AIRBORNE DATA ACQUISITION SYSTEM FOR THE RAH-66 COMANCHE AIRCRAFT

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ABSTRACT

The RAH-66 Comanche flight test program required a state of the art Airborne Data Acquisition System consisting of:

1) A modular distributed system that uses a series of software programmable building blocks capable of signal conditioning all types of sensors.
2) A digital multiplexing system capable of combining various types of digital streams at high rates including Synchronous and Asynchronous PCM, MIL-STD-1553B, and RS-422 data streams.
3) A Data Combiner Unit that accepts synchronous PCM data streams from one to eight sources at 4 MBPS or less and a frame size of up to 8128 words each that outputs four independent PCM streams at 8 MBPS or less and a frame size of up to 16384 words.
4) A Data System Control Unit that controls the tape recorder, serves as the interface to the Pilot’s Control Unit and monitors/reports status of the data acquisition system to the Pilots Control Unit.
5) An Airborne Computer that provides the control and interface to the pilot & copilot instrumentation displays.
6) A Cockpit Instrumentation Pilot Display System consisting of a Main Unit Multi-Function Display, a Load Factor/Hub Moment Display and a Right Wing Flight Control Position Display. The Main Unit Multi-Function Display has the capability to display multiple graphic pages generated by the Airborne Computer.
7) The ability to record high speed avionics buses from the (Mission Equipment Package) MEP such as MIL-STD-1553B, (High Speed Data Bus) HSDB, (Processor Interconnect) PI Bus, (Data Flow Network) DFN and PCM utilizing the Ampex DCRsi-107 Tape Recorder.

KEY WORDS

Airborne Data Acquisition System (ADAS), Remote Multiplexer Units (RMUs), Airborne Data Acquisition Multiplexer (ADAM), Data Combiner Unit (DCU), Airborne Computer Unit (ACU), Mission Equipment Package Data Acquisition System (MEPDAS).

INTRODUCTION

The COMANCHE Team, led by Sikorsky Aircraft Corporation and Boeing Helicopters, was selected to develop the next generation of armed reconnaissance helicopter for the U.S. Army. Flight testing of the prototype RAH-66 Comanche Helicopter began on January 4, 1996 at the Sikorsky Aircraft Development Flight Center, West Palm Beach, Florida. The flight tests have been validating the Mission Equipment Package (MEP), the digital fly-by-wire control system and various other major avionics subsystems in addition to the traditional Structural, Handling Qualities, Performance and Power Plant flight testing.

The small size of the aircraft, limited space for instrumentation, requirements for numerous measurements and the heavy use of digital flight management/control systems with data buses that must be recorded, required the use of a new generation, all digital, automated airborne telemetry and recording system capable of recording high speed PCM data streams along with an assortment of high speed data buses.

The need to acquire and record data simultaneously from avionic buses and the air vehicle PCM encoders required a system for multiplexing digital data streams at data rates much higher than usual for air vehicle flight testing. Continuous recording was required from SPU (Secondary Power Unit) startup to post flight engine shutdown to provide air vehicle sub-system monitoring for post flight analysis/trouble shooting and incident recording. It was required to record each data bus in its entirety wherever practical. The small size and relative inaccessibility of spaces within the air vehicle drove the use of a small modular programmable data acquisition system located in available spaces throughout the aircraft. The lack of space on the air vehicle for a central patch panel required that the system be capable of simultaneously recording over 1000 installed instrumentation parameters. In addition hundreds of selected MIL-STD-1553B Bus parameters and asynchronous PCM data parameters were incorporated in the PCM stream.

AIR VEHICLE DIGITAL DATA ACQUISITION SYSTEM

The Airborne Data Acquisition System (ADAS) provided the capability of recording various installed parameters depending upon each flight test requirement. A typical recording system setup might include 500 dynamic measurements (strain gages and accelerometers) and 400 static measurements (pressures, temperatures and performance or handling quality measurements). This ADAS capability allows tests related to more than one test discipline during each flight. The primary objectives of the ADAS are:

1. Provide the means for data acquisition of the measurements.
2. Provide real time telemetry for monitoring and/or processing of selected data.
3. Provide a common format to allow data processing at Sikorsky Aircraft and Boeing Helicopters.

