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SCHOOL OF MECHANICAL ENGINEERING

DEPARTMENT OF AERONAUTICAL ENGINEEING

SAE1603_Airframe Maintenance and Repair Practices

UNIT - 1
PHILOSOPHY OF AIRCRAFT MAINTENANCE

1.1 Aviation Maintenance Program Outlined (AC 120-16D)

Fig:1.1 An A321 from Iberia having its CFM56 changed

Aircraft maintenance is the overhaul, repair, inspection or modification of an aircraft or aircraft component. Maintenance may include such tasks as ensuring compliance with Airworthiness Directives or Service Bulletins. The maintenance of aircraft is highly regulated, in order to ensure safe and correct functioning during flight. National regulations are coordinated under international standards, maintained by bodies such as the International Civil Aviation Organization (ICAO). The maintenance tasks, personnel and inspections are all tightly regulated and staff must be licensed for the tasks they carry out.

Fig:1.2 Maintenance, Repair, Overhaul (MRO)

- The Maintenance, Repair, Overhaul (MRO) Market was US$135.1 Billion in 2015, three quarters of the $180.3 B aircraft production market. Of this, 60% is for civil aviation : air transport 48%, business and general aviation 9%, rotorcraft 3% ; and military aviation is 40% : fixed wing 27% and rotary 13%. Of the $64.3 Billion air transport MRO market, 40% is for engines, 22% for components, 17% for line, 14% for airframe and 7% for modifications. Its is projected to grow at 4.1% per annum till 2025 to $96B.

- Airliner MRO should reach $74.3 Billion in 2017 : 51% ($37.9B) single-aisles, 21% ($15.6B) long range twin-aisles, 8% ($5.9B) medium range twin-aisles, 7% ($5.2B) large aircraft, 6% ($4.5B) regional jets as turboprop regional airliners and 1% ($0.7B) short range twin-aisles.

- Over the 2017-2026 decade, the worldwide market should reach over $900 billion, led by 23% in North America, 22% in Western Europe, and 19% in Asia Pacific.

- In 2017, of the $70 billion spent by airlines on maintenance, repair and overhaul (MRO), 31% were for engines, 27% for components, 24% for line maintenance, 10% for modifications and 8% for the airframe; 70% were for mature airliners (Airbus A320 and A330, Boeing 777 and 737NG), 23% were for ―sunset‖ aircraft (MD-80, Boeing 737 Classic, B747 or B757) and 7% was spent on modern models (Boeing 787, Embraer E-Jet, Airbus A350XWB and A380).

- In 2018, the commercial aviation industry will need $88 billion for MRO while military aircraft should need $79.6 billion including field maintenance for 46.4%.Airliner MRO should reach $115 billion by 2028, a 4% compound annual growth rate from $77.4 billion in 2018. Major airframers Airbus, Boeing and Embraer enter the market, growing concerns about their intellectual property sharing, while shared data-supported predictive maintenance can reduce operational disruptions: among other factors, prognostics helped Delta Air Lines reduce maintenance cancellations by 98% from 5,600 in 2010 to 78 in 2017.

- Insourced maintenance can be inefficient for small airlines with a fleet below 50-60 aircraft. They have to either outsource it or sell its MRO services to other carriers for better resource utilization. For example, the maintenance on South African Comair's 26 Boeing 737s is outsourced to South African Airways' Technical Department. Another example is Spain‘s Air Nostrum operates 45 CRJs and ATR72s and its 300-person maintenance department provides line, base maintenance and limited component repair for other airlines 20% of the time.

1.1.2 Engines

Fig:1.3 commercial aviation engine

- The commercial aviation engine MRO market is anticipated by Aviation Week to be $25.9 billion in 2018, a 2.5 billion increase from 2017, led by 21% for the Boeing 737NG' CFM56-7B and the A320's CFM56-5B and IAE V2500 (also on the MD-90) tied for second, followed by the mature widebody engines: the GE90 then the Trent 700.

- Over the 2017-2026 decade, the largest markets for turbofans will be the B737NG's CFM56-7 with 23%, the V2500-A5 with 21%, the GE90-115B with 13%, the A320's CFM56-5B with 13%, the PW1000G with 7%, the Trent 700 with 6%, the CF6-80C2 with 5%, the CFM LEAP with 5% and the CF34-8 with 4%.[5] Between 2018 and 2022, the largest MRO demand will be for CFM engines with 36%, followed by GE with 24%, Rolls with 13%, IAE with 12% and Pratt with 7%.

- As an aircraft gets older, more of its value is transferred to its engines. Along the engine life it is possible to put value back in it with repair and overhaul, to sell it for its remaining useful time, or to disassemble it for its used parts, to extract its remaining value. Its maintenance value include the value of life-limited parts (LLPs) and the on-wing time before its performance restoration. The core value is the value of its data plate and non-LLPs. Engine makers deeply discount their sales, up to 90%, to win the multi-year stream of spares and services, resembling the razor and blades model.

- Engines installed on a new aircraft are discounted by at least 40% while spare engine values closely follow list prices. Accounting for 80% of a shop visit cost, LLP prices escalate to recoup the original discount, until engine availability increase with aircraft teardowns. Between 2001 and 2018 for the Airbus A320 or the Boeing 737-800, their CFM56 value increased from 27-29% to 48-52% of the aircraft value. The 777-200ER's PW4000 and the A330-300's Trent 700 engines rose from a share of 18-25% in 2001 to 29-40% in 2013. For the A320neo and 737 MAX, between 52% and 57% of their value lies in their engines: this could rise to 80-90% after ten years, while new A350 or B787 engines are worth 36-40% of the aircraft. After some time the maintenance reserves exceed the aircraft lease.

1.1.3 Power-by-the-Hour

- A *Power by the Hour* program provides budget predictability, avoids installing a loaner during repairs when an engine fails and enrolled aircraft may have a better value and liquidity.[16] It was coined by Bristol Siddeley in 1962 to support Vipers of the British Aerospace 125business jets for a fixed sum per flying hour. A complete engine and accessory replacement service was provided, allowing the operator to accurately forecast this cost, and relieving him from purchasing stocks of engines and accessories.

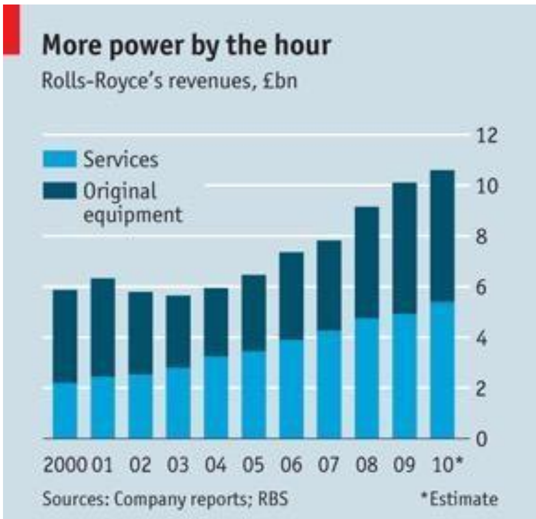


Fig:1.4Power-by-the-Hour

- In the 1980s, Rolls-Royce plc reinstated the program to provide the operator with a fixed engine maintenance cost over an extended period of time. Operators are assured of an accurate cost projection and avoid the breakdowns costs; the term is trademarked by Rolls-Royce but is the common name in the industry. It is an option for operators of several Rolls-Royce aircraft engines. Other aircraft engine manufacturers such as General Electric and Pratt & Whitney offer similar programs.
- Jet Support Services provides hourly cost maintenance programs independently of the manufacturers. GEMCO also offers a similar program for piston engines in general aviation aircraft. Bombardier Aerospace offers its *Smart Services* program, covering parts and maintenance by the hour.

1.1.4 Regulation

Aircraft maintenance is highly regulated, because the smallest slip can lead to an aircraft crashing with consequent loss of life. The International Civil Aviation Organization (ICAO) sets global standards which are then implemented by national and regional bodies around the world.

Local airworthiness authorities include:

- Agência Nacional de Aviação Civil (ANAC) Brazil
- Civil Aviation Administration of China (CAAC) China
- Civil Aviation Authority (United Kingdom) (CAA) United Kingdom
- Civil Aviation Safety Authority (CASA) Australia
- Directorate General of Civil Aviation (India) (DGCA) India
- European Aviation Safety Agency (EASA) Europe
- Federal Aviation Administration (FAA) United States
- Transport Canada (TC) Canada

1.1.5 Personnel

Fig:1.4 Field maintenance on a Cessna 172

Field maintenance on a Cessna 172 being conducted from a van used to carry tools and parts

The International Civil Aviation Organization (ICAO) defines the licensed role of aircraft maintenance (technician/engineer/mechanic), noting that "The terms in brackets are given as acceptable additions to the title of the license. Each Contracting State is expected to use in its own regulations the one it prefers." Thus, aircraft maintenance technicians, engineers and mechanics all perform essentially the same role. However different countries use these terms in different ways to define their individual levels of qualification and responsibilities.

