SMITHS AEROSPACE

GENERIC HEALTH AND USAGE MONITORING SYSTEM (GENHUMS)

A MODULAR APPROACH TO AIRCRAFT DATA MANAGEMENT.

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ABSTRACT

Smiths Aerospace (SA) offers a multi-aircraft capable Integrated Data Acquisition and Recorder System (IDARS) with built-in HUMS growth capability. A number of civil and military operators have selected the SI GenHUMS, including Bell Helicopter for the Bell-Agusta 609 civil tiltrotor and the UK Ministry of Defence (MoD) for the Chinook aircraft with additional options for Puma, Sea King and Lynx aircraft.

GenHUMS provides all conventional HUMS functionality, and incorporates key innovation in the areas of rotor track and balance, failure detection, flight regime recognition, alert generation, system configurability, and user interface. The architecture is unique in that all required airborne data acquisition and processing, including crash survivable cockpit voice and flight data recording, are combined in a single line replaceable unit. This architecture significantly reduces space, weight and power requirements and results in the highest reliability, least risk, lowest life cycle cost, HUMS known today. Fixed and portable PC-based ground stations provide configurable, user friendly, data extraction and analysis capabilities.

GenHUMS incorporates broad flexibility in modular software and hardware design critical to efficient, low cost adaptation across different aircraft types. This paper describes the system capabilities and summarizes the GenHUMS open architecture design approach with specific examples from recent programs.

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SMITHS INDUSTRIES
GENERIC HEALTH AND USAGE MONITORING SYSTEM
A MODULAR APPROACH TO AIRCRAFT DATA MANAGEMENT
CHARLES TRAMMEL

DATA MANAGEMENT SYSTEMS

- Over 10,000 recording, monitoring and data transfer systems on over 75 applications/platforms

Safety  Mishap Monitoring & Playback
Maintenance  Aircraft Usage, Prognostics, Diagnostics & Warranty Validation
Training  Training Data Recording & Playback
SI HELICOPTER HUMS

- Worlds first HUMS, November 1991
- Over 300 systems installed
- Over 1,000,000 flight hours
  - SH-60B
  - CH-53
  - S-61
  - S-76
  - Bell 212/412
  - XV-15
  - CH-47D
  - BV234
  - CH-46
  - Super Puma (Mk 1 & Mk 2)
  - Cougar
  - Dauphin EC365

- HUMS under development:
  - BA609
  - WAH-64
  - Bell 412
  - Sea King
  - Puma
  - Lynx

HUMS MODULAR BUILDING BLOCKS

TECHNOLOGY INSERTION

- USAGE
- EXCEEDANCE
- ROTOR
- TRACK & BALANCE
- VIBRATION
- ANALYSIS
- DRIVE
- TRAIN
- ENGINE & AIRFRAME
- AVIONICS
- DIAGNOSTICS
- STRUCTURES
- FUMS™
- SPECTRUM/ REGIME
- PILOT ASSIST
- GPWS
- LIMIT CUEING
- RPA

- SENSOR DATA ACQUISITION
- COCKPIT VOICE AND FLIGHT DATA RECORDING (CVFDR)
INTEGRATED DATA ACQUISITION & RECORDER

- A single box combines the functions of three units:
  - Flight Data Acquisition Unit
  - Flight Data Recorder
  - Cockpit Voice Recorder
- Provides significant acquisition, processing and recording growth capabilities
- Over 600 delivered
- Over 2100 ordered

Integrated Data Acquisition Recorder (IDAR)

IDAR EVOLUTION

- Crash Survivable Memory Unit 1984:
  - Crash Recorder Technology
  - SFDR Experience Base

- Signal Acquisition Unit 1984:
  - Data Acquisition
  - Data Processing
  - Analog & Digital I/O

- Voice and Data Recorder (VADR®) 1992:
  - High Capacity Memory Module
  - Advanced Generation Packaging
  - Voice Recorder Growth