The Microcom MicroDAS-1000 Data Acquisition System is the heart of the ADAS. This system takes in signals from installed sensors, voltage signals, selected bus signals and selected PCM words from the Flight Control Computer PCM streams. Remote Multiplexer Units (RMUs) are grouped in independent remote data systems called ADAMs (Airborne Data Acquisition Multiplexer). The RMUs that configure a specific ADAM accept input signals from various areas of the aircraft, signal condition the signals, provide excitation and digitize the data into an IRIG (Inter-Range Instrumentation Group) formatted PCM stream. The PCM outputs generated by each of the 8 ADAMs are wired to a Data Combiner Unit (DCU). The DCU combines the PCM streams and formats 4 PCM output streams containing all or a portion of the input data. Two streams are wired to the MEPDAS for recording on the DCRsi-107 Tape Recorder. One stream is sent to the Airborne Computer Units (ACUs) and the 4th stream is wired to the two telemetry transmitters.

All of the recorded data including MIL-STD-1553B, 3 FCC PCM streams, High Speed Data Bus (HSDB), PI Bus and 2 ADAS PCM streams are routed to the MEPDAS unit for formatting prior to recording on the DCRsi-107 Tape Recorder.

The L-Band telemetry system consists of two transmitters with dual selectable output power settings of 5 or 20 watts. Each transmitter has a frequency selector switch for the entire L-Band and is designed to transmit digital PCM data with a selectable digital bandpass filter. Each transmitter drives one omni-directional circularly polarized cylindrical antenna. One antenna is located on the upper surface of the horizontal stabilizer and the other antenna is located on the bottom section of the forward fuselage. A single 2 Mbit/sec PCM stream is wired to both transmitters. The Ground Based Telemetry Facility uses frequency diversity to track the best telemetry signal which is used for real time data processing/display.

Installation

Elements of the ADAS are located throughout the aircraft. This distributed system was mandated by the limited space for the ADAS components. The use of a distributed system saves wiring and cable harness weight by locating various subsystems at strategic points in the aircraft.

Electrical Power

The ADAS components are powered by two main power distribution units and four remote power distribution units. Each of these units provides 28 volts to various subsystems in the ADAS. The aircraft 270 VDC power is converted to 28 VDC power by two ACME Research 270 VDC to 28 VDC 0-110 AMP power converters located in the nose of the aircraft. Additional voltages (±15 VDC, +5 VDC and 28 VDC) are generated within the ADAS Remote Multiplexer Units (RMUs). In the event of an inflight emergency, the entire data acquisition system electrical load can be disconnected from the aircraft electrical system by one Master Instrumentation Power Switch located in the copilot's left side rail.

Transducers

Measurement transducers are installed throughout the aircraft to measure stress, motion, vibration, displacement, pressures and temperatures. Transducers, except airframe single active total stress measurements, are laboratory and/or aircraft system calibrated prior to first flight.

