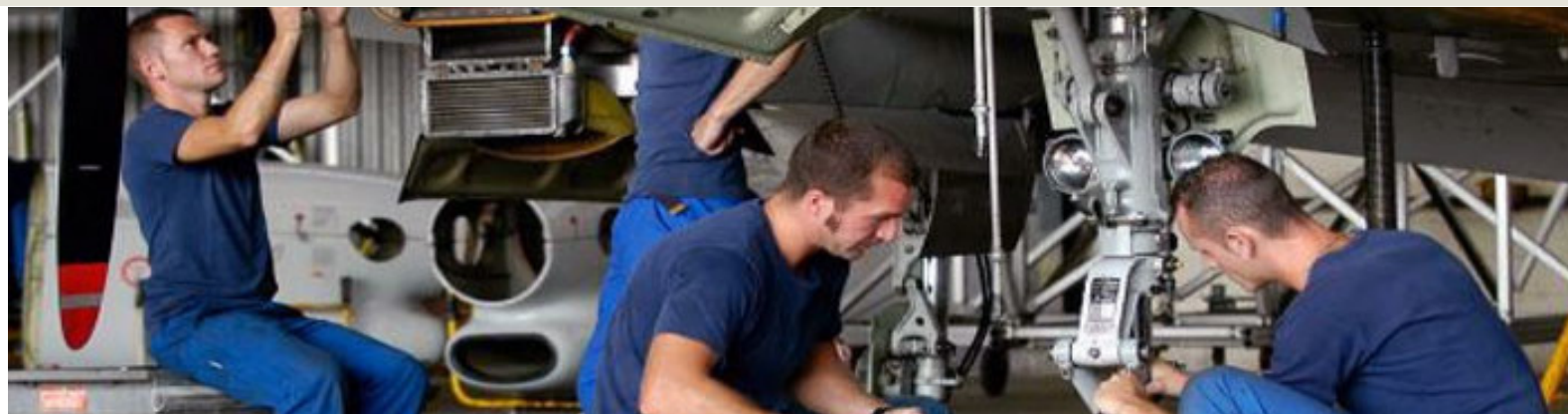




How to optimize the maintenance of new generation aircraft

military-Earth thinking notebook

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Similar to what has already been achieved in other areas such as human resources and weapons operations, methods for optimizing aircraft maintenance programs can be considered.

This will require, on the one hand, a thorough analysis of maintenance costs and a comparison of these costs with losses due to downtime. This broader concept of cost will make it possible to define relevant evaluation criteria and to quantify the levels of performance to be achieved. On the other hand, the armed forces will have to work more closely with industrialists and draw more inspiration from the methods put in place for civilian operators.

"Preparing for our uncertain world is the opposite of resigning oneself to widespread scepticism. It means striving to think well, it means making ourselves capable of developing and practicing strategies, it means finally making our bets with a clear conscience" (Edgar Morin).

Since 2008, the economic crisis has continued to weigh heavily on the budgets of European states. Thus, each government is seeking to control its deficits and reduce public spending. In France, the armies are not exempt from these restrictions, because even if the defence budget is stabilised in 2013 compared to 2012, at an amount of 31.42 billion euros excluding pensions, it remains below what was foreseen by the 2009-2014 military programming law [1].

In this context, it seems important to recall that, for 2013, the payment appropriations provided for scheduled equipment maintenance (EPM) - which covers most of the maintenance in operational condition of the equipment - will not be sufficient to cover the cost of the maintenance of the equipment.(MCO) excluding the wage bill - amount to EUR 2.91 billion and are up by almost EUR 225 million (or 8%) compared with the initial 2012

Finance Act. A large proportion of this amount remains dedicated to the aeronautical equipment of all the armed forces. With regard more specifically to this equipment, and in spite of tight budgets, the fleet renewal effort will continue in 2013 with the planned delivery of eleven Rafale aircraft, one C160 Gabriel, two ATL2s, the first A400Ms, three CN235s, one CN235, one CN235, one CN235 and one CN235.FALCON 50 and a multi-role air-to-air refueling and transport aircraft, as well as four Tiger helicopters, five refurbished Cougars and twelve NH90s (four in naval version and eight in land version). While the arrival of this new-generation equipment represents a tremendous opportunity to meet the requirements of force engagement and preparation, it will not be a source of savings on the EPM budget. Thus, today more than ever before, the question of extending the Ministry of Defence's desire for budget savings to aircraft maintenance is more topical than ever.

The optimisation of maintenance is complex; it requires the prior definition of evaluation criteria and performance levels.

What is maintenance? Strictly speaking, maintenance is the set of maintenance operations intended to increase the reliability or to compensate for the failures of an equipment [2]. 2) More generally, it is part of the actions carried out so that a company can prosper. Its objective is to limit the effects of disruptions in order to achieve the performance required of an equipment. This performance is grouped into two categories: operational reliability and control of maintenance costs.

