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LIFETIME MONITORING SYSTEM OVERVIEW OF 4TH GENERATION AIRCRAFT

Abstract
The continued growth in air traffic has placed an increasing demand on the aerospace industry to manufacture aircraft at lower costs, while ensuring the products are efficient to operate, friendly to the environment and that the required level of safety is maintained. The primary objective of the aerospace industry is to offer products that not only meet the operating criteria in terms of payloads and range but also significantly reduce the Direct Operating Costs (DOCs) incurred by their customers, the airlines. Since World War II Saab has developed and produced several generations of combat aircraft while has emphasized the importance of Lifetime Monitoring System (LMS) development.
The structure of today's military aircraft is designed considering the current and forthcoming airworthiness regulations, the users' requirements and manufacturing aspects. Presently and in the future LMS will play a major rule in ensuring the structural integrity of aircraft structures. the requirements of the aircraft manufacturer and the operator.

The article will give an overview about the activities on 4th generation aircraft lifetime monitoring system as a subsystem of Structural Health Monitoring (SHM).

A 4-IK GENERÁCIÓS REPÜLŐGÉPEK ÉLETARTAM FELÜGYELETI RENDSZERÉNEK ÁTTEKINTÉSE

Összefoglalás
A légi forgalom folyamatos emelkedése növekvő igényt támaszt a repülőgépipar számára, hogy alacsony költségű repülőgépeket gyártson, miközben biztosítsa azok megbízható működését, környezetbarát üzemeltetését és a követelményeknek megfelelő repülésbiztonság fenntarthatóságát. A repülőgépipar elsődleges célja, hogy ne csak olyan eszközöket ajánljon fogyasztóinak, melyek megfelelnek a hasznos terhelhetőséggel és hatótávolsággal szemben támasztott követelményeknek, hanem erőteljesen csökkentség a megrendelőik, a légitársaságok közvetlen működési költségeit. A második világháború óta a Saab a vadászgépek számos generációját tervezte és gyártotta, miközben folyamatosan hangsúlyozta az élettartam felügyeleti rendszer fejlesztésének fontosságát. A mai katonai repülőgép szerkezeti kialakítása az aktuális és várható légialkalmassági szabályok, a felhasználók követelményei és gyártó szempontjainak figyelembevételével kerül megtervezésre. Jelenleg és a jövőben is az élettartam felügyeleti rendszer jelentős szerepet játszik majd a repülőgép-szerkezetek szerkezeti integritásának biztosításában. A cikk áttekintést ad a 4-ik generációs repülőgépek élettartam felügyeleti rendszeréről, ami a szerkezeti felügyeleti rendszer részét képezi.

INTRODUCTION

The structure of today's military aircraft is designed considering the current and forthcoming airworthiness regulations, the customers' requirements and manufacturing aspects. No health monitoring systems were considered for today's large transport aircraft. Loads monitoring systems with on-board evaluation to adjust the maintenance programs were evaluated in the past but were not introduced after cost / benefit trades were carried out. Reducing the structural weight and enhancing the customer's satisfaction by decreasing the maintenance cost are some of the key drivers to become competitive in the future. Using this technology permits new advanced metallic, integral fuselage design as well as optimized Carbon Fibre Reinforced Polimers (CFRP) structures to ensure structural integrity. Maintenance aspects are increasingly significant in reducing the Direct Maintenance Costs (DMC) as most other DOCs such as fuel, airport fees, etc. have little potential for further reduction.[1]
Decreased maintenance costs will have a very positive effect, especially for airlines that are running into trouble with their costs. The biggest challenge is to find appropriate SHM technologies that can be used under in-service conditions. These technologies must prove that they are able to monitor the integrity of aircraft structures, while being reliable and durable.
The variability in usage and the fact that the airframe as well as basic systems is designed for one specific usage profile make life tracking of individual aircraft essential. A service life monitoring system supports both flight safety and fleet availability.
There are two main principles for service loads monitoring. One is founded on direct measurements (DM) of loads using calibrated strain gauge installations while the other makes use of recorded flight parameters and a mathematical model to calculate the loads indirectly (IM). The first method has its advantage in the direct recording of loads in pre-selected vital structure without any needs for configuration control. The main disadvantage is that other structure is not monitored at all and that strain-gauges require scheduled calibrations. The main advantage with the second method is that all structure covered by the loads model can be handled. The disadvantages are that the load model can be unreliable for some structure or load cases and that load models need to mature and are mostly not available in early service stages. A mix of the two systems is sometimes preferable.

