BORIS POPOVIĆ, Prof. Pilot
TINO BUCAK, M.Sc.
NIKICA HOTI, Prof. Pilot
Fakultet prometnih znanosti
Zagreb, Vukelićeva 4

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U. D. C.
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HUMS - HEALTH AND USAGE MONITORING SYSTEM

ABSTRACT

The article presents a principle layout of a modern HUMS along with the basic system operating procedures. The article also deals with the impact of HUMS on aircraft maintenance procedures and economy, the impact on maintenance system architecture and the implementation of cost-saving measures. The improvement of flight-safety as a consequence of HUMS application is also discussed.

KEY WORDS

FADEC, HUMS, MTBF, FDR, CVR, FLIDRAS, BUCS, RIN, IMC

1. INTRODUCTION

Constant requirements for greater flying safety and lower costs and simpler maintenance have stipulated the need to develop a system that would monitor certain aircraft components, as well as the aircraft itself. The beginnings of such a way of solving aircraft maintenance problems have appeared with the FADEC system (Full Authority Digital Engine Control), the first integrated system of monitoring and protecting aircraft engines.

2. FADEC

Apart from protecting the aircraft engines from exceeding the scope of allowed loading and simplifying their control, FADEC system has the capabilities of recording most of the essential engine parameters which is of great assistance in the process of maintenance. Based on the gathered data during engine operation, the maintenance experts can diagnose the operating condition of a given engine, the condition of single components, and it is also possible to foresee where the problems in future exploitation may be expected, and how long it would take until certain components will have to be replaced.

Such a system has also a characteristic significant for the safety of flying, because it records all excesses (intentional or accidental) of engine parameters from the allowed scope, regardless of the aircraft crew, thus providing an objective engine operating analysis not depending on the pilot's observations.

FADEC system also enables transfer from the aircraft maintenance system based on the components replacement after a set period of time (either active or passive) to the system of components replacement depending on their condition. Such an aircraft maintenance system results in a significant reduction of costs due to prolonged useful life of components, the possibility of predicting and planning the need to replace certain components, reduction of necessary spare parts on stock, simpler and shorter diagnosing of engine condition, fewer and shorter test flights, etc. Since this system increases the engine reliability, and therefore also the reliability of the whole aircraft, the insurance costs are also reduced, because insurance companies recognise such maintenance system.

3. HUMS - TASKS OF THE SYSTEM

Although aircraft engines are part of every aircraft belonging to the top of the list both regarding their significance and their price, some aircraft, especially helicopters have components that are of critical importance and that were not monitored by FADEC system. Therefore, attempts were started to design a system which will perform a similar function as the FADEC system, but on the whole of the aircraft. This resulted in HUMS, mainly intended for helicopters, but the efficient effects of the system have expanded significantly its application fields even outside aviation.

HUMS application results in:

- increased number of properly operating aircraft,
- reduction in duration and number of test flights,
- reduced costs of aircraft insurance,
- reduced costs of fuel and engine maintenance,
- reduced operating costs,
- reduced number of unnecessary disassembling of components from the aircraft,
- reduced number of discontinued flights,
- reduced stocks of spare parts,
- reduced number and duration of technical checks,

- instantaneous control of bearing wear,
- increased MTBF (Mean Time Betweeen Failiure) of components,
- increased lifetime of electronic instruments by reduction of vibrations,
- insuring that accurate flying documentation is being kept
- possibility of predicting / prevention of components failure,
- providing automatic engine operating check,
- possibility of recording and storing data obtained during flight, that cannot be obtained on the ground,
- making it possible for the crew to spend less time in monitoring the cockpit instruments, and paying more attention to the situation outside the aircraft,
- increase in the aircraft availability,
- increased flying safety due to availability of real-time diagnostics in flight,
- identification and elimination of procedures leading to aircraft damage,
- reduced need of the crew to memorise emergency procedures,
- increased possibility of analysing accident causes by increasing the number of monitored and stored parameters.