Recognized licenses for aircraft maintenance personnel include:

- Aircraft Maintenance Engineer (AME), also called Licensed Aircraft Maintenance Engineer (LAME or L-AME).
- Aircraft Maintenance Technician (AMT), or colloquially Airframe and Power plant (A&P).
- Aircraft Maintenance Mechanic (AMM).
- As there will be 41,030 new airliners by 2036, Boeing expects 648,000 new commercial airline maintenance technicians from 2017 till then: 256,000 in Asia Pacific (39%), 118,000 in North America (19%) and 111,000 in Europe (17%).
- European authorities
- Aircraft maintenance personnel in Europe must comply with Acceptable Means of Compliance (AMC) Part 66, Certifying Staff, issued by the European Aviation Safety Agency (EASA).
- AMC Part 66 is based on Joint Aviation Regulations (JAR) promulgated by the Joint Aviation

Authorities and on Air Transport Association (ATA) Specification 104.

There are four levels of authorization:
Level 1: General Familiarization, Unlicensed
Level 2: Ramp and Transit, Category A can only certify own work performed for tasks which he/she has received documented training
Level 3: Line Certifying Staff and Base Maintenance Supporting Staff, Category B1 (electro mechanic) and/or B2(Avionics) can certify all work performed on an aircraft/engine for which he/she is type rated excluding base maintenance(generally up to and including A-Check)
Level 4: Base Maintenance Certifying Staff, Category C can certify all work performed on an aircraft/engine for which he/she is type rated, but only if it is base maintenance (additional level-3 staff necessary). This authorization does not automatically include any level 2 or level 3 licenses.

- Checks and inspections
- Routine checks
- Aircraft maintenance checks are periodic inspections that have to be done on all commercial/civil aircraft after a certain amount of time or usage.
- Airbus has indicated that data diagnostics could put an end to aircraft unscheduled grounding for fault repairs around 2025, supported by big data and operational experience. Predictive maintenance, diagnostics and health monitoring could eliminate unscheduled groundings, by making maintenance schedule intervals more frequent to avoid AOGs and the associated operational interruptions, ultimately eliminating them. Data or monitoring can tell that some parts do not need a scheduled check, but a full transition to this model will need much greater experience. With more history, examples and regulatory confidence, the maintenance manual could become a dynamic document for each specific aircraft with every check and interval based on its operational history.
- Airworthiness release
- At the completion of any maintenance task a person authorized by the national airworthiness authority signs a release stating that maintenance has been performed in accordance with the applicable airworthiness requirements. In the case of a certified aircraft this may be an Aircraft Maintenance Engineer or Aircraft Maintenance Technician, while for amateur-built aircraft this may be the owner or builder of the aircraft.[23]
- Automated inspection

Fig:1.5 Airworthiness

1.1.6 Airworthiness responsibility

Who is responsible for Airworthiness?

a) This is a shared responsibility.
b) The pilot is ultimately responsible!
c) As a pilot, you need to understand this.
d) As a flight instructor, you need to make sure that your students understand this.
e) Operating rules prohibit the operation of an aircraft that is not airworthy

Airworthiness is the measure of an aircraft's suitability for safe flight. Certification of airworthiness is conferred by a certificate of airworthiness from the state of aircraft registry national aviation authority, and is maintained by performing the required maintenance actions.

In the U.S., Title 14, Code of Federal Regulations, Subchapter F, Part 91.7 states:

a) No person may operate an aircraft unless it is in an airworthy condition.

b) The pilot in command of a civil aircraft is responsible for determining whether that aircraft is in condition for safe flight. The pilot in command shall discontinue the flight when unairworthy mechanical, electrical, or structural conditions occur which compromise the airworthiness."

1.1.7 Regulations

The principal regulation about airworthiness is found in ICAO international standard of Annex 8 to Chicago Convention on International Civil Aviation which define "airworthy" - in respect of an aircraft, engine, propeller or part there of - as "The status of an aircraft, engine, propeller or part when it conforms to its approved design and is in a condition for safe operation". The application of airworthiness defines the condition of an aircraft and its suitability for flight, in that it has been designed with engineering rigor, constructed, maintained and is expected to be operated to approved standards and limitations, by competent and approved individuals, who are acting as members of an approved organization and whose work is both certified as correct and accepted on behalf of the state of aircraft registry.

Apart from this organization, there are another ones like Federal Aviation Administration(FAA) or European Aviation Safety Agency(EASA) that establish their own rules, but how they are part of ICAO, this societies can't go against it.

Moreover, in the case of the FAA, the regulations about airworthiness is found in title 14 in the document of Code of Federal Regulations, whereas in EASA, the specifications in relation with this topic could be found in several regulations as nº 216/2008 (Basic Regulations), nº 748/2012 (Initial Airworthiness), nº 2015/640 (Additional specifications about airworthiness) and nº 1321/2014 (Continuing airworthiness).[1]

1.1.8 Basic Regulation

In the regulation (UE) 2008, are established common rules in the aviation sector and is created the European Aviation Safety Agency. At the article 5 of this regulation appear the first specifications about airworthiness and at the article 20 is about airworthy certification.

The main objective of this rule is to establish and to maintain a high and uniform security level at the civil aviation in Europe. For that reason, It lays down different rules according to the airworthiness:

- The jets will accomplish the essential established requirements in annex I in airworthy section.
- It will be proved that the products possess a type certificate. Moreover, it is necessary too include modifications certificate of the same jet, it should be included in supplementary type certificate. Both of them it could be sold when the applicant would have proved that his product achieve the regulations' basis.
- It is not operated any airplane if it has not an acceptable type certificate.
- The certificate of airworthiness will be issued when the applicant has demonstrated that the aircraft is conformed to the design of the model approved in its type certificate and that the pertinent documentation, inspections and tests confirm that the aircraft is in a condition for safe use. The certificate of airworthiness shall be valid as long as it is not canceled, or annulled, or is left without effect and provided that the aircraft is kept in accordance with the essential requirements for maintenance of airworthiness.

- The Commission will ensure, in particular, because the current state of the art and best practices in airworthiness are reflected; that keep in mind the experience accumulated in service by aircraft throughout the world, as well as scientific and technical progress; allow immediate response, once the causes of accidents and serious incidents are determined; do not impose requirements on aircraft that are incompatible with the obligations assumed by the Member States by virtue of their belonging of the International Civil Aviation Organization (ICAO).

1.1.9 Initial airworthiness

The Regulation (EU) No. 748/2012 are established the dispositions of application on the airworthiness and environmental certification of aircraft and related products, components and equipment, as well as the certification of design and production organizations.

Besides of the technical requirements and common administrative procedures by the airworthiness and environmental certification, it could be finding too at the regulation nº 748/2012 the following aspects:

- The dispatch of type certificates, of restricted type certificates, of supplementary type certificates, as well as the modifications of already said certificates.
- The dispatch of repairs design approvals.
- The demonstration that environmental protection requirements are achieved.
- The dispatch of noise level certificates.
- The identification and certification of products, components and equipment.
- The certification of the design and production organizations.
- The dispatch of airworthiness directives

This regulation contains an annex, Part-21, which specifies the requirements and procedures for the certification of aircraft and related products, components and equipment, and design and production organizations. Apart from this annex, there are also several certification specifications, including CS-25 for large aircraft, and CS-23, for medium and small aircraft.

1.1.10 Additional specifications about airworthiness

The Regulation (EU) nº 2015/640 establishes additional airworthiness specifications for operations and contains two annexes. The Annex I (Part 26), Subpart A, is devoted to general provisions on the appropriate authority, temporarily inoperative equipment and demonstration of conformity. Subpart B of the aforementioned annex focuses on large aircraft and contains specifications related to seats, berths, seat belts and harnesses; location, access and markings of emergency exits; emergency interior lighting and operation of emergency lights; interiors hold; flammability of the coatings of cargo compartments; fire protection for toilets; acoustic warning of the landing gear and systems for opening and closing the flight crew compartment door - incapacitation of a crew member. Annex II contains an amendment to Annex III (part ORO) of Regulation (EU) No. 965/2012.

1.2 Countinuing airworthiness

The Regulation (EU) No. 1321/2014 controls the continuing of the airworthiness of aircraft and aeronautical products, components and equipment and the approval of the organizations and staff who involve in these tasks. It contains 7 annexes, although Annex V has been repealed. Annex I (Part M); Section A (Technical requirements), "establishes the measures that must be taken to ensure the continuing of airworthiness, including maintenance. Moreover, it specifies the conditions that must be achieved by the people or organizations involved in the management of airworthiness maintenance." Section B (Procedures for the competent authority) "establishes the administrative procedures to be followed by the competent authority for the application and enforcement of Section A of Part M."

The Annex II (Part 145); Section A (Technical requirements), "establishes the requirements which an organization must obey to be able to award or maintain a continuing approval of the elements and aircraft". The Section B (Procedures for Competent Administration) "establishes the administrative procedures that must be followed by the competent authority to execute its tasks and responsibilities in connection with the concession, modification, suspension or revocation of approvals of maintenance organizations Part 145".

The Annex III (Part 66); Section A (Technical requirements), "define the aircraft continuing license and set the requirements for its application, dispatch and continuity of its validity". The Section B (Procedures for the competent authority) "establishes the procedures, requirements, administrative requirements, measurement and control of compliance with Section A of Part 66".