Reliability in the broadest sense covers reliability, safety, maintainability and availability [3], and depends on the conditions under which the equipment is used: equipment must be capable of meeting specific needs, in good time, for the intended duration, without damage to operators and their environment. For example, the fact that armies use their equipment in sometimes extreme conditions obliges manufacturers to take much more stringent precautionary measures when designing an aircraft in order to ensure its safe operation.

Maintenance costs are associated with the notion of logistical support and management of the material and human resources needed to operate an item of equipment (spare parts, specific tools, maintenance teams). In assessing these costs, civilian companies add operating losses due to shutdowns to carry out maintenance tasks. Currently, there is no equivalent from a military point of view to the evaluation of operating losses. However, the unavailability of equipment leads to delays in missions (training and education of personnel, delayed or cancelled operational missions, etc.) and personnel costs (allowances for training, field service, non-operational personnel, etc.). All this has a cost that should be included in the justification of the budgets allocated to the EPMs. Maintenance is expensive, but its cost should be compared to the cost of losses caused by shutdowns. Thus, in order to make relevant choices, it is necessary to broaden what is taken into account in maintenance costs in order to be able to clearly define the performance levels to be achieved.

Maintenance optimization is complex because it has to take into account many interdependent considerations, and its selection criteria are sometimes antagonistic (such as availability and costs). To illustrate this, the following scenario can be considered: Let us assume that there is equipment within the armed forces whose reliability has been optimised in relation to the conditions of use, which follows an appropriate maintenance programme and is maintained by a sufficient number of qualified technicians with an

unlimited stock of spare parts and specific tools at their disposal. This scenario would allow optimal availability, but the cost of such a system is questionable. Therefore, is such a level of availability necessary to fulfil our operational contract? Optimising the maintenance of an equipment therefore requires making prior choices based on relevant evaluation criteria, and defining the necessary and sufficient performance levels for carrying out the missions.

The specificity of aeronautics: a regulation that involves many players

The International Civil Aviation Organization (ICAO)[4] was established in November 1944. Dependent on the United Nations, [its](#) role was initially to participate in the elaboration of standards allowing the standardisation of international aeronautical transport. Today, one of the fundamental objectives of the Organization is to improve the safety of air transport. For the European Union, it is the European Aviation Safety Agency (EASA)[5] which is the keystone of the aviation safety strategy. Its mission is to promote the highest possible level of safety for civil aviation. To this end, the Agency develops common European rules, issues certification and monitors the application of standards through inspections in the Member States[6]. The aspect of safety is therefore paramount in the field of aeronautics.

There are two requirements for flying an aircraft. On the one hand, the model must be certified, i.e. there must be a type certification file, defining the model as designed by the manufacturer and approved by the certification authority. The compliance of this sheet with the regulations in force is the responsibility of the manufacturer. On the other hand, the particular aircraft must be declared airworthy[7], i.e. it must have a valid certificate of airworthiness, in compliance with its type certificate, maintenance manual, airworthiness directives issued by EASA and any other regulatory requirement. Ensuring that an aircraft is airworthy at all times is a job in itself. It implies knowing the last completion and the next due date of all the operations recommended by the maintenance manual, the date of installation and the date of all serialized equipment, and to guarantee the perpetual conformity with the type certification sheet and the strict application of airworthiness directives. This responsibility lies with the operator, and therefore with the armed forces in the case of military aircraft, who delegate this responsibility to their PART 145 approved maintenance organisation [8].

The development of maintenance programmes

Thus, armies are responsible for the continuing airworthiness of their aircraft. They must ensure that the instructions for their maintenance comply with the maintenance programs as specified by the manufacturer and approved by the certification authority. Such programmes shall be initially developed at the time of design and before type certification of a new aircraft and shall serve as a reference for the whole life of the equipment. Designed on the basis of theoretical data and reliability tables from certification tests, these programmes are developed using methods based on MSG-3 logic. This analysis and decision logic derives from the Reliability Centred Maintenance (RCM) concept [9], which allows the development of preventive maintenance instructions and inspection plans based on the consequences of failures. The purpose of the ROM is to improve the safe operation of equipment; however, it does not take into account costs.

In order to change these maintenance programmes, the regulations require the maintenance organisation to comply with a pre-established procedure, to demonstrate that the desired changes result in equivalent or improved, and therefore more stringent, maintenance standards, and to inform the manufacturer. This is the only room for manoeuvre available to the operator in total autonomy in this area. Indeed, insofar as the modifications would make the initial maintenance programmes less restrictive, only the manufacturer can carry out studies to prove that the airworthiness of the aircraft is not called into question, and only the manufacturer can submit the new programme to the certification authority for approval. Because of the cost of such studies, the manufacturer has little interest in optimizing the programs it initially advocated, unlike operators, who are continually seeking to reduce the maintenance costs of their aircraft.