4. DESCRIPTION OF HUMS SYSTEM

The number of analysed parameters and the complexity of the system determine the scope of diagnostic procedures that may be performed in the aircraft condition analysis. The greater the number of monitored parameters, the higher the possibility and objectivity of accurately determining the aircraft condition.

The complexity of the system ranges from very simple ones, which measure only three parameters and weigh about 1 kg (Altair HUMS 1022 for Robinson R 22 helicopter, Figure 1), to systems that monitor over 130 parameters (HUMS for EH 101 helicopter).

Figure 1 - Control box HUMS Altair 1022 on-board aircraft

HUMS can record the data about:
- flight parameters (Air Data Information)
- accelerations (accelerometers)
- aircraft position
- all excesses from the allowed operating regimes of engine, rotor and transmission,
- flying hours, operating hours, and engine cycles and APU (Auxiliary Power Unit)
- torque on engine shaft
- number of revolutions of the compressor, turbine, rotor, etc.
- temperature parameters (of exhaust gases, oil, etc.)
- pressures (fuel, oil, hydraulic, pneumatic system, etc.)
- trail and balance of rotor blades
- power and voltages of electrical systems
- position of single aircraft components (landing gear, flaps, flight commands, etc.)
- other signals of different origins and purposes (synchro-signals of remote transmission, servo-mechanisms, etc.)

Since HUMS records data, the same or similar as the Flight Data Recorder (FDR), but it records also data not recorded by FDR, expanded instruments SS CVFDR (Solid State Cockpit Voice Flight Data Recorder - Figure 2) were designed to record combined data previously stored in CVR (Cockpit Voice Recorder), FDR and HUMS. This expanded format of data storage is of great use in improving the possibility for analysing the causes of aircraft accidents.

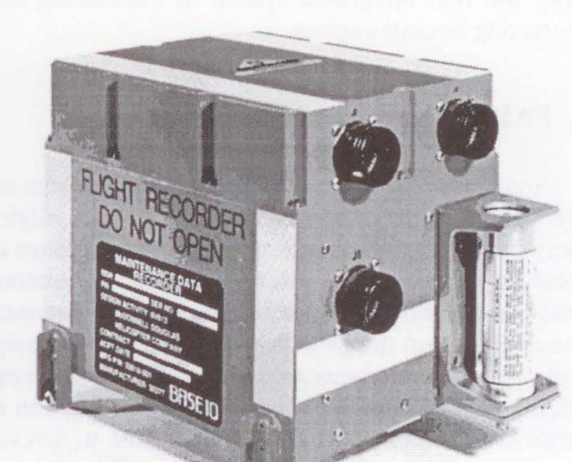

Figure 2 - Solid State Cockpit Voice Flight Data Recorder (SS CVFDR) for helicopter AH-64D Longbow Apache by Stewart Hughes company

5. ELEMENTS, CHARACTERISTICS AND OPERATING PRINCIPLE OF HUMS

HUMS instruments can be installed on an aircraft already during the manufacturing process, which happens almost regularly today; they may be offered as an option when purchasing an aircraft, or they may be additionally installed on older aircraft.

One of the advantages of modern HUMS instruments is that their installation into various types of aircraft requires only the modification of software (as a rule) rather than new instruments.

The parts of HUMS on-board aircraft (Figure 3) are the following:

- HUMS processor (Digital Flight Data Acquisition Unit - DFDAU)
- HUMS display
- Airborne Interface Unit (AIU) - optional, serves for transfer of data from aircraft to a portable medium (diskette, tapes, etc.)
- SS CVFDR (Solid State Cockpit Voice and Flight Data Recorder) - optional, integrated system for recording sounds in the pilot cockpit and all the measured flight parameters
- sensors

