NATIONAL DEFENCE UNIVERSITY
Doctoral Council

Dipl. Eng. Rtd. Lt. Colonel Iván Péter Vonnák

MAINTENANCE OF AVIATION TECHNICAL DEVICES ''ON CONDITION" PROVIDING THE MOST EFFECTIVE TOOLS TO REDUCE THE COSTS OF RUNNING MILITARY AIRBORNE EQUIPMENT

as published by the author candidate for PhD (RESUME)

Supervisor: Prof. Dr. Gyula Óvári CSc

Budapest 2011

SCIENTIFIC APPROACH OF THE SUBJECT

The costs of maintaining different types of airborne equipment have greatly increased recently with special emphasis on military. For the same reason lifecycle management has been given more attention in past decades.
The lifetime of military systems (lasting between defining objectives and targets, and systems phase-out) consists of comprehensively identified sections including manufacturing, sales, transportation, operation and phasing out i.e. consists of the entire lifecycle from design through the full process of supply.
The lifecycle cost management shows the feasibility features and ownership characteristics which provide active facilities and tools for the user to respond.
From the aspect of user (buyer) costs are devided into 3 main groups:

- purchase price
- costs raised by ownership
- costs of overhaul, modernization, and disposal

The present Dissertation will concentrate on costs raised by ownership, since this period spans the entire lifetime from the point of operation and maintenance. Operation and maintenance costs are vital in the above period.
During lifecycle management cost reduction is mainly available in the maintenance cost, whereas the author has been given a primary job in the field of operating MiG-29 (B-UB) types of aircrafts. When these aircrafts were received by our service, I had the privilege to be one of the first officers responsible for maintenance as well as engines; furthermore auxiliary systems have gone through strategic changes of operation and methods of enhancing cost effectiveness, which have been elaborated and approved; also attended by the author of the present Dissertation.
The main areas of the activities of responsibility of the author of this Dissertation have been:

1. Demage exempt material testing and diagnostics to be applied in testing airframes and engines. Coordinating, supervising the activity of engineers of Repair and Maintenance Workshops involved in linked R&D programmes, evaluating test results and transferring the experiences into practice.
2. Analyzing strategies of maintenance systems on condition, adapting methods to match all aircrafts irrespective of their type.
3. Verifying and applying test methods and diagnostics for life extension of aircrafts with a complex approach.
4. Elaborating a mathematical formula and model which describes material deterioration and durable alterations backed by laboratory tests. The same formulae can be applied to forcast technical condition changes.
5. Selecting a SWOT analysis method providing inflight security grading of main airframe structures, parts and onboard systems creating the most important database for maintaining the systems on condition.

6. Taking part in preparing documentation – also considering Hungarian expericences – for Transition to on condition maintenance.
7. Introducing On Condition Maintenance enables the application of the latest diagnostics, preparing a reliable forcast for alterations in technical conditions, reducing the frequency of testing, omitting factory overhaul i.e. resulting in minimizing downtime and typical work procedures of the aircrafts.

OBJECTIVES OF RESEARCH

Besides treating flights safety as most essential issue the following aims have been targeted in my Dissertation:

1. Checking opportunities provided by diagnostics and material testing, by surveying technical condition by preparing forcast of condidion as well as presenting solutions, results and necessary limitations of application in maintenance on condition irrespective of the type of aircraft.
2. Analyzing strategy of maintenance on condition, adaptation to any type of aircraft.
3. Application of easy-to-use risk management methods, already proven in quality management systems for classifying onboard systems, equipment and the main structures of aircrafts.
4. Defining maximum operating time by applying solidness-calculated model, based on experiments and providing means of transition to maintenance on condition.
5. Testing and adapting possibilities of diagnostic methods in a complex way with respect to engines and airframe systems, providing bases for maintenance on condition for any type of aircraft.
6. Presenting the fact that costs of maintenance on condition are less then the costs of traditional preventive maintenance.

RESEARCH METHODS

1. Relevant Hungarian and foreign documentation has been studied, scientific articles and descriptions have been researched through, also using word web.
2. Knowlege pertaining to subject has been systematically absorbed.
3. Demage free test procedures application and their intruduction was considered on aircrafts.
4. The author took part in preparing the documentation at the Design Bureau of the military aircraft and on the basis of that work, the introduction of the system of maintenance on condition to the Hungarian Defence Forces, was performed and supervised.
5. The author took part in research „SINUS” for MiG-21 and MiG-23 and later in research „Révház” for MiG-29 engines which were contained in program named „Resonance Diagnostic Measuring and Analyzing System for RD-33 Engine of MiG-29 Aircraft to Define their Technical Condition”. The activity was performed in cooperation with CEAT LTD from Central Physical Research Institute.

6. In frame of joint R&D program carried out by Hungarian Defence Forces and AID LTD named „VÉGVÁR” the author tested the tribological measuring results of engines and auxiliary equipment, role and maintenance effects in establishing forcast of condition.
7. In frame „TOLMÁCS” research program demage free material testing documentation was processed together with Hungarian Defence Forces, Central Physical Research Institute and Aviatronic Ltd.

SUMMARY OF PERFORMED MEASUREMENTS BY CHAPTERS

The present Dissertation consists of Introduction, 3 Chapters, Conclusion and Attachments.