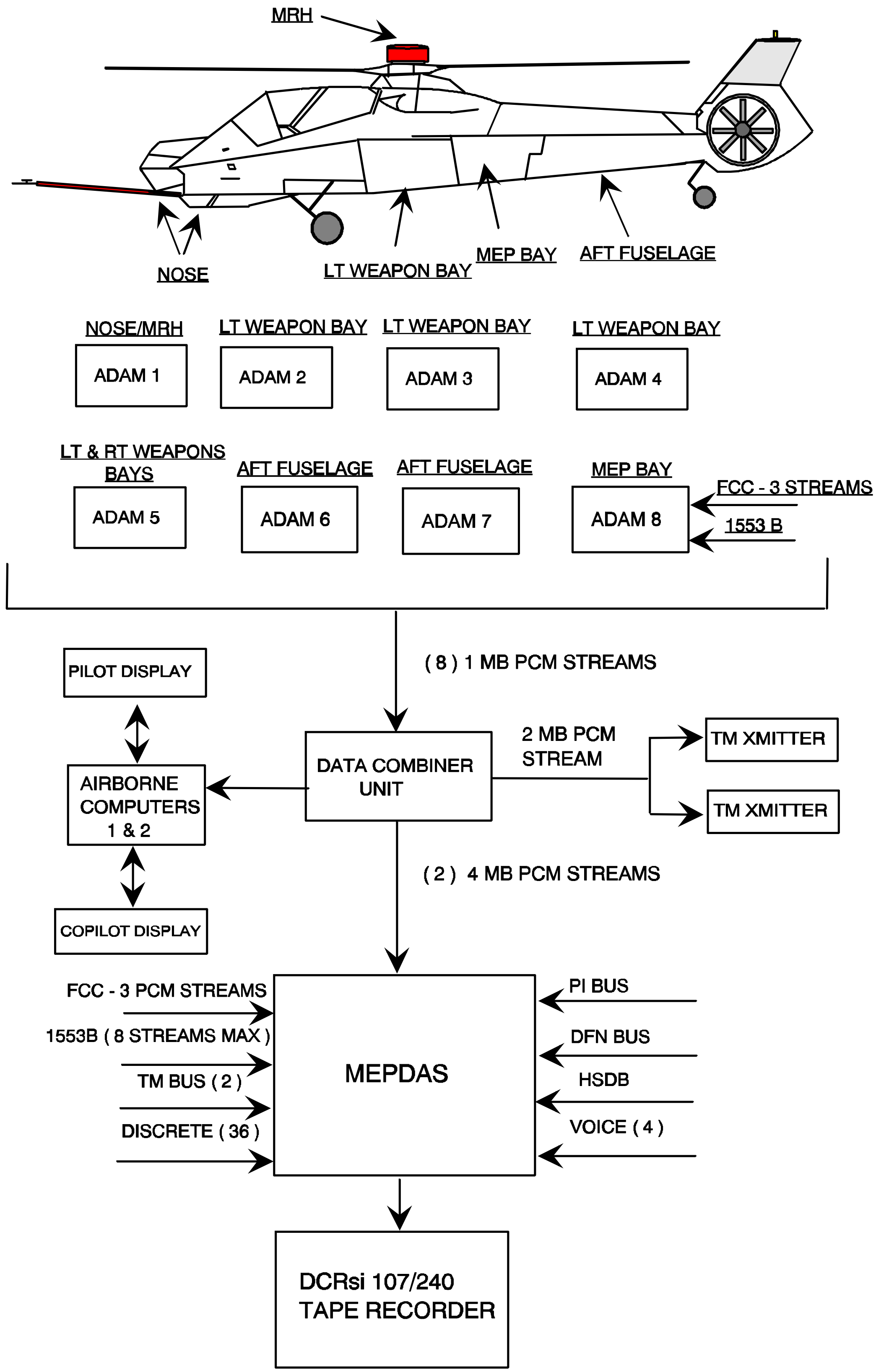
Stress and Load

Steady/vibratory stresses and loads are measured with strain gages installed on aircraft dynamic components and airframe structures utilizing one, two and four active strain gages per measurement. The majority of the strain gages used were 1000 ohm gages. The 1000 ohm strain gages were used on composite and titanium and 350 ohm strain gages were used on aluminum.

Vibrations

Airframe and subsystem component vibration levels are measured with linear piezoresistive accelerometers (Endevco Model 2262CA-25 & 2262CA-100). Engine and Gearbox vibrations are measured utilizing Endevco Model 6222SM6 piezoelectric differential crystal accelerometer.

RAH-66 AIRCRAFT #1 AIRBORNE DATA SYSTEM



Servo Accelerometers

The aircraft acceleration at the C.G. (Center of Gravity) is obtained from a high output servo accelerometers. The vertical acceleration (Load Factor) is obtained from a Systron Donner Model 4311A-3.5-P97. The lateral and longitudinal acceleration at the CG is provided by Systron Donner Model 4311A-3.5-P96. The servo accelerometer is electrically damped, providing a very sharp filtered output at approximately 3 Hz.

Data Boom Parameters

The Data Boom Assembly is mounted on the end of a Sikorsky manufactured Data Boom that extends forward of the nose of the aircraft in order to clear the rotor downwash effects of the main rotor system.The Data Boom Assembly (Space Age Control, Model No. 100510-1) contains a pitot/static gimbal vane assembly which permits universal movement of approximately $\pm 21^{o}$. The pitot/static inputs are plumbed to Rosemount airspeed, altitude and altitude rate transducers located in the nose of the aircraft. In addition resistance potentiometers are contained on the Data Boom Assembly to measure Aircraft Sideslip and Angle of Attack. A separate installation for the Rosemount Temperature probe is located on the Sikorsky manufactured Data Boom.