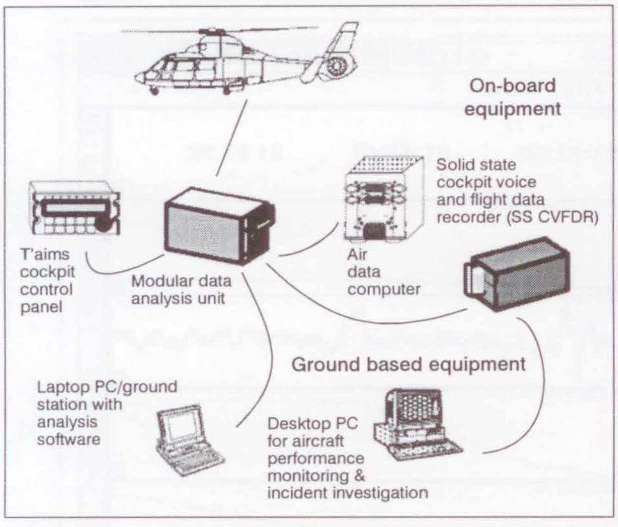

Figure 3 - HUMS architecture by T'AIMS company Teledyne Controls

Parts of HUMS on the ground:

- DRU (Data Retrieval Unit), used to transfer data from the portable medium (diskette, tape, etc.) of a computer for analysis
- HUMS Information Management System or Ground Station Computer (GSC), computer for the analysis of the gathered data
- GSC Interface Unit (GIU) - option, interface for networking GSC computer with limited access
- MDR cassette - optional, portable medium

The characteristics of modern HUMS systems are the following:

- real-time display of aircraft condition
- SS CVFDR uses accident-proof memory
- possibility of data analysis by means of FLIDRAS (Flight Data Replay and Analysis System)
- possibility of the system operating individually or networked
- computer control of trends
- real-time presentation of all excesses of the area of permitted fields
- constant monitoring of engine vibrations and transmission
- possibility of monitoring the condition for the purpose of early detecting a defect in dynamic components
- possibility of day and night control of the trails and balance of rotor blades
- possibility of increasing the duration of components usage by monitoring the condition
- possibility of using the system for staff training.

6. ECONOMIC INFLUENCE OF HUMS ON THE AIRCRAFT MAINTENANCE COSTS

Because of the mentioned characteristics, there is a wide interest in applying HUMS. By investing in HUMS, the aircraft operators reduce substantially the maintenance costs, and even the insurance costs, also significantly increasing the flight safety. Also the costs of administration, storage and ordering of spare parts are reduced. The operators realise substantial gain by improving the image of the company to the potential clients.

By applying HUMS, the aircraft manufacturers gain high-quality feedback information on the behaviour of their aircraft in exploitation, thus enabling improvement of design and of in-service procedures. Besides, the manufacturers can offer their customers also integral maintenance systems, in which the manufacturer takes the responsibility for full aircraft maintenance for a fixed price.

By applying HUMS, government bodies achieve significant increase in flying safety, and therefore they advocate intensely this type of aircraft maintenance. Besides, the analysis of accidents involving aircraft equipped with HUMS is much simpler (and faster and with lower costs) than with aircraft without the system.

Apart from direct effects generated by HUMS in reduction of aircraft maintenance costs, there are also more complex projects which, using the data obtained by HUMS, lead to reduction in costs and/or improve-