The Annex IV (Part 147); Section A (Technical requirements), "establishes the requirements that must be fulfilled by the organizations that request authorization to carry out training courses and specific examinations in Part 66". Section B (Procedures for competent administration) "establishes the administrative requirements that must be followed by the competent authorities for the application of section A of this part".

The Annex V bis (Part T); Section A (Technical requirements), "establishes the requirements to ensure maintenance of the continuing airworthiness of the aircraft referred to in Article 1, letter b), in accordance with the fundamental requirements set out in Annex IV of the Regulations (EC) No. 216/2008. The conditions to be had by the people and organizations responsible for managing the maintenance of airworthiness and the maintenance of the aircraft in question are also specified". The Section B (Procedures for Competent Authorities) "establishes the administrative procedures that must be followed by the competent authorities in charge of the application and compliance of Section A of Part T".

The Annex VI contains only a table of correspondence between Regulation (EC) No. 2042/2003 and these regulations.

1.2.1 Maintenance manual

The manufacturer‘s aircraft maintenance manual contains complete instructions for maintenance of all systems and components installed in the aircraft. It contains information for the mechanic who normally works on components, assemblies, and systems while they are installed in the aircraft, but not for the overhaul mechanic. A typical aircraft maintenance manual contains: A description of the systems (i.e., electrical, hydraulic, fuel, control) Lubrication instructions setting forth the frequency and the lubricants and fluids which are to be used in the various systems, Pressures and electrical loads applicable to the various systems, Tolerances and adjustments necessary to proper functioning of the airplane, Methods of leveling, raising, and towing, Methods of balancing control surfaces, Identification of primary and secondary structures, Frequency and extent of inspections necessary to the proper operation of the airplane, Special repair methods applicable to the airplane, Special inspection techniques requiring x-ray, ultrasonic, or magnetic particle inspection, and A list of special tools.

1.2.2 Aircraft Maintenance Manual Format

This maintenance manual has the following sections:

Introduction: TL Ultralight introduction, section index, revision listing.

1) General - Listings of general specifications, capacities, abbreviations, task directives, Master Equipment Lists, feedback and warranty forms.
2) Inspections - General daily service, weight & balance, Instructions on and checklists for the completion of the 25 hour periodic and annual condition/100-hour inspections, as appropriate and parts lists.
3) Structures - A description of aircraft structures, subsystems and instructions for assembly, detailed parts and assembly drawings.
4) Engine - A description of and instruction for the maintenance of the aircraft‘s engine.
5) Fuel System - A description of the system, schematic diagram, and instructions for the maintenance and repair of the aircraft fuel system.
6) Propeller - A description of and instructions for the maintenance of the propeller.
7) Systems - A description of the systems and instructions for the maintenance and repair of various subsystems.
8) Instruments and Avionics - A description of and instructions for the maintenance, testing, replacement of instruments and avionics.
9) Electrical System - A description of the system, schematic diagram, and instructions on locations circuits and repair.
10) Painting and Coatings - A description for the repair of small damages, aircraft graphics and paint materials.

1.3 MAINTENANCE ORGANIZATION

1.3.1 Maintenance schedule

THE MAINTENANCE SCHEDULE. Sections 119.49 and 121.135(b) require you to have maintenance time limitations, also called a maintenance schedule. These same rules permit you to use standards for determining your maintenance time limitations, which are the regulatory basis of FAA-approved reliability programs. The maintenance time limitations set out the what, how, and when of your scheduled maintenance effort. Although in the past the schedule included only basic overhaul limits and other general requirements, today it includes a specific list of each individual maintenance task and its associated interval. The regulations are broad enough to permit you to organize all of these individual tasks into a series of integrated scheduled work packages of your own design that provide a continuous succession of necessary or desirable scheduled maintenance tasks for your entire airplane.

- Maintenance record keeping system
- Accomplishment and approval of maintenance and alterations
- Contract Maintenance
- Continuing analysis and surveillance
- Personnel training

Task-Specific Training TL Ultra light, sro may require type-specific training in order to accomplish a task in either the maintenance manual or in an authorization for a major repair, maintenance, or alteration. The FAA does not give approval to these task specific training programs for SLSA. TL Ultra light, sro may specify any task specific training it determines is appropriate to accomplish a task.

Examples of task-specific training include:

1. Engine manufacturer heavy maintenance or overhaul school, or both,
2. Instrument installation or repair course
3. Parachute manufacturer repair course
4. Aircraft manufacturer course.

1.4 HAZARDOUS MATERIALS AND DANGEROUS GOODS

1.4.1 Maintenance, repair and operations (MRO)

Maintenance, repair, and overhaul involves fixing any sort of mechanical, plumbing or electrical device should it become out of order or broken (known as repair, unscheduled, or casualty maintenance). It also includes performing routine actions which keep the device in working order (known as scheduled maintenance) or prevents trouble from arising (preventive maintenance). MRO may be defined as, "All actions which have the objective of retaining or restoring an item in or to a state in which it can perform its required function. The actions include the combination of all technical and corresponding administrative, managerial, and supervision actions."

- MRO operations can be categorized by whether the product remains the property of the customer, i.e. a service is being offered, or whether the product is bought by the reprocessing organization and sold to any customer wishing to make the purchase (Guadette, 2002). In the former case it may be a back shop operation within a larger organization or smaller operation.

- The former of these represents a closed loop supply chain and usually has the scope of maintenance, repair or overhaul of the product. The latter of the categorizations is an open loop supply chain and is typified by refurbishment and remanufacture. The main characteristic of the closed loop system is that the demand for a product is matched with the supply of a used product. Neglecting asset write-offs and exceptional activities the total population of the product between the customer and the service provider remains constant.

1.4.2 Definition

MRO (maintenance, repair and operating supply) items are used in production and plant maintenance and can be items such as maintenance supplies, spare parts, and consumables used in the production process.These items can be either valuated or non-valuated and depending on the value of the items, no physical inventory is performed.

Examples

MRO items include
- Oils
- Lubricants
- Gloves
- Safety equipment
- And cleaning products

❖ In the supply chain, you might think that you're too busy to concern yourself with maintenance, repair and operating supplies (or maintenance, repair and operations or maintenance, repair and overhaul - depending on what you want your MRO to stand for), but you'd be very wrong.

❖ Optimizing supply chain means that you're doing all you can to supply your customers what they want, when they want it - and spend as little money as possible making that happen. Without paying careful attention to all facets or your operations - including MRO - you may not accomplish that optimization.

1.4.3 MRO Responsibility

- ❖ Some organizations put MRO oversight, control or buying within an administrative role. Since MRO items aren't typically managed by your enterprise resource planning tool (ERP), materials resource planning system (MRP) or warehouse management system (WMS), admin employees (like receptionists or admin assistants) are often tasked with placing orders with MRO suppliers on an as-needed basis.

- ❖ But by placing MRO responsibility within your supply chain team, you can take as step toward ensuring your company's operations remain optimized. A supply chain buyer offers several advantages over an admin buyer.

1.4.4 Supply Chain Oversight of MRO

- ➢ First, a supply chain buyer will approach MRO buying with an eye toward safety stock, usage, inventory management and lead times.

- ➢ Supply chain professionals can design and implement a proactive approach to MRO management. Since MRO items are typically not part of your company's official or financial inventory, there may not be a real-time record of how many spare parts, maintenance supplies or consumables you have on hand.

A supply chain pro can rectify that for you.

- Do you know what your lead times are when you need to resupply your MRO items?

- Do you know what your company's usage or depletion rate of MRO items is?

- Do you know how close you are to running out of your MRO items?

- Do you even know how many MRO items you have and what they are?

If not, put MRO under the control of your supply chain team.

1.4.5 Strategic Sourcing and MRO

- A supply chain pro can also approach MRO supply management with a strategic sourcing approach. When was the last time you put your MRO spend out for sourcing review? While some of your inventory items might be hard to re-source (for regulatory, source-control, specification or engineering reasons), your MRO supplier might be able to be sourced from other suppliers more readily.

- If you haven't negotiated MRO costs within the last year or so - or tried to find other MRO suppliers to drive savings - put MRO under the control of your supply chain team. Would saving 3% or 5% or 10% on your MRO spend have an impact to your company's bottom line? Exactly.