ESP-64HD Pressure Scanner

The ESP-64HD Pressure Scanners consist of an array of 64 silicon piezoresistive pressure sensors, one for each pressure port, which are electronically multiplexed at rates up to 20,000 Hz through an integral built-in instrumentation amplifier. The miniature, high density design permits placement of these scanners in space-limited locations. The pressure scanners are used to measure air pressures in and around each of the engines and throughout the aircraft including the IR suppresser, SPU, ECS (Enviromental Control Unit) and tail tunnel pressures.

Temperatures

Temperature measurements are made with Chromel-Alumel (Type K) thermocouples. A 32 Channel Isothermal Connector manufactured by Hades Corporation (P/N ISOK500A32) is used to provide a temperature reference junction. These units are small in size and are placed throughout the aircraft (Left and Right Weapons Bays, Engine Compartments, Left MEP Bay and the Aft Fuselage in the area directly in front of the Fan Shroud). Imbedded within the connector are two 500 ohm RTD’s. The RTD is used to provide the temperature of the connector. This becomes the reference point temperature for each of the 32 thermocouples connected to this isothermal connector. The ground data processing station uses this Isothermal Connector temperature to adjust and calculate the actual thermocouple output temperature.

Engine Shaft Torque Measurement System

The Engine Instrumentation Shaft Torque Measurement System consists of a 3 channel measurement system installed on the Engine to Main Transmission High Speed Drive Shaft to measure drive shaft torque and temperature.

Wireless Data Corporation was the supplier of this High Speed Shaft Data Acquisition System. The speed of the shaft and the requirement for long life mandated that a non-contacting (wireless) method be used. To obtain an accurate value for the torque measurement, the temperature of the shaft must be known, to correct the recorded value to a true value. Two systems (one per engine) were installed on aircraft #1.

Pressures, Flows, and Proximity

Pressure measurements are made with Druck Model PDCR 330 PSIA, PSIS and PSIG pressure transducers. For differential pressures greater than 15 PSID, the Model PDCR Model 340 is used. Fluid flow measurements are made with Flow Technology FT series turbine flowmeters with magnetic pickups. Various size pickups are used to mate with the various diameter hydraulic tubing located on the aircraft. Each of the chosen flowmeters can measure the hydraulic flow from 1 to 10 GPM. The MGB (Main Gear Box) input shaft alignment is measured with the Bentley Nevada Model 3300 Series Proximity Transducer System. The vertical and lateral displacement variations about a neutral point are measured.

ADAS System Configuration Utilizing the MicroDAS-1000 Data Acquisition System

The MicroDAS-1000 and ADAS is a distributed system with various elements located throughout the aircraft. Every available space has been utilized for ADAS components but major elements are located in specific areas of the aircraft. These areas include the Forward Fuselage, Cockpit, Main Rotor Head, Left and Right Weapons Bay, Left MEP Bay and Aft Fuselage.

Data System Control Unit (DSCU1000-001-02)

The Data System Control Unit (DSCU) functions as the interface between the outside world and the ADAS by performing all system control functions. The DSCU receives control commands, from either a GSC (Ground Support Computer) or a PCU (Pilots Control Unit), through the CONTROL INPUT serial data link, decodes those commands, reads status inputs and/or generates control outputs, then returns a COMMAND REPLY word over the CONTROL COMMAND OUTPUT serial data link.

Ground Support Computer (GSC1000-001-02)

The Ground Support Computer (GSC) is a ruggedized portable PC/AT type industrial computer. It is used to create and edit setup files, issue calibration commands, and monitor the status of the ADAS.

Pilot's Control Unit (PCU1000-001-02)

The Pilots Control Unit (PCU) system is composed of a Primary and a Remote Unit. Except for functions associated with the system power switching, these units are the interface between the flight crew and the ADAS during flight operations. The primary unit receives operator inputs through front panel switches and a numerical keypad and provides system status information to the flight crew through displays that include both conventional indicator lights and a text character display. The Remote Unit receives operator inputs through front panel switches and provides status information through conventional indicator lights.

