CHAPTER 1

INTRODUCTION

1.1 TECHNICAL BACKGROUND

This chapter focuses on the technical background of the research problem that is being studied. The basic topics like maintenance, types of maintenance, maintenance planning and scheduling and factors to be considered during planning and scheduling of maintenance tasks are discussed in detail.

All basic terms that are used in maintenance organization are defined. It outlines the different types of maintenance tasks carried out to ensure the airworthiness of aero-engines.

1.2 AERO-ENGINE MAINTENANCE

Aero-engine maintenance is defined as the overhaul, inspection, fixing, preservation and the reinstatement of parts of aero-engine and its components. An aero-engine is delivered from the manufacturer to the airliners in an airworthy condition with all the systems in a fully operational state.

Since an aero-engine is continuously used for commercial income through flights to different destinations (topographies), it is bodily subjected to structural fatigue initiated by aerodynamic loads, vibration, flight maneuver loads, thrust loads, loads during takeoff and landing performances and ground roll loads (taxi and towing).
The operating environment can also cause damage routinely to the aero-engine, such as corrosions resulting from water or chemicals. Natural phenomena can also cause physical damage to the aero-engine. Objects such as stones or nuts can cause damages commonly called as Foreign Object Damage (FOD) and man-made objects such as ground equipments can also cause damage to the aero-engine.

Bird Aircraft Strike Hazard (BASH) can extensively damage an aero-engine. However, the predominant issues for the physical damages of aero-engine are due to Fatigue and Corrosion. Through normal continuous usage, aero-engine systems will experience deterioration and reduced performance due to fatigue and other factors previously mentioned. Aero-engine maintenance is essentially important to ensure the full operative condition of aero-engine systems and the airworthiness of the aero-engine.

1.3 MAINTENANCE SCHEDULES

A Maintenance Schedule is the one that deals with what is to be maintained on an aircraft and how often. The Original Equipment Manufacturer (OEM), who is also the Type Certificate Holder (TCH) of that product, publishes the details of maintenance activities. The aircraft comprises of airframe, engine, propeller and other equipments. Hence, not only there will be several sources of basic information, there will be details of 'What and when' but also 'How' the parts are to be maintained. Moreover there are details on the types of tasks that are to be performed.
1.4 COMPILATION OF MAINTENANCE SCHEDULES

Maintenance of Aircraft is a very vital constituent of International Aviation Industries. All aviation regulatory authorities mandate for an efficient and fool proof maintenance system so as to assure air safety. The air traffic is growing day by day. There is a huge competition among the operators. The flight schedules are very stringent. This situation imposes several conditions like more utilization of aircraft and less deviation from flight schedules etc. This trend will continue forever and will increase from time to time. The additional pressure may lead to human error and consequent breakdowns of aircraft components or systems.

Most of the accidents in aviation are mainly due to human factors. This Industry has devised a lot of systems to minimize such accidents of maintenance-related breakdowns. As previously stated, the first place for information is the OEM/TCH documents that are relevant to the aircraft that is being operated. As data is obtained from several manuals, there will be a collection of tasks to be accomplished at varying intervals. These intervals can be based either on flying hours, flight cycles or calendar time and sometimes the combinations of all three. It is quite often inconvenient to take each task as it comes and accomplish it. It is usually expedient to parcel the tasks into packages of work that can be carried out when it is convenient to do so. But it should be done at a frequency not exceeding the approved intervals.

The general rule, which can be applied for compiling work packages, is that tasks that can quite often be done earlier than when it is recommended before. They can only be done later with agreement of Civil Aviation Department (CAD) and only in exceptional circumstances. If the tasks that have more than one frequency in terms of flying hours, flight cycles and calendar time, then the event that occurs first will be the governing one. For large transport aircraft, the tasks can be found in Maintenance Planning
Document provided by the TCH. Smaller aircraft usually have the TCH recommended maintenance program.

The frequency of maintenance tasks is affected by the way in which the aircraft is operated. When the TCH recommendations are first compiled they will have in mind a 'typical' flight profile for the aircraft type; any deviation from this may need an adjustment on the basic recommendations. For example, an aircraft may have a 'typical' flight profile of six hours for every cycle while another may be of six cycles every hour. It can be seen that in these cases a schedule based solely on flying hours may mean, the first aircraft is maintained too often and the other not enough, so, with the help of the TCH, usually a schedule can be developed for any particular type of operation.

The area of operation is another important consideration. For example operating over salt water may require special tasks, such as engine compressor washes and other maintenance, to be done on a more frequent basis. Similarly, operation in sandy areas or off rough strips may affect the tasks required. The age of an aircraft may also affect the number and frequency of maintenance tasks. Particularly, if it is an aged aircraft more structural inspections and significant repairs will have to be carried out. Significant parts of the aircraft such as engines, propellers and/or Auxiliary Power Unit (APU) should be detailed with their type and make etc. Quite often operators have a choice of equipment and adding them with a different engine to a common maintenance schedule. This will require careful identification of individual task that are applicable to each aircraft. Finally, the modification state of equipment onboard has to be considered, as it may be unique to the aircraft on any particular Maintenance Schedule.
1.5 FREQUENCY OF MAINTENANCE

Maintenance task will have a time interval based on the most appropriate parameter to maintain the condition of an item to which the task refers. As discussed before, the three types of frequency are: Flying hours, Flight cycles and Calendar time. Sometimes there will be two limits with the operator normally having to comply with; the limit comes first in their particular operation, which will decide the service interval.

