Improve Your Knowledge (IYK)

Reflections on Systems Engineering (ES) - Scheduled Maintenance

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We have already dealt with the issue in MSC 35 and 36, "flashes", where we refer to the elements of technical-logistical support applied in the operational phase, thus focusing on maintenance, training, ground support equipment (GSE), maintenance manuals and spare parts. In this MSC, we will emphasize Scheduled Maintenance, which includes all preventive and predictive maintenance actions to keep the aircraft and its systems in operational condition, over the operational life. Enjoy.

The Technical-Logistic Subsystem of an aeronautical system, which is developed in concomitance with the Operational Subsystem, is composed, we repeat, of the following elements: maintenance, training, ground support equipment (GSE) and spare parts. All elements revolve around the maintenance element, i.e. maintenance is the focus of all of them.

In passing, we would like to remind you that the development of an entire aeronautical system also brings together the indispensable requirements of the Airworthiness Authority (ANAC, FAA, EASA, etc.), focused entirely on safety for both the Operational Subsystem and Technical-Logistic Subsystem; in particular, the maintenance.

Maintenance is a design feature called Maintainability, which can be conceptualized as a design and installation feature, which is expressed as the probability of an item being maintained in a specific condition or restored to that condition, within one determined period of time, when the maintenance is performed according to the procedures and resources (elements) developed for this activity.

Two types of maintenance are defined: corrective maintenance and preventive maintenance.

Corrective Maintenance - Includes all maintenance actions performed on an aircraft or its systems, due to a malfunction or failure of the same, in order to restore them to the expected operational condition. The corrective maintenance cycle includes: location of failure or malfunction, disassembly, removal and replacement of items, and repair, assembly and testing of the operability of the repaired item.

The process of corrective maintenance itself is simple: if, for example, a structural failure arises, the aircraft will be unavailable for corrective maintenance on the aircraft (On Aircraft or On A/C).

If it is a malfunction or failure of an aircraft system equipment, that equipment is removed and sent to a workshop for proper repair, ie off the aircraft (Off Aircraft or Off A / C). In this case, the aircraft would only be unavailable if there was no turning equipment of the same PN (Part Number) in stock for replacement.

Preventive Maintenance - includes all maintenance actions foreseen in a scheduled maintenance plan, aiming to maintain aircraft / systems under the expected operational conditions. Preventive maintenance is carried out by means of inspections, monitoring of the operational condition of the aircraft / systems, replacement of critical items and calibration. It may also be included in the category of preventive maintenance the small services (track servicing), such as lubrication, supply, checking of oil levels, etc.

Preventive maintenance has two objectives:

1. Minimize corrective maintenance, which means costs and unavailability of the aircraft,

which causes problems in airline revenue, or delays that bring annoyance to users; and

2. avoid malfunctioning or failure of critical items, that is, with catastrophic or hazardous failure conditions, between one inspection and another.

There is a special case of preventive maintenance, called Predictive Maintenance, consisting of monitoring with equipment dedicated to checking the condition of the aircraft/systems, using methods of checking the degradation state of the structure/systems, as accurately as possible , deciding then, according to well elaborated criteria, the continuity or not of the operation of the aircraft / systems, in spite of some observed wear, establishing the period for a new inspection.

To perform predictive maintenance, it is necessary to know how the item fails (fault physics) and to use test methods that include special equipment, such as borescopes (engine, for example), X-rays (cracks), etc.

Maintenance Levels - Corrective and preventive maintenance can be performed on the aircraft itself (On A / C) or off the aircraft (Off A / C), in the case of aircraft systems, in maintenance workshops. Three levels of maintenance are considered:

1. First level maintenance On A / C, also called Organizational Maintenance, held at the site where the aircraft operates;
2. Second level maintenance On A/C or Off A/C, also called Intermediate Maintenance, held in workshops near the operator's website; and
3. Third Level Maintenance (Depot Level) On A/C or Off A/C, in the operator's own remote workshop, or at the manufacturer, or in an authorized workshop.

In its application process, maintenance can be scheduled and unscheduled.