Remote Multiplexer Unit (RMU1000-001-02)

The Remote Multiplexer Unit is a fully programmable signal conditioning and bus monitor unit with an IRIG standard PCM output. It is the basic building block of the MicroDAS-1000 data acquisition system. The ADAS utilized the following Signal Conditioner Modules:

Strain Gage Conditioner	Frequency to Digital Converter Conditioner
RTD Conditioner	2 Channel Analog Voltage Conditioner
Accumulator Conditioner	16 Channel Analog Mux Conditioner With Low Gain
Bit Discrete Mux Conditioner	16 Channel Analog Mux Conditioner With High Gain
Rotor Azimuth Conditioner	Pressure/Thermocouple Scanner Module
IRIG PCM Input Module	Integrating Charge Amplifier Conditioner
1553 Bus Monitor Module	

Integrating Charge Amplifier Conditioner With RMS To DC Converter

Data Combiner Unit (DCU1000-001)

The Data Combiner Unit (DCU) is a data merger for the 8 PCM data streams from the 8 ADAS ADAMs. It provides 4 independent programmable PCM outputs. All information can be loaded into the entire system through one connector point at the DCU. The GSC carries on a one to one conversation with each RMU. The GSC commands each RMU through the DCU by the RMU unit number. When the GSC asserts a reset command, it asserts a RESET command to RMU slave 1, then to RMU Slave 2 etc. until all RMU's have been addressed.

Airborne Computer Unit (ACU1000-001-02)

The Airborne Computer Unit (ACU) is a PC/AT compatible computer which has been ruggedized for airborne use. The unit runs the MS-DOS operating system and is capable of running a full spectrum of PC/AT standard applications. The unit accepts commands from the Ground Support Computer (GSC), key inputs from the Instrumentation Pilot Display Unit (PDU) and data from an IRIG Standard PCM data stream. The computer processes this data and provides this data in graphical format to the PDU in standard VGA monitor output and a serial data RS-422 stream.

Pilot's Display Unit (PDU)

The Cockpit Instrumentation Display System (CIDS) is an integrated multi-function control and display system. The CIDS consists of three primary assemblies, the Forward Cockpit Pilot's Display Unit (PDU), the Rear Cockpit PDU, and the Power Supply Unit (PSU). The PDU's interface directly with separate Airborne Computer Units (ACU) located in the nose of the aircraft. The display format consist of various Alpha-Numeric displays and three 3 x 4 inch color Active Matrix Crystal Displays (AMLCD).
The Forward Cockpit ACU and PCU are physically and functionally independent of the Rear Cockpit ACU and PCU. The PDU and its associated ACU permits each pilot to select different display groups and independently initiate data peak resets. Each ACU generates the required flight test data to be displayed by the PDU. The pilots select PDU display formats in-flight to display specific parameters for each test profile. Functionally, the three main display units of each PDU function as:

1) a Multi-Function Display / Monitor (16 preprogrammed display formats)
2) a RS-422 graphics terminal displaying Hub Moment and Load Factor
3) a RS-422 graphics terminal displaying Flight Control Position

Video Data Acquisition System

The Video System records three video signals (Left and Right Side of Copilots Instrument Panel and the Pilot's Instrument Panel). The video cameras are Elmo Model MN401X Micro Charge Coupled Device Color Cameras. IRIG B time is inserted using a Sekai Model REI-8380 Vertical Interval Time Code Inserter. The video signals with time code are recorded on a Teac Model V-83AB-FS 8 mm VCR.

SUMMARY

The Airborne Data Acquisition System (ADAS) provided the capability of recording a wide variety of installed parameters depending upon each flight test requirement. This ADAS capability allowed conducting tests related to more than one test discipline during each flight. The primary objectives of the ADAS were to provide the means for data acquisition of the measurements, provide real time telemetry for monitoring and/or processing of selected data during flight and provide a common data acquisition system format to allow PCM data processing at the Sikorsky Aircraft Development Flight Center Data Processing Facility and Boeing Helicopter's Atlas Data Processing Facility.

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