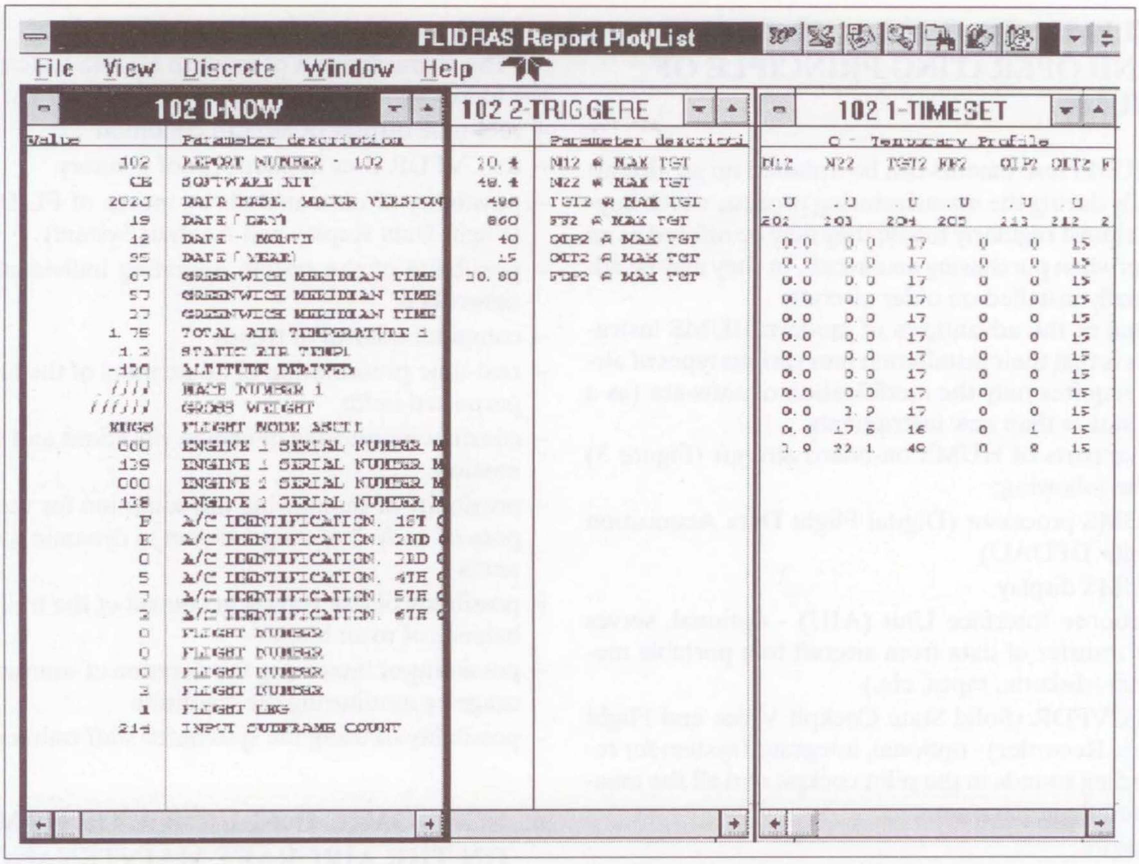

Figure 4a - Presentation of HUMS data of T'AIMS company Teledyne Controls in the form of Tables