THE OPERATIVE SYSTEM

The loads monitor system for Gripen is a mixed system. The direct measurements system was designed early during the initial development of the aircraft and was available already in test aircraft. The system has series status and is operative in every aircraft and monitor primary structural joints e.g. fuselage-wing, fuselage-canard, fuselage-fin etc. The indirectly measurements (IM) system is used for monitoring of parts which was not considered in the early days or was impractical for direct measurements e.g. control surfaces, weapon pylons, external stores etc. All additional monitoring (presently not known or considered today) will be made in the IM-system.

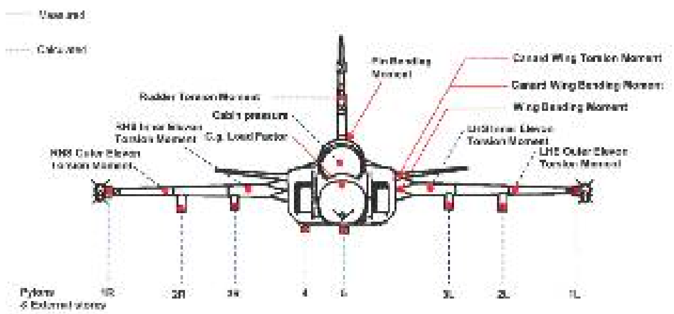

Figure 1. Measurement points of Gripen [2]

THE DIRECT MEASUREMENT SYSTEM

The analogue strain-gauge bridge signals are in the DM-system are amplified and low-pass filtered. The signals are subsequently sampled and digitized and thereafter scaled and put into discrete intervals. Range-pair-range cycles are identified and counted and stored into a load matrix for each monitored entity. This is all done on-board the aircraft and the load matrices are down-loaded to ground station after a certain service period. [3] The strain-gauge bridges need however to be regularly calibrated. For Gripen is this done during flight every 200 hours of flying. The pilot activates a calibration mode of the loads monitor system while flying specified maneuvers. New strain-gauge factors are calculated and replacing the previous ones.

THE INDIRECT MEASUREMENT SYSTEM

The flight and configuration parameters for the IM-system are monitored and down-loaded directly as time-histories. These parameters and load matrices from the DM system are transferred to the maintenance ground support system (GSS) via data transfer unit (DTU) and a remote hand control. Load sequences for airframe parts as well as for systems belonging to the armaments are calculated using validated load models e.g. extracted aero data and finite element model results. An extension to include general systems will make use of other models such as thermal and fluid models etc. From this point the data from the IM-system are treated with the same processing algorithms as data from the DM-system i.e. data signal scalling etc and range-per-range counting and consist hereafter of load matrices for all monitored entities regardless if the data has been recorded from strain-gauge bridges or from flight parameter based load models.[3]

THE COMMON SYSTEM

The matrices are added to previously accumulated matrices to reflect all fatigue loading up to the point of evaluation. The end-user tool has access to the range –pair-range matrix database from which required date can be selected, processed and presented in various forms and formats. The system allows also for access to data in specific customer maintenance systems.
A clear picture of the fatigue life status and forecast of the remaining time to next inspection can be given by a fatigue/crack sensitive severity index. The method to derive the effective stress range and the numerical values of the parameters in the severity index are founded on fatigue crack growth tests. The specimens used in those tests are made of the same materials as used in primary aircraft structure and furnished with typical cracks and subjected to load spectra likely to occur in real structure. The severity index converts nominal flights hours into effective flight hours which are tolerance parts depending on parts considered. The system supports also the rotation of designated parts between different aircraft.[3]
The structure and system have been designed to meet the required service life and inspection free

periods by analysis. There are, however, physical aspects that could not be properly modeled. Such properties include residual stresses that originate from subcomponent assembly, metal sheet forming, welding, casting and forging.

This problem involves distribution and magnitude of residual stresses, relaxation during flights and redistribution during crack extension. Problems that can not be fully taken into account by modeling must be covered by full scale experimental testing. These emphases the importance to have a well defined, and load monitored, test verification program to support the fatigue lives and inspection free periods to which severity indices relate.

FELHASZNÁLT IRODALOM

[1] Hans Ansell and Thomas Johansson: Widespread fatique damage in combat aircraft, Saab Military Aircraft, Linköping Sweden 1995

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[3] http://dtas2007.fyper.com/userfiles/file/Paper%2034_Ansell-Blom.pdf

Vissza a tartalomhoz >>>