- Integrated Data Acquisition and Recording (IDAR) 1995
IDAR ARCHITECTURE APPROACH

Modular Design and Growth Capacity

Airborne software upgrade via PCMCIA card
- Allows for technology refresh via software

Measurements and diagnostics controlled by tables
- Allows monitoring changes without software changes

Spare modular slots for 3rd party technology insertion
- Scientific Atlanta Vibration Acquisition Unit module(s) (Generic HUMS)
- Cubic Ground Proximity Warning System (GPWS) module (IAF CH-53D)
- Chadwick-Helmuth Vibration Monitoring System (VMS) module (US Navy SH-60B HUMS Demonstration System)
- Other specialist functions
AIRBORNE SYSTEM TECHNOLOGY INSERTION

FUNCTIONAL SUBSYSTEM MODULARITY

INTEGRATED DATA ACQUISITION AND RECORDER (IDAR)

GROUND PROXIMITY WARNING SYSTEM

ANALOG DISCRETE CONTINUOUS PARAMETERS

EXISTING AIRCRAFT SENSORS

EXISTING AIRCRAFT INTERCOM

PCMCIA MEMORY CARD

HEALTH & USAGE MONITORING SYSTEM

COCKPIT CONTROL UNIT

DATA TRANSFER UNIT

OPTICAL BLADE TRACKER

TACHOMETERS

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EXIT
IDAR BASELINE CVFDR APPROACH

- Cockpit Voice Recorder compliant with ED-56a and TSO-C123a
- Flight Data Recorder compliant with ED-55 and TSO-C124a - flight data interface via ARINC-717 and/or RS-422
- Combined Cockpit Voice and Flight Data Recorder (CVFDR) compliant with ARINC 757
- Built-in growth to Flight Data Acquisition and HUMS
- Helicopter applications: Helijet S-61 CVR and S-76 CVFDR

IDAR GROWTH APPROACH - FDAU & CVFDR

- Flight Data Acquisition Unit (FDAU) requirements provided by IDAR configured with Enhanced Digital Processing Unit (EDPU) and optional Analog Processing Unit (APU)
  - ARINC 429, RS-422 and MIL-STD-1553 digital interfaces
  - AC/DC, synchro and strain gauge interfaces
  - Frequency and input/output discrete interfaces
- Built-in growth to HUMS
IDAR FDAU INTERFACE SUMMARY

- Enhanced Digital Processing Unit (EDPU) CCA
  - 8 ARINC 429 Rx channels / 3 ARINC 429 Tx channels
  - 6 RS-422 communication channels
  - 2 dual redundant MIL-STD-1553 communication channels
- Analog Processing Unit (APU) CCA (optional)
  - 80 configurable AC/DC inputs (synchro requires matched pair)
  - 6 differential phase reference inputs
  - 8 variable frequency inputs
  - 96 configurable input discretes (28VDC/Open & Open/Ground)
  - 8 output discretes (Open/Ground)
  - 14 low level differential DC inputs (strain gauges)
- Additional interfaces provided by populating spare CCA slots

IDAR FDAU/CVFDR APPLICATIONS

- USAF/USN Joint Primary Aircrew Training System (JPATS)
- Embraer ALX Super Tucano
- Eurocopter Deutschland EC-135 and BK-117
  - also selected for BO-105
- USAF UH-1N, KC-135, B-1B and U-2
- Israel Air Force CH-53, UH-60 and C-130
IDAR GROWTH APPROACH - GENERIC HUMS

- Addition of Vibration Acquisition Unit (VAU) CCA(s) and associated sensors to FDAU & CVFDR configuration
- VAUs provide acquisition and processing for:
  - Vibration monitoring
  - Rotor Track & Balance (RTB)
  - Drivetrain/gearbox diagnostics

Legend:
EDPU - Enhanced Digital Processing Unit
APU - Analog Processing Unit
VPU - Voice Processing Unit
VAU - Vibration Acquisition Unit