1.5 Additional Maintenance Program Requirements

- Engineering
- Material
- Planning
- Maintenance control center
- Training
- Computing Publications

1.6 The Maintenance and Engineering Organization

- Organization of Maintenance and Engineering
- Organizational Structure

–Span of control
–Grouping of similar functions
–Separation of production and oversight function

1.7 The Maintenance & Engineering Organizational Chart

Manager Level Functions

1.7.1 Technical Services Directorate

- Engineering
- Production and planning control
- Training
- Technical publications
- Computing services

1.7.2 Aircraft Maintenance Directorate

- Hangar Maintenance
- Line Maintenance
- Maintenance control center

1.7.3 Overall Shops Directorate

- Engine shops
- Avionics shop
- Mechanical component shops
- Structures

1.7.4 Materiel Directorate

- Purchasing
- Stores
- Inventory control
- Shipping and receiving

1.7.5 Maintenance Program Evaluation Directorate

- Quality assurance
- Quality control
- Reliability
- Safety

1.8 Organizational Structure and the TPPM

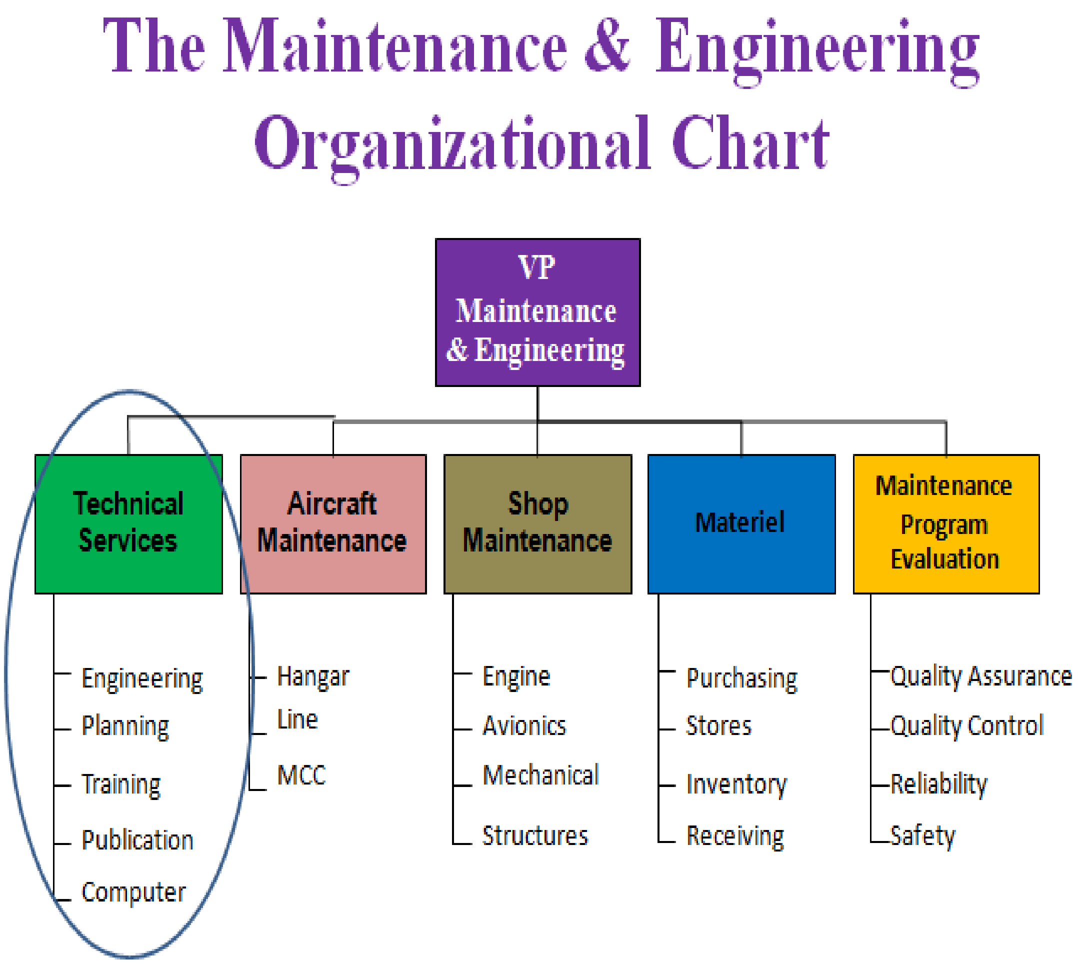


Fig:1.5 Typical Organization

Variations from the Typical Organization

- Small airlines
- Large airlines
- Full versus partial organizational structure

1.9 The Role of the Engineer

Typical Duties

Carries out assignments of daily aircraft maintenance and overhaul programs. Checks condition of aircraft and engine, makes repairs, replacements and adjustments, in accordance with approved maintenance procedures. May direct the work of a number of Air Mechanics and Trades Helpers. May be required to fly with aircraft as flight engineer. Performs other related duties as assigned.

Thorough knowledge of aircraft maintenance procedures and inspection systems Knowledge of aircraft materials and parts and the regulations governing their acceptance for registered aircraft and the process of quarantine action. Knowledge of safety precautions and fire prevention. Ability to select and record data necessary to substantiate airworthiness. Proficiency in the use of measuring instruments and test equipment.

1.9.1 The Role of the Mechanic

Employees in the trade of Aircraft Maintenance Engineering (Mechanical) maintain, inspect and undertake fault diagnosis of aircraft engine systems and airframe components on fixed and rotary wing aircraft.

They:

- remove and install engine systems and airframe components on aircraft;
- inspect engine systems and airframe components on aircraft;
- test and diagnose problems with engine systems and airframe components on aircraft.

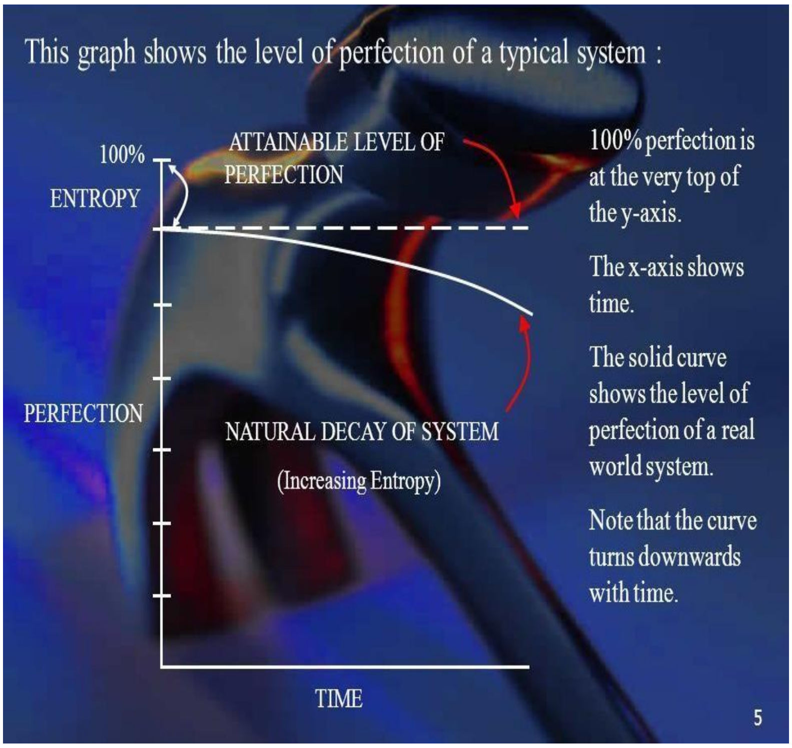
Aircraft engine systems and airframe components include landing gear, wheels and brakes, aircraft pressurization systems, aircraft pneumatic and hydraulic systems, aircraft flight control systems, aircraft environmental control systems, aircraft fire detection and preventions systems, aircraft ice and rain protection systems and their components.

Aircraft Maintenance Engineering (Mechanical) tradespersons are employed in the in the following industry sectors:

Civil aviation maintenance organizations operating under relevant civil aviation safety authority airworthiness regulatory systems, including major airlines, regional airlines, general aviation, third party aircraft maintenance organizations and component maintenance organizations; and

Defense force aviation maintenance organizations operating within the relevant airworthiness regulatory systems, including Defense Force organizations and civilian contractors maintaining defense force aircraft and aircraft components.