A solution to reduce maintenance costs: the Maintenance Review Board process

The Maintenance Review Board Report (MRBR) is a document issued by the aircraft manufacturer specifying the minimum maintenance program for the continued airworthiness of an aircraft. The MRBR is a living document, i.e. subject to periodic revisions and amendments to incorporate, as and when required, the lessons learned from the aircraft's operational experience. The ultimate goal is to ensure the continued airworthiness of a fleet of aircraft by performing only those tasks that are appropriate and effective. MRBRs are produced by Maintenance Review Boards (MRBs), which are maintenance review boards involving the manufacturer, the certifying authority and the operator. Decisions are mainly taken on the basis of qualitative information provided by the operator and supported by feedback data.

The MRB process is broadly defined as the set of activities necessary to develop and update MRBRs [10]. The main objectives of this process are to ensure that the planned maintenance instructions (tasks and schedules) established for an aircraft meet the continuing airworthiness and maintenance requirements of the aircraft. The main objectives of this process are to ensure that the planned maintenance instructions (tasks and schedules) established for an aircraft meet the continuing airworthiness and environmental requirements established by EASA, that these tasks are realistic and capable of being performed, and that the implementation of these planned maintenance instructions will result in minimum expenditure. As part of the continuous improvement of their services, some French manufacturers [11] are already offering their customers MRB-compliant monitoring only on their civil range. This service requires the implementation of a system for acquiring information from reports written by the operators: these reports give them the opportunity to express their views on the relevance of maintenance tasks, and allow detailed monitoring of breakdowns and their consequences. In addition, this service includes a system of periodic evaluation of all tasks in the maintenance programme in order to eliminate those that have become unnecessary and to systematically re-evaluate their periodicity. The implementation of such a process, which involves close collaboration between manufacturers and maintainers, is contractual.

At present, this type of service is not included in the contracts between the armed forces and aircraft manufacturers. However, it is possible to include the MRB process in contracts. The benefit of such a development for the armed forces would be to be able to participate in the development of maintenance programmes dedicated to them. This opportunity would make it possible to take into account the specific conditions of use and

implementation of our aircraft, which today must meet the requirements of adaptability, simplicity and robustness. It would also allow better control of maintenance costs and the adjustment of maintenance programs to possible budget restrictions.

The process of developing maintenance programmes for aircraft has evolved from an environment in which each manufacturer proposed its own unique programme to one in which the regulator, the manufacturer and the operator work together to adapt programmes and design modifications. As a result, maintainers are no longer simply monitoring and repairing; they are looking to anticipate events and evaluate alternatives to make the best use of equipment within the technical and budgetary constraints imposed on them.

Applied to the defence sector, these new methods fully comply with the principle of budgetary discipline: fair sufficiency based on the concepts of economy and purpose. Economy, because the aim is to avoid redundancies in order to ensure that maintenance is properly sized, and purpose, because they make it possible to adapt maintenance solutions to the actual use of aircraft, while providing the forces with equipment that meets the requirements of tomorrow's commitments.

1) "Between 2009 and 2012, the defence mission has benefited from €125.8 billion (compared with €128.8 billion planned), with actual resources gradually deviating from the initially planned trajectory", Source La Tribune of 18/09/12.

2) There are a multitude of ways to maintain equipment: one can vary the types of maintenance, the types of tasks and their frequency, the levels of intervention... Maintenance can be corrective, preventive (for sub-assemblies that are subject to wear and tear), or conditional (with an overhaul and inspection program).

3) The reliability of a piece of equipment is its ability not to fail. Maintainability of equipment is its ability to be repaired quickly. Equipment availability can be characterized by the duration of unplanned downtime due to breakdowns, and planned downtime due to maintenance operations.

4) International Civil Aviation Organization (ICAO).

5) In English, European Aviation Safety Agency (EASA); the basic Regulation (EC) No 216/2008, which entered into force on 8 April 2008, defines the tasks of the Agency.

6) The regulations in question were initially created for civil aviation, but are fully transposable to the armed forces for the latest generations of aircraft.

7) Airworthiness is defined as the ability of an aircraft to carry out its mission under acceptable conditions of safety with respect to the crews, persons and goods carried, but also with respect to other airspace users and the goods and persons overflown.

8) Approved under Part 145 of Regulation (EC) No 2042/2003; the approval is called FRA 145 for military support organisations.

9) In English, Reliability Centred Maintenance (RCM).

10) An international body independent of industry, the International Maintenance Review Board Policy Board (IMRBPB), has the role of monitoring, harmonising and standardising the policies, procedures and practices used by MRBs worldwide.

11) These are Airbus, Dassault and Eurocopter.

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