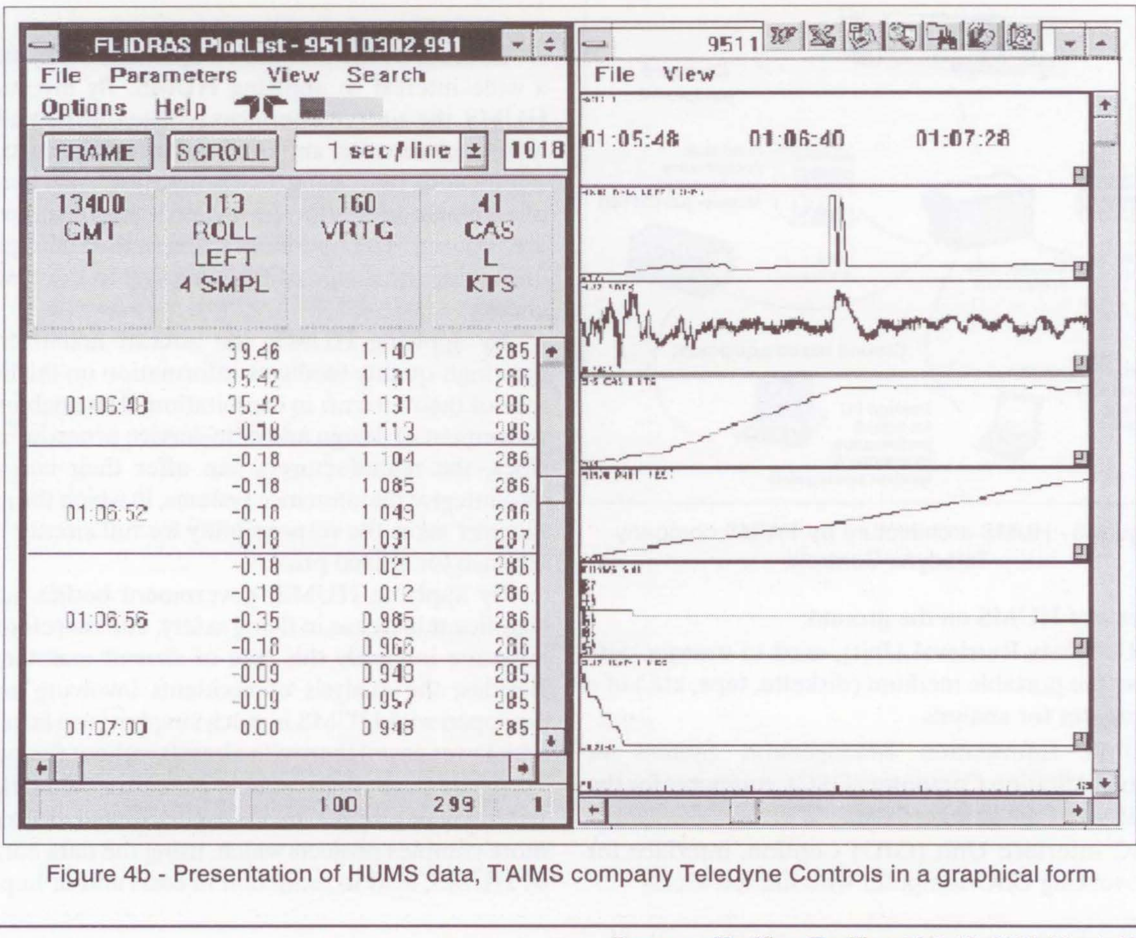

Figure 4b - Presentation of HUMS data, T'AIMS company Teledyne Controls in a graphical form ment of operator's image, not regarding individual aircraft but by rationalisation of the whole maintenance system. Some of the mentioned projects are: Bell's Usage Credit System (BUCS) and Integrated Maintenance Concept (IMC)

7. BELL'S USAGE CREDIT SYSTEM (BUCS)

BUCS has been developed in co-operation between the companies Bell Helicopter Textron and Teledyne Controls with the aim of offering service of integrated aircraft maintenance system of clients purchasing helicopters by the Bell company.

Bell's Usage Credit System (BUCS) has the basic characteristics:

- central gathering of operational data
- analyses the flight spectrum and determines the effective component hours
- adjusts the remaining usage period of the components by the calculation of the effective flying time and the Retirement Index Number (RIN)

The system is designed in such a way that the Bell Helicopter Textron company installs in its helicopters HUMS equipment of the company Teledyne Controls, and the company Stewart Hughes Ltd. delivers HUMS ground equipment. Then the company Bell Helicopter Textron, with data obtained from its customers, continuously monitors the data obtained by HUMS, and calculates the Retirement Index Number (RIN) of certain components. The Retirement Index Number (RIN) is the number which presents which level of its lifetime a certain component has reached at that moment. HUMS allows the RIN calculation by recording almost all operating conditions of a certain aircraft component, so that a component is not replaced after a certain time period has passed or a certain number of flying hours. Instead, special, complex algorithms are used to calculate the wear of components depending on the load, vibrations, temperature and other factors which form the general conditions under which the given component performs its function. By applying such a system, the manufacturer Bell Helicopter Textron can provide special benefits and discounts to users regarding maintenance because they have full control of aircraft exploitation regimes, and can very easily diagnose the condition of an aircraft and of certain components (Figure 4).

Apart from benefits for the aircraft manufacturers and operators in reducing maintenance costs, additional benefit for the operators is the issuing of the Flight Operations Quality Assurance (FOQA) certificate, which confirms that the operations have been performed in accordance with the recommendations and procedures stipulated by the aircraft manufacturer. Such certificate has a significant influence on the positive image of the operator in the eyes of the service user and government bodies.