Two Types of Maintenance



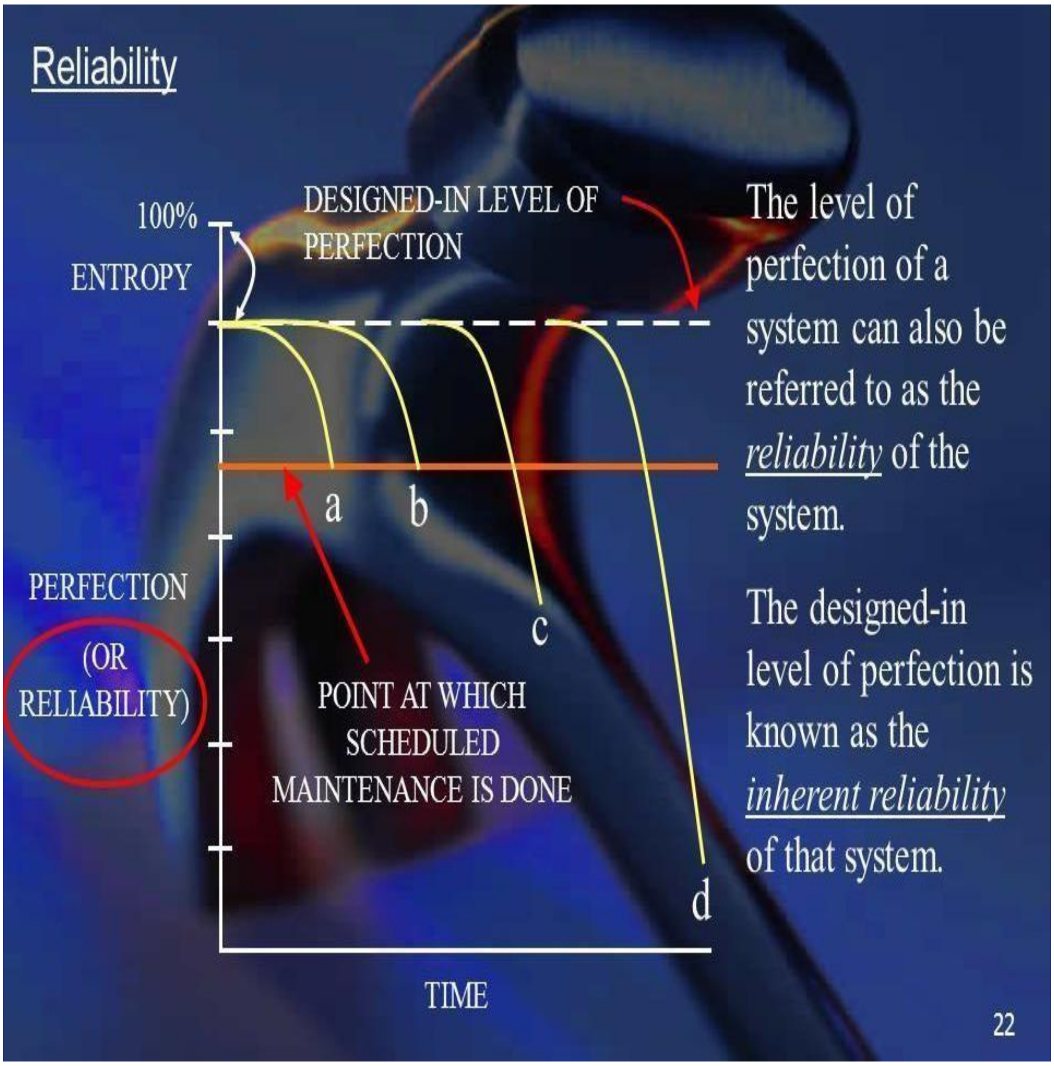
1.9.2 SCHEDULED MAINTENANCE:

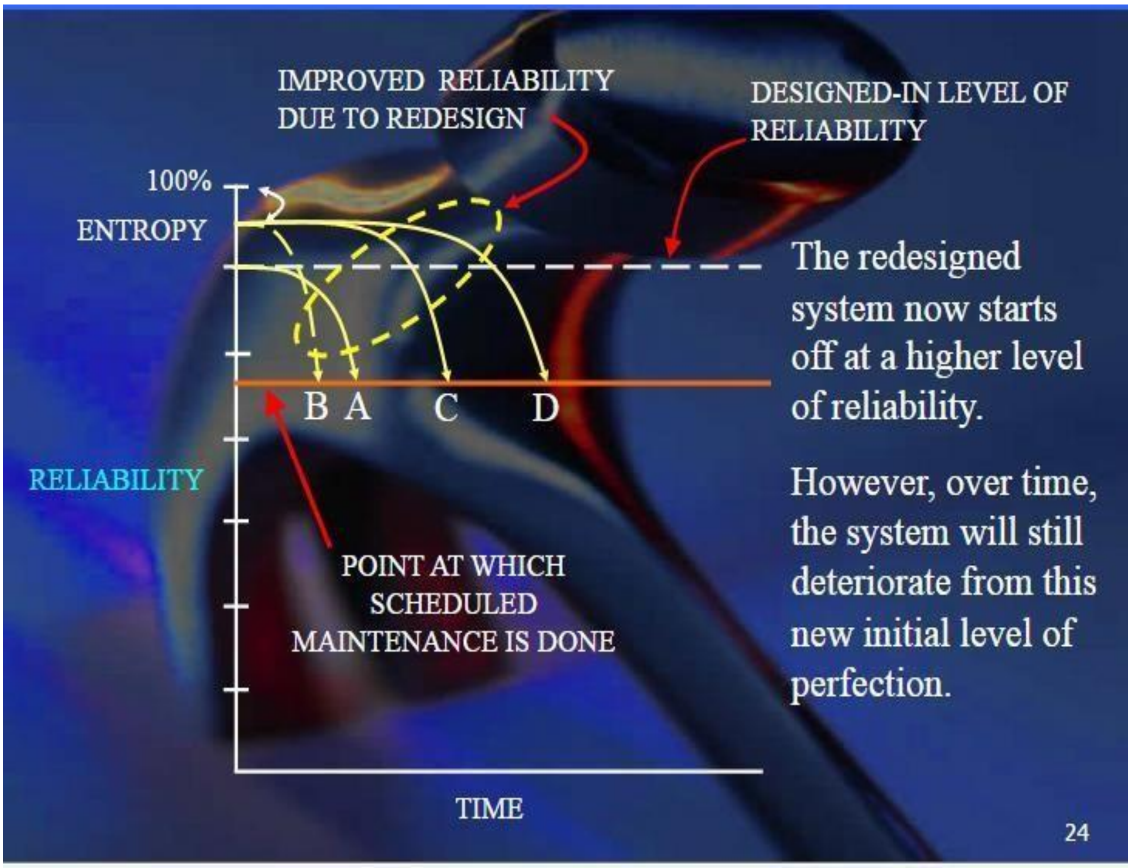
Scheduled maintenance consists of all the individual maintenance tasks performed according to the maintenance time limitations, also called a maintenance schedule. Your scheduled maintenance activities should include procedural instructions for the maintenance tasks and procedures for recording the results of the inspections, checks, tests, and other maintenance. Your procedures should also provide for time-related activities such as recurring ADs, Certification Maintenance Requirements (CMR), and life-limited parts retirement.

1.9.3 UNSCHEDULED MAINTENANCE:

Unscheduled maintenance includes procedures, instructions, and standards for maintenance that occurs on an unscheduled or unforeseen basis. A need for unscheduled maintenance may result from scheduled maintenance tasks, pilot reports, or unforeseen events, such as high-load events, hard or overweight landings, tail strikes, ground damage, lightning strikes, or an engine over-temperature.
In your maintenance manual, you should include instructions and standards for accomplishing and recording unscheduled maintenance.