The scheduled maintenance houses the preventive maintenance, carried out according to a well-established program and according to well-defined criteria. The unscheduled maintenance is one that occurs when the aircraft has, for example, a structural problem, or a system that has a malfunction or fails, ie goes into fault.

The Maintenance Planning Document (MPD), applied throughout the operational phase, defines several aircraft stops, with carefully defined time intervals for performing preventive maintenance. These are called checks A, B, C, D, which may involve inspections from the simplest (A) to the more complex ones (D). During these checks, repairs to the aircraft structure or preventive removals of items to undergo Off A / C maintenance can occur, preventing them from having problems in the interval between the current check and the next check.

Note that scheduled and unscheduled maintenance can be On or Off A/C.

Unscheduled maintenance, whether On A/C or Off A/C, is always corrective, that is, it only occurs when a problem arises with the aircraft or with equipment on one or other of its systems. This is the case of electronic items and some items from other segments not considered critical.

We must make it clear, and this must be evidenced, that MPD does not apply to electronic items, since they operate or do not operate, it is not possible to check for wear or not of these equipments.

MPD turns to other segments, such as the mechanical segment (flight controls, hydraulic power, landing gear), propulsive segment, structural segment, etc., ie those segments that are not subject to the Safety Assessment activity , in its magnitude, as provided in CFR 14 Part 23.1309 or Part 25.1309, with analysis methodology contained in AC 23.1309-1E and 25.1309-1A.

The time intervals for MPD preventive maintenance tasks are based on the Reliability - R of the items, hence their generic name: Reliability Centered Maintenance (RCM).

The RCM focuses on the so-called critical items of these segments, meaning those items whose loss or malfunction may lead to catastrophic or hazardous failure conditions. In other words, preventive maintenance focuses primarily on safety and is also concerned with the operational availability of the aircraft.

The most accurate technique of the RCM was developed in the 1960s, from the efforts of commercial airlines, which brought together a group called the Maintenance Steering Group (MSG), which drafted document B747 - Maintenance Steering Group Handbook, acronym MSG-1, published in 1968, and then upgraded to the MSG-2 version in 1970, and finally to MSG-3 in 1980, which remains to this day the document

guiding this technique. All such versions have been found to be acceptable to the Airworthiness Authority which holds the respective type certification.

MSG-3 is used to develop the initial scheduled maintenance requirements for modern commercial aircraft, published in the Maintenance Review Board Report (MRBR), in two volumes (one for fixed wing aircraft and one for rotary wing aircraft).

The MSG-3 introduced a Top-Down approach to arrive at the origin of a critical failure at the aircraft level (something like FTA - Fault Tree Analysis), in the Safety Assessment process, concentrating on failure conditions (consequences of failures) with catastrophic or hazardous severity.

The methodology is developed by a group of maintenance specialists, the process being monitored by the Maintenance Review Board (MRB), which, in the end, approves the Maintenance Planning Document (MPD).

In the operational phase, a process of monitoring the MPD is practiced, which proposes the necessary corrections. It is a process of continuous improvement, both of tasks and of intervals between them. Fixes are coming as maintenance people gain experience in the field. It is up to MRB to conduct the process of reviewing and approving correction suggestions.

The MPD is adapted to meet the requirements of each operator of that aircraft. Once approved by the regulatory authority (FAA, EASA, ANAC), it becomes an Approved Maintenance Schedule (MAS), but only for that operator, ie each operator has its MPD.

Well, let's stop here. As always, we try to give a brush on the subject. It is suggested that the program developed by MSG-3 (V. Ref. 2) be consulted to familiarize itself with the step-by-step development of the methodology.

Thank you.

References:

1. *Blanchard, B. S.; Verma, Dinesh; Peterson, Elmer L. Maintainability: A Key to Effective Serviceability and Maintenance Management. John Wiley & Sons, Inc. , USA. 1995.*
2. *Airlines For America (A4A) MSG-3: Operator/Manufacturer Scheduled Maintenance Development, Volume 1 – Fixed Wing Aircraft; Volume 2 – Rotorcraft, Rev. 2015.1, USA.*