ITC Presentation 2021

Abstract Title: Universal modular full flight-testing system Interest Area/Track: Flight Test

Keywords: DAS, DAQUS, Signal Conditioning, Flight Recorder, Video, Audio, Pilot Display, Flight Engineer Display, Full Duplex Telemetry Link, Tracking Antenna, Real Time Data Recovery and display, Post Flight Analysis, IRIG-106 Chapters 4, 7, 8, 9, 10, 11

Level of Difficulty: Intermediate to Expert

Learning Objective(s): Describes a proven solution for a complete modular next generation flight vehicle data acquisition and analysis system.

Presentation Text:

The introduction of new standards particularly IRIG 106 Chapter 7, 10 and 11 have opened the door to a new way of thinking about onboard flight test signal conditioning systems. These must not necessarily continue to be considered as systems that are setup in a predefined manner to match the requirements of a specific flight test scenario, but may be looked at as a flexible resource that can be, to a certain extent, changed in real time to match a series of tests with different requirements.

Having realized this truth our thinking about what an on-board flight test system, and how it is used, should also change.

In this presentation we at IMC and JDA, working together, are pleased to be able to introduce a new type of flight test system that takes advantage of this change to offer new ways of working for flight tests engineers that will reduce their workload and open new doors.

To start with it is clear that in order to be efficient and successful in modern flight testing, you need solid precision measurement technology for the analog world, but with that said we must also focus on BUS based sensors and devices as more become available and go into use.

Many of these BUS based sensors and devices have proprietary bus protocols based on Ethernet, Serial, etc. and it is becoming clear that the fast, adaptive acquisition of such data sources is now just as important as that of analog sources.

The IMC measurement product range lends itself well to this analog environment as it includes customer proven, high-precision 24-bit DAS technology which serves as the basis for their flight test data acquisition systems. These are paired with the IMC/JDA developed ultra-flexible digital BUS data acquisition and processing systems in order to integrate almost any device (including legacy customer supplied units) into the IMC/JDA flight test measurement systems configuration.

To achieve this level of flexibility the application of internationally recognized standards was key to the implementation of the system, these include:

- IRIG 106 various chapters
- Ethernet 1000/100/100
- GPS position and timing synchronization
- NTP and PTP network timing
- ONVIF video capture and camera control

As an overview, the IMC/JDA onboard flight test system consists of the following main elements:

- Onboard Chapter 10/11 direct feed signal conditioning modules
- Onboard Chapter 10/11 direct feed camera feeds
- Pilot display, Ethernet
- Engineering workstation displays, Ethernet
- Intelligent packet combiner/recorder
- Intelligent ethernet based Chapter 7 RF transmitter TIER0, TIER1 and TIER2 (L, S & C band)
- Intelligent ethernet based Chapter 7 RF receiver TIER0, TIER1 and TIER2 (L, S and C band)
- Modular airborne antennas with integrated amplification (L, S and C band)
- Ethernet backbone

The heart of the IMC/JDA flight test system is the Intelligent packet combiner/recorder this provides the functions of:

- IRIG106 Chapter 10/11 data packet combiner
- IRIG106 Chapter 10/11 recorder
- IRIG106 Chapter 10/11 packet selector/filter for telemetry link
- GPS synchronized NTP and PTP network Time Server
- Selected packet decoder and data server for pilot display and any engineering workstations
- IRIG106 Chapter 7 telemetry encoder
- RF transmitter TIER0, TIER1 and TIER2 (L, S and C band) (suitable for use with modular airborne antennas with integrated amplification, also available from IMC/JDA)
- Intelligent IRIG106 Chapter 7 RF receiver controller
- IRIG106 Chapter 7 uplink decoder

The entire airborne system communication and control is based around the Ethernet bus protocol.

It was decided early in the design that the system should be distributed in structure and that all data transfers should be encapsulated, and therefore time stamped, within the data acquisition units themselves. To provide sufficiently accurate timing the NTP and PTP ethernet time protocols were selected, with a system developed that provides timing to an accuracy of 0.000001 seconds in the data acquisition units.

A mechanism is included to provide accurate information regarding the relationship between the real total system time and the internal 10MHz counter originating from the combiner/recorder required to conform to IRIG106 Chapter10/11 compatibility.

The setup of the entire airborne flight test system is managed from the IMC Studio software via the generation of IRIG106 Chapter 9 (TMATS) files, which are fed into the combiner/recorder over one of its available interfaces on that unit (Ethernet, RS232, USB). The TMATS files are used to initially setup the entire system and also as the basis for a single TMATS header, which is the first packet in any Chapter 10/11 recording.

One of the new functions of the intelligent packet combiner/recorder is its ability, under customer control, to decode selected Chapter 10/11 data packets on the fly, calibrate the parameter data and distribute that recovered information to the Pilot Display and any connected engineering display workstations.

As the combiner/recorder is also a IRIG106 Chapter 7 telemetry encoder, the data available to be sent over that telemetry downlink may be any combination of the decoded parameter data and/or selected Chapter 10/11 encapsulated data packets.

Within the IMC/JDA system design we have taken advantage of the Chapter 7 ability to provide a control uplink to the vehicle under test.

As the entire airborne system is configured via uploaded Chapter 9 (TMATS) files we can send sections, or a whole new, TMATS files up to the combiner/recorder while the flight test is in progress.

These uplinks can control:

- The downlink Chapter 7 telemetry contents, data rates and structure.
- The downlink RF characteristics including data rate, transmission frequency, modulation type etc.
- The downlink transmission power.
- The content of the Pilot and any engineering displays.
- The control for the recorder start/stop/new file etc.
- The Chapter 10 data packet selection for decoding, recording, RF transmission etc.

In other words, the configuration of the airborne system may be changed at any time via an uplink from the ground station, thus saving time and money for your flight test program by allowing multiple disparate tests to be carried out during a single flight.

One of the most important features of the total system design is the ability, through the use of internationally recognized standards throughout, to integrate customer supplied legacy equipment, with minimal effort, into the IMC/JDA systems infrastructure.

Another important feature is the minimal internal cabling required within the air vehicle under test. Basically, just ethernet and 28V power is sufficient to bring the system together.

Of course, compatible ground equipment is also available from IMC/JDA including:

- Autotracking antennas with Chapter 7 uplink capability
- SNR RF Polling Systems (L, S and C Band)
- RF Transmitters TIER0, TIER1 and TIER2 (L, S and C Band)
- RF Tracking and Data Receivers TIER0, TIER1 and TIER2 (L, S and C Band)
- Bit Synchronizers
- IRIG106 Chapter 4/7/8 Compatible Telemetry Decoms
- IRIG106 Chapter 4/7/8 Compatible Telemetry Encoders for the TMATS uplink

In conclusion IMC/JDA have developed a new class of onboard flight test system that leverages internationally accepted standards to move beyond fixed airborne system configurations. Many previously disparate functions are now integrated in an intelligent, and uplink controllable, manner while still maintaining a path to integrate customer supplied legacy equipment into the total system.

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