1.9.4 Reliability

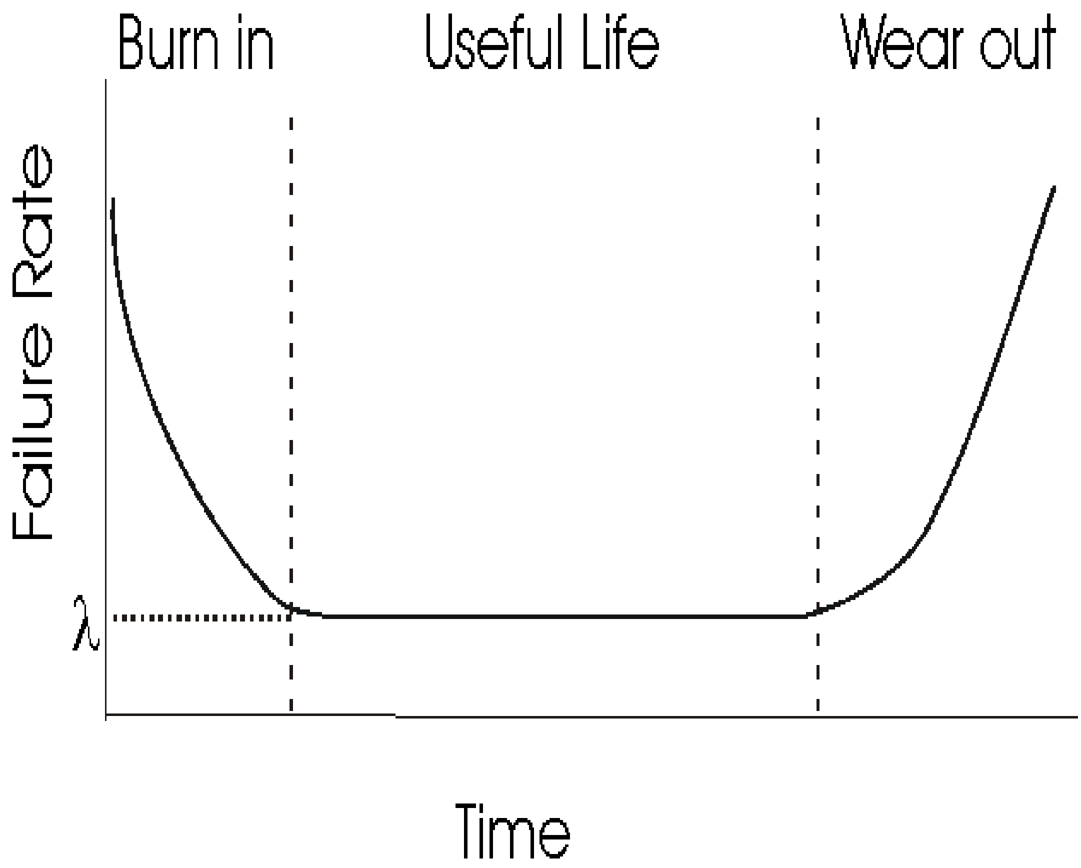


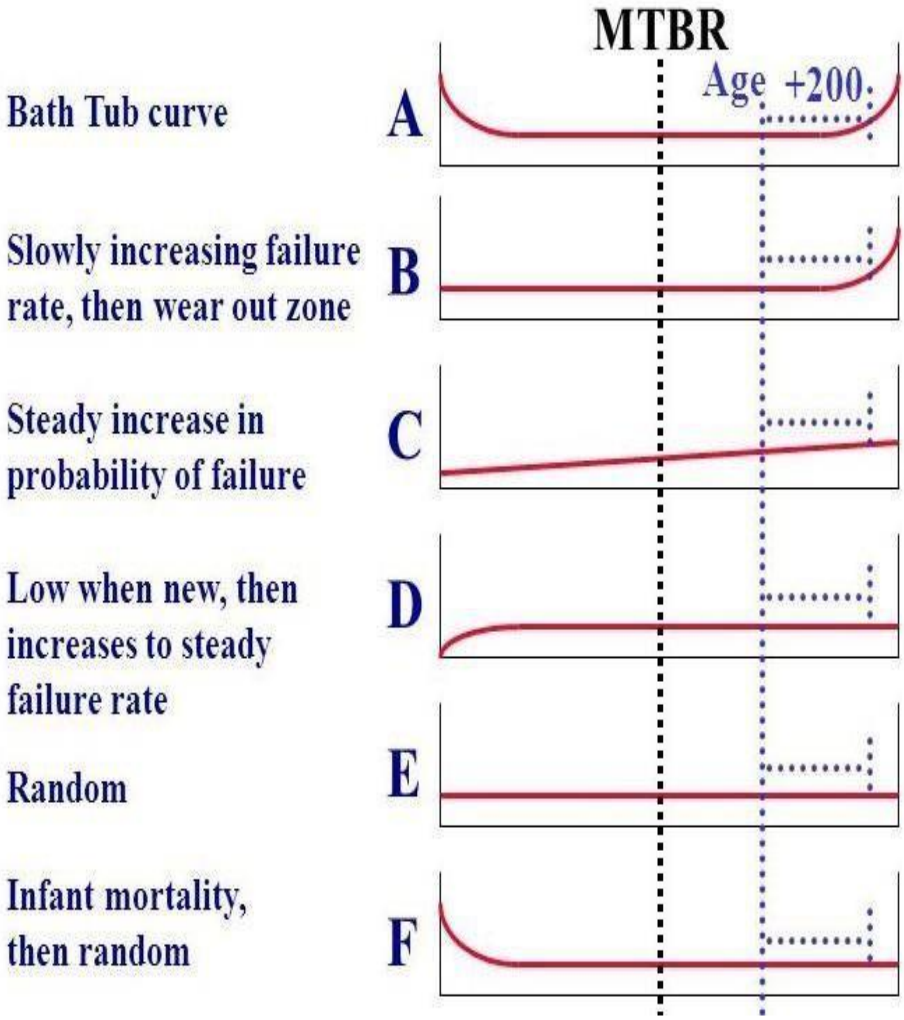


Re

design

Fig:1.6 **Failure Rate Patterns**


Burn in
Useful Life
Wear out
Failure Rate
λ
Time



•Other Maintenance Considerations

•Establishing a Maintenance Program

UNIT - 2

DEVELOPMENT OF MAINTENANCE PROGRAM

2.1 Introduction

The technical meaning of **maintenance** involves operational and functional checks, servicing, repairing or replacing of necessary devices, equipment, machinery, building infrastructure, and supporting utilities in industrial, business, governmental, and residential installations. Over time, this has come to often include both scheduled and preventive maintenance as cost-effective practices to keep equipment ready for operation at the utilization stage of a system lifecycle.

The marine transportation, offshore structures, industrial plant and facility management industries depend on maintenance, repair and overhaul (MRO) including scheduled or preventive paint maintenance programmes to maintain and restore coatings applied to steel in environments subject to attack from erosion, corrosion and environmental pollution.

Road repair

Over time, the terminology of maintenance and MRO has begun to become standardized. The United States Department of Defense uses the following definitions:

- Any activity such as tests, measurements, replacements, adjustments, and repairs—intended to retain or restore a functional unit in or to a specified state in which the unit can perform its required functions.
- All action taken to retain material in a serviceable condition or to restore it to serviceability. It includes inspections, testing, servicing, classification as to serviceability, repair, rebuilding, and reclamation.
- All supply and repair action taken to keep a force in condition to carry out its mission.
- The routine recurring work required to keep a facility (plant, building, structure, ground facility, utility system, or other real property) in such condition that it may be continuously used, at its original or designed capacity and efficiency for its intended purpose.

Maintenance is strictly connected to the utilization stage of the product or technical system, in which the concept of maintainability must be included. In this scenario, maintainability is considered as the ability of an item, under stated conditions of use, to be retained in or restored to a state in which it can perform its required functions, using prescribed procedures and resources.

In some domains like aircraft maintenance, terms maintenance, repair and overhaul also include inspection, rebuilding, alteration and the supply of spare parts, accessories, raw materials, adhesives, sealants, coatings and consumables for aircraft maintenance at the utilization stage. In international civil aviation maintenance means:

- The performance of tasks required to ensure the continuing airworthiness of an aircraft, including any one or combination of overhaul, inspection, replacement, defect rectification, and the embodiment of a modification or a repair.

This definition covers all activities for which aviation regulations require issuance of a maintenance release document (aircraft certificate of return to service - CRS).

2.2 Types

The basic types of maintenance falling under MRO include:

- Preventive or scheduled maintenance, where equipment or facilities are inspected, maintained and protected before break down or other problems occur.
- Corrective maintenance where equipment is repaired or replaced after wear, malfunction or break down.
- Predictive maintenance, which uses sensor data to monitor a system, then continuously evaluates it against historical trends to predict failure before it occurs.

Architectural conservation employs MRO to preserve, rehabilitate, restore, or reconstruct historical structures with stone, brick, glass, metal, and wood which match the original constituent materials where possible, or with suitable polymer technologies when not.

2.2.1 Preventive

Main article: Preventive maintenance

Further information: Planned maintenance

Preventive maintenance is maintenance performed with the intent of avoiding failures, safety violations, unnecessary production costs and losses, and to conserve original materials of fabrication. The effectiveness of a preventive maintenance schedule depends on the RCM analysis which it was based on, and the ground rules used for cost efficacy.

2.2.2 Corrective

Main article: Corrective maintenance

Corrective maintenance is a type of maintenance used for equipment after equipment break down or malfunction is often most expensive – not only can worn equipment damage other parts and cause multiple damage, but consequential repair and replacement costs and loss of revenues due to down time during overhaul can be significant. Rebuilding and resurfacing of equipment and infrastructure damaged by erosion and corrosion as part of corrective or preventive maintenance programmes involves conventional processes such as welding and metal flame spraying, as well as engineered solutions with thermoset polymeric materials.

2.2.3 Predictive

Main article: Predictive maintenance

More recently, advances in sensing and computing technology have given rise to predictive maintenance. This maintenance strategy uses sensors to monitor key parameters within a machine or system, and uses this data in conjunction with analysed historical trends to continuously evaluate the system health and predict a breakdown before it happens. This strategy allows maintenance to be performed more efficiently, since more up-to-date data is obtained about how close the product is to failure.

2.3 Maintenance Steering Group

2.3.1 Description

MSG-3 (Maintenance Steering Group) _Operator/Manufacturer Scheduled Maintenance Development‘ is a document developed by the Airlines For America (A4A) (formerly ATA). It aims to present a methodology to be used for developing scheduled maintenance tasks and intervals, which will be acceptable to the regulatory authorities, the operators and the manufacturers. The main idea behind this concept is to recognize the inherent reliability of aircraft systems and components, avoid unnecessary maintenance tasks and achieve increased efficiency. The underlying principles are that:

- Maintenance only effective if task applicable
- No improvement in reliability by excessive maintenance
- Needless tasks can also introduce human error
- Few complex items exhibit wear out
- Monitoring generally more effective than hard-time overhaul - Condition-based maintenance (sometimes known as CBM)
- Reliability only improved by modification
- Maintenance may not be needed if failure cheaper

MSG-3 is widely used to develop initial maintenance requirements for modern commercial aircraft which are published as a Maintenance Review Board Report (MRBR). It has two Volumes (1 for Fixed Wing Aircraft and 2 for Rotorcraft), and its application will proceed alongside the Type Certification process.

2.3.2 Background

MSG-1 was first published in 1968 and used for developing scheduled maintenance for B747. Subsequently MSG-2 was developed and used for developing scheduled maintenance for 1970‘s aircraft such as L1011 and DC-10. MSG-2 was process orientated and used a bottom-up approach. It also introduced ‗condition monitored maintenance‘ concept.

Based on the experience and the identified weaknesses of MSG-2, the original version of MSG-3 was first published in 1980 and it introduced a top-down approach by focusing on ‗consequences of failure‘. MSG-3 expected the assessment of functional failures and the assignment of the consequences of those failures into two basic categories, ‗SAFETY‘ and ‗ECONOMIC‘. Unlike MSG2, MSG3 is a task orientated and this eliminated the confusion associated with the different interpretations of ‗Condition Monitoring‘, ‗On-condition‘ and ‗Hard time‘. The other fundamental improvement was the recognition of ‗damage tolerance rules‘ and the ‗supplemental inspection programmes‘.