The Introduction describes actual features, engine characteristics, motives and research methods.
In chapter I. reasons of changing maintenance strategy are detailed, necessary steps of introducing maintenance on condition are described, application of respective diagnostic devices are detailed.
In chapter II. existing and proposed maintenance strategies are presented, selection methodology is shown, modes of maximizing operation time is elaborated via considering technical features of aircraft systems, condition forcasts always concentrating on not jeopardizing flight safety.
In chapter III. results reached in field of diagnostics of engines, auxiliary systems are described as well as operating and comprizing complete diagnostic system is detailed enabling introduction of real maintenance on condition.
In the conclusion section, the concrete transition program to maintenance on condition at the Hungarian Defence Forces is presented, which was succesfully introduced and resulted in positive output in economic figures.

SUMMARY OF CONCLUSION

The actual technical condition of aircrafts and engines can be accurately defined by carefully selecting diagnostic devices and test equipment. If it is possible to analyze test results then other cost effective maintenance strategies can be introduced.
Aircrafts having same flight hours can be in different technical condition due to differencies in operation and maintenance methods. New methods became essential to securely define depth, quantity, contents and periodicity of repair and maintenance. It seems that the best method is maintenance on condition. It is known that flight safety is influenced by onboard systems but the most decisive element is the airframe. To be able to calculate the real lifetime of aircraft, the control of highly exploited systems and power transmission systems has to be performed with regard to changes and their time factor. The most feasible way is to elaborate a computed model which specifies developing of rifts. In this way sensitivity and resistance of structures can be established, time till first control, cycle time of controls, and tire operation time can be defined.

On basis of the above, the transition to maintenance on condition of MiG-29 aircrafts was succesfully performed in the Hungarian Defence Forces which enables adaptation for other

types as well. In case of engines and auxiliary systems vibration, tribological and endoscopic tests are integrated into a complex system. Due to experiences of factory overhaul with regard to specific failures, parameters, that data can be handled as basic limits. Then the measuring results can be continuously compared, the operability of engines and auxiliary systems can be easily defined and as such, the reals maintenance on condition system can be applied. The presented system meets the requirements of maintenance on condition method, in a way that flight safety will also improve. Banning of factory repairs which require significant human and material resources, simplifying direct servicing, reducing number of replacement parts and elements, operation time between overhauls brings cost effective results. Calculations show that by introducing maintenance on condition average cost will be reduced by 34,2 %, and cost per flight hour will be reduced by 39,5 %.
Introducing real maintenance on condition will result in considerable advantages from the point of the user.

NEW SCIENTIFIC ACHIEVEMENTS

The new scientific results of this Dissertation have been summerized in the following Statements:

1. By introducing strategic maintenance on condition of MiG-29 aircrafts it has been proven that in case appropriate damage free methods are selected then the technical condition can be defined precisely.
2. It has been presented by using a new method (FMEA) that the risk classification of flight safety features of aviation systems, structures and equipment, which is essential to perform maintenance on condition can be done such accurately that the manufacturer will prepare the technical documentation accordingly. It has been proven that if countries not having an aviation industry will change to maintenance on condition then the relevant cost will be reduced. It has also been proven in practice in Hungarian Defence Forces.
3. It has been proven that it is important to trace the performance of the damaged elements when the remaining operating time has to be established. For modelling deterioration of material a mathematical method was presented which reflects the real scenario and has been proven by factory measurement results. The manufacturer was convinced about the practiacl advantages and made the recomendation of strategic change available in the official documentation.
4. It has been proven that in case of engines and auxiliary equipment the current technical conditions can be defined by using damage free material test devices and diagnostic methods carefully selected, and with appropriate alterations highly precised results are produced. It has been demonstrated that the complex handling of measuring and test results will enable forcasting of changes in technical condition. The advantage of the method is that maintenance on condition can be generally applied for any type of engine and auxiliary system.

APPLIED METHODS TO UTILIZE RESEARCH RESULTS AND RECOMMENDATIONS

1. Maintenance on condition will reduce costs of operating aircraft onboard systems and airframes. The same is supported by the fact that after our aviation service had changed to maintenance on condition, and due to applied high level diagnostics, the usual periodical checks and maintenance works with the consent of the manufacturer, were done after 1400 flight hours instead of 1000 hours. This is a considerable cost reduction and gain of more flight hours.
2. The transition model elaborated for aircraft airframe and onboard systems is not tied to a particular type and can be used universaly.
3. In case of engines and auxiliary equipment, the research is in the phase of collecting profile database of failures. When the database is complete not only traditional extension of operating time will be possible, but maintenance on condition too. It is also valid for engines and auxiliary systems, that in case the diagnostic devices and methods are carefully selected, then the same method will be universal.
4. Besides significant cost reduction, the demonstrated method represents an important part of our internationally recognized high grade aviation technical status, which enable saving jobs and creating new ones.

Recommendations:

In addition to the increasing costs of operating military aviation systems, the Hungarian Defence Forces will have to utilize its own human resources and comparative advantages deriving from high level engineering knowledge.

The above enable introduction of real maintenance on condition – which independetly from the type of aircraft – results in significant cost reduction.

The adopted diagnostic methods should be integrated into a complex system, databases and softwares have to be developed and expanded for evaluation, and accordingly the new maintenance strategy will be cost effective.

The experienced staff of Hungarian Defence Forces Aviation Technical Repair Workshop have been applying damage free material testing, technologies and diagnostics for quite some time, they are capable of further developing systems in their independently audited laboratories which should be saved for the future.