8. THE SYSTEM OF INTEGRATED MAINTENANCE CONCEPT (IMC)

IMC has been developed for the needs of the Ministry of US Defence, for the moment only for the family of helicopters Sikorsky H-60, used by all three forms of armed forces. The objective of the project is to reduce the costs of one flight hour by 20% by the year 2005. One of the main assumptions to realise this project is precisely the application of HUMS.

The project foresees substantial reduction in costs due to the application of HUMS and introduction of preventive maintenance concept regarding the condition of components instead of preventive maintenance according to the fixed lifetime of components, based on improvement of trail and balance regulation of helicopter rotors, and reduction of number and duration of non-operative (test) flights. The calculations do not include savings in the increase of reliability and durability of electronic and dynamic components as result of vibration reduction, and the reduction of working hours spent on maintenance.

The project studies the option of direct purchase of HUMS, as well as the option of leasing. In the former case, with the investment of a sum of $337 million, the costs are eventually reduced by $3,005 million. In case of leasing, the investment of $187 million brings a saving of $1,045 million.

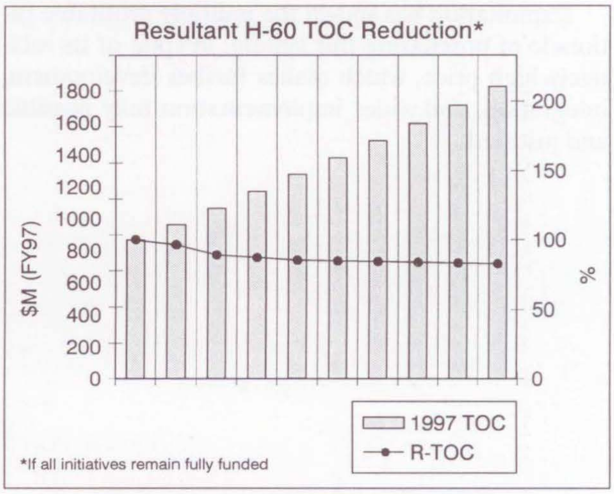

Figure 5 - The projection of reduction in Total Operating Costs (TOC)

Apart from the mentioned savings, more than 300 days out-of-service due to maintenance of helicopters are avoided, and the aircraft themselves are in a better overall condition.

The above mentioned makes it clear that investing in HUMS, apart from other additional measures can be profitable in an approximate ratio of 1:10.

9. THE INFLUENCE OF HUMS ON THE DEVELOPMENT OF AIRCRAFT DIAGNOSTIC AND MAINTENANCE SYSTEM

The development of HUMS has stimulated also the development of diagnostic systems that were initially part of HUMS, to be used later also independently. One of the examples is Rotor Analysis and Diagnostic System company Stewart Hughes Limited and Signal Processing Systems Incórporated. In the initial development phase, the system was HUMS subsystem, but it found its application also as an independent diagnostic system, not only for helicopters but also used for dynamic balancing of propellers, and spectral analysis of aircraft engine and reducer vibrations (e.g. C-130 Hercules).

10. CONCLUSION

The direct advantage of the development and use of HUMS is indicated in significant improvement of the possibility of accurate monitoring of the aircraft technical condition, increase of general flying safety, and clear simplification of the failure diagnosing process. Indirectly, the development of HUMS stimulates the development of other diagnostic systems and expansion of their application.

Exploitation has shown the multiply profitable rationale of purchasing this system, in spite of its relatively high price, which makes further development, integration, and wider implementation fully possible and justified.

SAŽETAK

HUMS - SUSTAV NADZORA ISPRAVNOSTI I UPORABE

Rad daje osnovni prikaz modernog sustava HUMS, s osnovnim karakteristikama rada sustava. Također se obrađuje utjecaj HUMS-a na održavanje zrakoplova i ekonomičnost, utjecaj na arhitekturu sustava za održavanje i primjenu mjera za smanjivanje troškova. Isto se tako razmatra povećanje sigurnosti letenja kao posljedica primjene HUMS-a.

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