Since 1980, regular amendments have been made to MSG-3, the most recent in 2015 but, as yet MSG-4 has not followed. The latest version of MSG-3 introduced some elements related to Structural Health Monitoring Systems (SHMS), which was the result of issue papers published by the International Maintenance Review Board Policy Board (IMRBPB).

2.3.3 Application

- A so-called Industry Steering Committee (ISC) appoint specialist Maintenance Working Groups who carry out detailed analysis [using the MSG-3 process]. The latter then develop an appropriate series of maintenance tasks for ISC approval.
- The Maintenance Review Board (MRB) consists of appropriate regulatory personnel to monitor development and finally approve the Initial Maintenance Programme. The ISC submit the complete schedule to MRB for approval, and once approved, the MRB will approve it to as a Maintenance Planning Document (MPD).
- As experience with an aircraft type accumulates, the Type Certificate Holder (or manufacturer) and the various operators will seek to develop the MPD throughout the aircraft life. This is due to the fact that the initial MPD may be conservative, and task intervals may be increased as experience is gained. Maintenance periods may also be extended as components are modified to give longer life. However, all extensions should be agreed in a controlled manner i.e. under regulatory oversight.
- As a further step, the MPD will be adapted to suit a particular operator's requirements. Once it has been approved by the appropriate regulatory authority, it becomes an Approved Maintenance Schedule (AMS), but for that operator only.

The basic goal of MSG-3 is to identify maintenance tasks which are both effective and efficient in enabling a new aircraft to be designed and operated in a manner which achieves a satisfactory level of safety and reliability throughout its life. The process is applied for the following four sections:

- Systems and Power plant (including components and APUs)
- Aircraft Structures
- Zonal Inspections
- Lightning/High Intensity Radio Frequency (L/HIRF).

Each section contains methodology and specific decision logic diagrams. Specifically, the ‗Systems & Powerplant‘ section requires the identification of Maintenance Significant Items (MSI) before the application of logic diagrams to determine the maintenance tasks and intervals.

Similarly, in the ‗Aircraft Structures‘ section the initial step is to divide the aircraft structure into

workable areas or zones. Within these Structural Significant Items (SSIs) will be selected within which Principal Structural Elements (PSEs) can be identified. A failed PSE will be capable of causing a catastrophic effect. The remainder of the structure is referred to as Other Structure (OS).
MSG-3 again provides methods and logic diagrams which are to be used for the development of structural inspections tasks. Regulatory guidance concerning damage tolerance and the fatigue evaluation of structure is also found in (FAR/CS 25.571)

In addition to the tasks and intervals identified by MSG-3, there will be other issues associated with ***Certification Maintenance Requirements*** (CMR). These will be identified during an aircraft's Systems Safety Assessment (see FAR/CS25.1309), typically from latent failures or combined events. These may demand additional tasks at different intervals to the MRB report [FAA, 2011].

- ❖ Maintenance Steering Group (MSG) Approach
- ❖ Process-Oriented Maintenance
- ❖ Task-Oriented Maintenance
- ❖ Maintenance Program Documents
- ❖ Maintenance Intervals Defined
- ❖ Changing Basic Maintenance Intervals

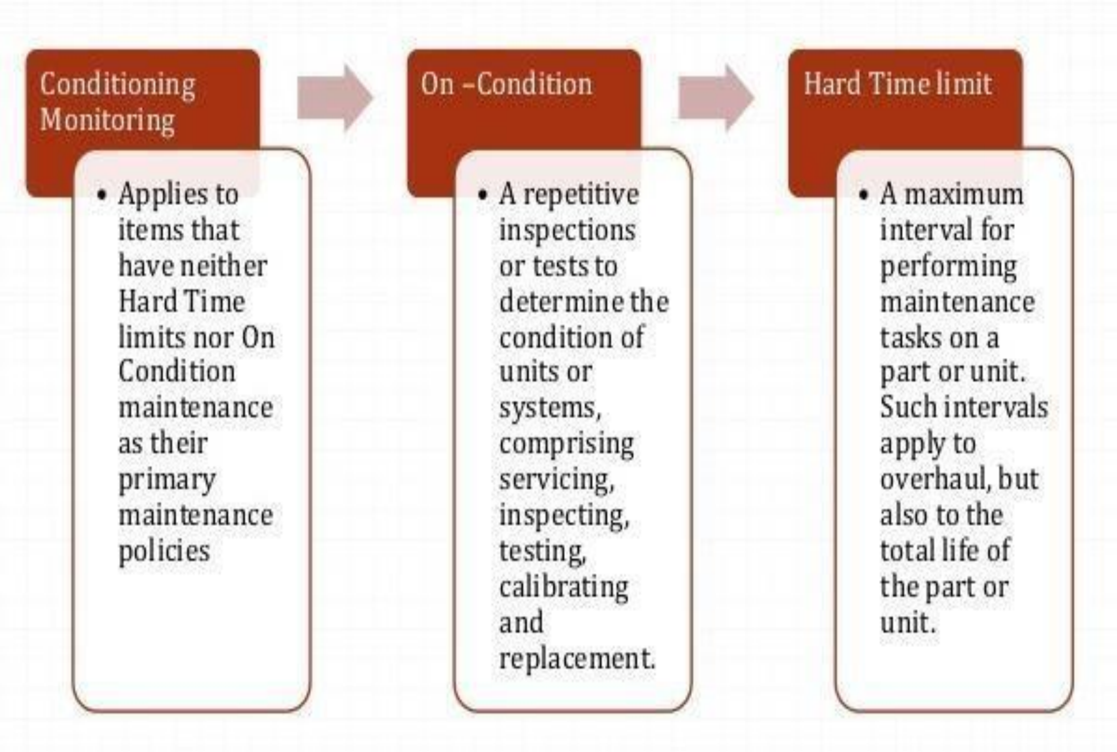
Two basic approaches to Maintenance

a) Process-oriented

b) Task-oriented

Difference between two

- is the attitude toward maintenance actions
- the manner in which actions are assigned to components and systems



2.4 Process-oriented Approach

Hard time (HT) - Is the removal of an item at a predetermined interval (hrs, cycles, calendar time).
On-condition (OC) - Item will be checked at specific intervals (hrs, cycles, or calendar time).
Condition monitoring (CM) - Monitors failure rates, removal rates etc. to facilitate maintenance planning.

HT and OC are for components or systems that have definite life limits or detectable wear out periods. CM items are operated to failure and failure rates are tracked to aid in future prediction or failure rate prevention.

2.4.1 Hard time (HT)

Items that can have an adverse effect on safety but no maintenance check for that condition

- Rubber seals, bushing etc..
- Structural inspection, landing gear overhaul, and life limited engine parts, mechanical actuators, hydraulic pumps and motors, electric motors and generators
- Can be OC as long as not safety related…

2.4.3 On-condition (OC)

On-condition limited to continued airworthiness by measurements or tests without doing a tear-down inspection
Examples

- Tire tread and brake linings
- Scheduled borescope inspections of engines
- Engine oil analysis
- Brake wear indicator pins
- Control cables (measure for diameter, tension, and broken strands)
- Linkages, control rods, pulleys etc (measure for wear, end or side play, or backlash)

Fig:2.1 Borescope

2.4.4 Condition monitoring (CM)

- CM components are operated until failure occurs – unscheduled maintenance
- ATA states regarding CM:

–Item has no direct, adverse effect on safety

–Must not have any ―hidden function‖ (not evident to crew) that could effect safety

–Must be in condition monitoring or reliability program

–Avionics and electronic components

- Basic elements include – data on unscheduled removals, maintenance log entries, on-board data systems, shop findings etc. – can be used to adjust HT and OC intervals
- Only monitors failure not the condition of items

2.4.5 Task-Oriented Maintenance

➢ Uses predetermined maintenance tasks to avoid in-service failures
➢ Redundancy and reliability programs utilized
➢ ―Top-down‖ approach or ―consequence of failure‖
➢ Safety driven
➢ Used to identify suitable scheduled maintenance tasks to prevent failures and maintain the inherent reliability of the system

2.5 THREE CATEGORIES:

o Airframe systems tasks
o Structural item tasks
o Zonal tasks

2.5.1 Maintenance Task for Airframe Systems

2.4.6 Lubrication
2.4.7 Servicing
2.4.8 Inspection
2.4.9 Functional Check
2.4.10 Operational Check
2.4.11 Visual Check
2.4.12 Restoration
2.4.13 Discard

2.5.2 Maintenance Task for Structural Systems

Structural deterioration

- Environmental Deterioration

–Climate or environment

– may be time dependent

- Accidental Damage

–Result of human error or impact with an object

- Fatigue Damage
- –Crack or cracks due to loading or stress

Structural inspection techniques

- General Visual Inspection

–Visual exam that will detect obvious conditions or discrepancies

2.6 ENGINE VISUAL INSPECTION (L/O,RI,RM,A&P)

Check for possible contaminants in the fuel filter, and change it if necessary. If you spot pollution in the engine space, carry out a complete inspection or change the fuel filters of the auxiliary tanks in the interior of the cabin. • Assembly of the engine cover: Check the locking of the tap, the oil and the cooling liquid level. Look for possible worn places on the hoses especially at places, or where they are connected to or near metallic parts of the engine. Carefully check the link of the carburetor with the carburetor bowl stirrup. Looseness or slack in the rubber connector at the neck of the carburetor, is cause for replacement even though it has been tightened, take it off and exchange it according to the carburetor manual.