GENERIC HUMS APPLICATIONS

- UK Ministry of Defence HUMS
  - Chinook CH-47D
  - WAH-64
  - selected for Sea King, Puma and Lynx
- Bell-Agusta BA609
- Israel Air Force CH-53
- US Navy SH-60B HUMS Demonstration
- Bell 412/212
UK MINISTRY OF DEFENCE GENERIC HUMS

- UK MoD GenHUMS
  - Contractor flight trials complete
  - In production - 40 Chinook Mk2s being HUMS retrofitted at approximately 2 aircraft per month (number 9 & 10 in progress)
  - Program for Sea King (88 A/C), Lynx (145 A/C), Chinook Mk3 (8 A/C), and Puma (42) being finalized

UK MOD GenHUMS FUNCTIONALITY

- CVFDR - ED-55 and ED-56a
- Automatic rotor track and balance
- Extensive transmission monitoring/diagnostics
- Usage - engines, airframe, transmission, APU
- Engines - vibration monitoring, power assurance, LCF, etc.
- Common airborne and ground equipment for multiple aircraft types
BELL-AGUSTA BA609 CIVIL TILTROTOR HUMS

- BA609 CVDFR/HUMS
  - GenHUMS derivative, < 15 pounds
  - DO178B Level B airborne software
  - ARINC 429 aircraft interfaces
  - Airborne HUMS computer, Data Transfer Unit and Control Display Unit
  - Windows NT/200 Ground Station

BA609 HUMS GROUND STATION

- Provides first-line maintenance support with analytical tools
- Health monitoring
- Usage calculations
  - Aircraft
  - Engine components
- Displays: single flight, trends
- Reports: individual aircraft, fleet
- Database maintenance
- Network and remote viewing
- Security and user access levels
- Baseline for future SI HUMS Ground Stations
IAF CH-53 GenHUMS/GPWS PROGRAM

- CH-53 IDAR Crash Data Recorder (CDR) trial installation was successfully completed in April 1999 and production installations started fall of 1999 (35 A/C)
- CH-53 HUMS and GPWS verification flights completed March 2000
- Preliminary HUMS and GPWS flight trials completed August 2000
- GPWS scheduled for production installation on CH-53 and UH-60

SH-60B HUMS DEMONSTRATION PROGRAM

- HSL-41 Naval Air Station North Island
- Smiths Industries IDAR based CVFDR & HUMS
- Chadwick-Helmuth Vibration Monitoring System (VMS) in IDAR
- Demonstration of Non-Developmental Item (NDI) Open Architecture System
- Installed March 1995 - demonstration completed and equipment removed August 2000
- Over 2,500 flight hours of successful operation
UK MOD WAH-64 APACHE HUMS

- IDAR based combined Voice and Data Recorder (VADR®) and separate HUMS Processor Module (HPM) for WAH-64 Apache Longbows (67 A/C)

Integrated Data Acquisition and Recording (IDAR) 1995:
- Voice Processing Unit
- Flight Data Acquisition Unit

Voice and Data Recorder (VADR®) 1999:
- Small, lightweight CVFDR
- High Capacity Memory Module
- Integrated Flight Data Acquisition Unit
- Dual 1553 WAH-64 aircraft interface

HUMS Processor Module (HPM) 1999:
- Two HUMS CCAs
- RS-422 interface to VADR®

WAH-64 HUMS FUNCTIONALITY

- Phase 1 - partial HUMS will complete flight test June 2001
- Phase 2 - full HUMS
- Functionality
  - Rotor Track and Balance *
  - Vibration monitoring - transmission, engine and airframe *
  - Event capture *
  - Usage monitoring - engines, airframe, transmission and APU
  - Engine performance monitoring
  - Exceedance monitoring
  - CVFDR - ED-55, ED-56A
  * Phase 2