for VHF air traffic communications. Maturity of the VDL Mode 3 system and availability for production-ready equipment was shown via the TSO and Supplemental Type Certificate issued in 2004.

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