In cases of structural inspections, the threshold and repetitive inspection frequency can vary depending on the type of operation being used. Structural inspections are always based on flight cycle limits as their reliability is directly related to cyclic fatigue. When reviewing the effectiveness of a Maintenance Schedule, or carrying out an annual review, it is the frequency of all the tasks that is being considered. Reliability monitoring is the continual monitoring of task frequency. It is permissible to amend these frequencies recommended by the manufacturer by making application to CAD. As the operation of an aircraft is usually unique to an operator, a conscientious owner/operator will develop the schedule to maximize reliability and minimize costs.

1.6 TYPES OF MAINTENANCE TASKS

There are basically two types of maintenance carried out in aero-engine maintenance. They are;

i) Scheduled Maintenance

ii) Unscheduled Maintenance

i) Scheduled maintenance is meant for preventing any malfunctions or failure during operation. It is also called as
preventative maintenance. An airliner as per the established plan to inhibit further deterioration of aircraft systems and the potential loss of functionality performs it. It is the planned activity occurring at specific flight hours, cycles of flight or calendar days.

ii) **Unscheduled maintenance** is corrective or reactive maintenance performed in response to an imminent or existing failure of an aircraft system or component. Unscheduled maintenance is the maintenance performed by an airliner without prior planning.

While the former has already been imported into the airliner’s flight schedule, by its unpredictable nature, the latter has the potential to disorganize the schedule of flight.

As it is an unscheduled maintenance task, it consumes more time and it is costlier than the scheduled maintenance task. The preplanning to guarantee the availability of parts, manpower, materials and equipment for scheduled tasks makes the former more efficient and cost effective than the latter.

### 1.7 AIRCRAFT SCHEDULED MAINTENANCE CHECKS

Aircraft Scheduled Maintenance checks are the inspections that are done periodically on all commercial/civil aircraft after a certain amount of airframe hours. Airlines and airworthiness authorities refer to the detailed inspections as "checks". They are as follows: ‘A’ check, ‘B’ check, ‘C’ check and ‘D’ check. ‘A’ and ‘B’ checks are considered as the lighter checks and ‘C’ and ‘D’ checks are the heavier checks.
i) ‘A’ CHECK

‘A’ CHECK is performed at every 500 - 800 flight hours or 200 - 400 cycles approximately. It requires about 20-100 man-hours and is commonly performed overnight in a hangar. The interval of this check varies from aircraft to aircraft by their cycle count (A set of takeoff and landing is a cycle), or the number of airframe hours since the last check. The airline can delay the occurrence of this check by certain predetermined conditions.

ii) ‘B’ CHECK

‘B’ CHECK is performed at every 4-6 months approximately. It requires about 150 man-hours and is commonly performed within 1-3 days at an airport hangar. B-checks are carried out on the similar occurrence that of the previous check. These checks may be incorporated into consecutive A-checks. The B-checks can be accommodated between check A-1 and check A-10.

iii) ‘C’ CHECK

‘C’ CHECK is performed at every 15-21 months approximately or after a certain number of Flight Hours (FH). The manufacturer normally decides these intervals. In this check, the whole aircraft is inspected and it is much broader than B-Check. This check does not permit the aircraft to fly; in other words, the aircraft will be grounded till this check is completed. The aircraft is not allowed to leave the maintenance site. The space requirement for this check is higher than the other two types. A complete hangar space will be required for carrying out the C-Check. The time required to complete the check is normally 1–2 weeks and the effort involved requires 6000 man-hours. The schedule for the C-Check is characterized by many factors and components and thus it varies from aircraft to aircraft.
iv) ‘D’ CHECK

‘D’ CHECK is the more wide-ranging check for an aircraft. It is also called a Heavy Maintenance Visit (HMV). It is carried out at every 5 years of operation. It is a check that, takes the entire aircraft apart for inspection and overhaul. Also, if needed, the removal of paint may be required for inspecting the fuselage metal skin. This check requires around 40,000 man-hours, or a period of about 2 months for completing it. This time period varies based on the aircraft and the number of skilled persons available. It also requires the most space than all other maintenance checks. It can be performed only at a suitable maintenance base. It is considered to be the more costly maintenance check of all, with total costs range for about a million-dollar.

1.8 AIRCRAFT UNSCHEDULED MAINTENANCE CHECKS

This type of maintenance tasks will be carried out only after any incident, malfunction or any breakdown. The manufacturers have devised so many techniques to locate the problem and also to identify the causes of such failures or malfunctions. One such technique is Failure Mode and Effects Analysis (FMEA). This is a very effective and efficient tool for problem solving. This is also a very helpful tool to expedite the inspection and repair tasks so that the time needed for defect rectification is minimized. Thus the unnecessary grounding of aircraft or its systems can be avoided. The Manufacturers have also implemented module concepts in order to easily detect and rectify any malfunction and also allow the operators to cannibalize the items from aircraft to aircraft. This practice helps the airliners to maximize the utilization of available aircraft hours.