- Detailed Inspection–Use of inspection aids, (i.e. mirrors, hand lenses) may require surface cleaning and detailed access
- Special Detailed Inspection–Use of Nondestructive inspection (NDI): dye penetrant, high-powered magnification, magnetic particle, eddy current

Zonal Maintenance Task

- Ensures all systems, components, and installations within a specified zone receive adequate screening, security of installation and general condition

- Look, listen, and feel test

–General visual inspection

–Detailed visual inspection

2.7 Maintenance Steering Group

The issue of the effects of corrosion on structural integrity of aircraft has been a question of concern for some time. The Maintenance Steering Group (MSG) system has evolved from many years of corporate knowledge. The first generation of formal air carrier maintenance programs was based on the belief that each part on an aircraft required periodic overhaul. As experience was gained, it became apparent that some components did not require as much attention as others and new methods of maintenance control were developed. Condition monitoring was thus introduced in the decision logic of the initial maintenance steering group document (MSG-1) and was applied to Boeing 747 aircraft.

The MSG system has now evolved considerably. The experience gained with MSG-1 was used to update its decision logic and create a more universal document for application to other aircraft and powerplants. When applied to a particular aircraft type the MSG-2 logic would produce a list of Maintenance Significant Items (MSIs), to each of which one or more process categories would be applied, i.e. 'hard time', 'on-condition', or/and 'reliability control'.

The most recent update to the system was initiated in 1980. The resultant MSG-3 system is based on the basic philosophies of **MSG-1** and **MSG-2**, but prescribes a different approach in the assignment of maintenance requirements. Instead of the process categories typical of MSG-1 and MSG-2, the MSG-3 logic identifies maintenance requirements.

The processes, tasks and intervals arrived at by the use of MSG can be used by operators as the basis for their initial maintenance program. In 1991, industry and regulatory authorities began working together to provide additional enhancements to MSG-3. As a result of these efforts, Revision 2 was submitted to the FAA in September 1993 and accepted a few weeks later. Major enhancements include:

- Expansion of the Systems/Powerplant definition of inspection
- Guideline for the development of a Corrosion Prevention and Control Program (CPCP)

- Increased awareness of aging aircraft requirements
- Extensive revision to the structure logic.

The MSG-3 structures analysis begins by developing a complete breakdown of the aircraft systems, down to the component level.

- ➢ The MSG (Maintenance Steering Group) Logic Process is now over 40 years oId. (MSG-3 is 30 years old). Consider that if we extrapolate backwards from the introduction of MSG we reach the 1930‘s.

- ➢ During the early days of aviation, maintenance programs were simple and without any real analytical process or in fact reliability programs to speak of.

- ➢ As Aviation grew throughout the late 1950′s and into the 1960‘s it was obvious that something had to be done in a different way. Post accident analysis also played a role in creating the demand for a more structured and regulated process.

- ➢ The first steps saw the manufacturer (and in those early days of Jet Aviation there were many manufactures) The basic concept was to determine an appropriate time and to overhaul in fact all component (whether they need it or not was not a consideration).

- ➢ During the latter part of the 1960‘s a task force was created to investigate more cost effective (but equally safe processes) from this, led the concept we now call –on condition maintenance‖.

- ➢ A document was produced during 1968 by ATA (Air Transport Association) -titled Maintenance Evaluation and Program Development, which also became know as –MSG-1,‖ The process was trialed on the Boeing 747. The MSG-1 process used decision logic to develop scheduled maintenance.

MSG-1 / MSG -2 introduced three control processes.

- ➢ Hard Time limit: Maximum interval for performing maintenance tasks on a part or unit. Such intervals apply to overhaul, but also to the total life of the part or unit.

- ➢ On-Condition: Repetitive inspections or tests to determine the condition of units or systems, comprising servicing, inspecting, testing, calibrating and replacement.

- ➢ Conditioning Monitoring: Applies to items that have neither Hard Time limits nor On Condition maintenance, and simply means that the part is left to expire having been determined its failure is not of critical consequence. (however such items were considered as candidates for the Reliability Program)

- ➢ MSG-1 was superseded MSG-2 in the early 1970‘s and used a logic process which considered failures starting at the component level and moving up, with a focus on the understanding that all aircraft, engines and components, reach a period when they should be discarded or overhauled and returned to a –as new‖ condition.

- ➢ Over time a number of drawbacks were found using the MGS-2 process

- ➢ MSG-2 was not designed to consider economic effects, rather maintaining aircraft safety irrespective of the costs involved.

- ➢ MSG 2 Hidden failures (to the pilots) do not receive appropriate consideration.

- ➢ Because MSG-2 is a bottom up approach it was found to be more labour intensive.

- There was some inherent contradiction in the terminology for example –On Condition‖ and –Condition Monitored‖.

- MSG-2 did not pay sufficient attention to modern Corrosion Prevention measures.

- United Airlines in fact made a significant contribution to the further development with sponsorship from the US department of defense. The project considered a different approach to deliver effective maintenance. This was again a logic driven process and in fact became the basis for the MSG-3 process, introduced in 1980 and still in use today (with several revisions).

- The major difference with MSG-3 is that it is a task-oriented approach to maintenance using a methodology which looks at the various failure modes from a system level, or –top down‖.

- In addition economic considerations play a role – Maintenance tasks are performed for safety, operational, or economic reasons.

- The MSG-3 process provide for both preventative maintenance as well as considering tasks to expose potential failures

Maintenance steering group (MSG-1)

Began in 1968 (B747) with reps from Boeing‘s design and maintenance groups, from the suppliers, airlines who desired to purchase aircraft and the FAA.

6 Industrial Working Groups IWGs:
–structures
–mechanical systems
–engine and auxiliary power plant (APU)
–electrical and avionics systems
–flight controls and hydraulics
–zonal
Used –bottom-up‖ review to determine which process to use HT, OC or CM.

Maintenance steering group (MSG-2)

Step 1: Identify the maintenance or structure items requiring analysis.
Step 2: Identify the functions and failure modes associated with the item and the effect of a failure.
Step 3: Identify those tasks which may have potential effectiveness.
Step 4: Assess the applicability of those tasks and select those deemed
necessary. Step 5: For structures only, evaluate initial sampling thresholds.
MSG-2 has slight changes in the following systems when compared with MSG-1

2.8 Maintenance steering group (MSG-3)

- Failure is assigned safety and economic whether it is an evident or hidden failure
- Level One analysis
- Level Two analysis

Some of the major advantages of MSG-3

- MSG-3 is a Top-down process, which enables a step by step systematic analysis.
- MSG-3 delivers lower maintenance costs with typical savings ranging from 15% to 25% for the

same aircraft type on conversion from MSG-3 to MSG-3

- ➢ MSG-3 typically delivers a substantial cost reduction in hard time component removal and replacement
- ➢ MSG-3 results in fewer maintenance tasks but not the importance of managing competencies.
- ➢ Some MSG-3 tasks are carried out for economic reasons, while others are carried out to deliver an improved safety level.
- ➢ Based on an effective and efficient model MSG-3 has continued to be developed to include as a core consideration CPCP (Corrosion Prevention and Control Program), Structural Significant Item Inspection, and Enhanced Zonal Analysis, which introduced the term EWIS Electrical Wiring Interconnect Systems, and Lightning/High Intensity Radiated Fields.
- ➢ Development work continues with Type Certificate Holders continuing to work with aircraft operators, regulators, and the ATA to update MSG-3 to consider improvements to the methodology.
- ➢ The MSG 3 process applies a function, failure, failure effects and causes analysis on each element using a Failure Modes Effect Analysis (FMEA). Potential damage is considered possible from accident, environment or fatigue.
- ➢ Working Groups consider Structure, Systems, Subsystems, Engines, and Zonal with the work being performed by the Maintenance Review Board (MRB). The output of the MRB is known as the Maintenance Review Board Report (MRBR).
- ➢ The main output features of the MSG-3 include On Condition / Hard Time and a very important and much miss understood process called the Zonal Inspection Program ZIP.
- ➢ The MSG system has changed significantly over the last 20 years, MSG-3 is an effective process which can be applied to both aircraft and poweplants.

2.9 Maintenance Review Board Report (MRBR)

- ✓ The MRBR is the basis of the Maintenance Planning Document (MPD).
- ✓ The ―MRB process‖ consists of all the activities performed to produce, review, accept and amend the Maintenance Review Board Reports (MRBR) and Supplement to MRBR.
- ✓ This work instruction developed by the Industry Steering Committee provides guidelines that may be used during the development and revision of the initial minimum scheduled maintenance requirements for derivative or newly type certificated aircraft.
- ✓ The same process must be followed by the Regulatory Authority of the state of the manufacturer when it has been requested by the Applicant to provide assistance to the Applicant during the Applicant‘s compliance demonstration to Certification Specification.

The MRB process is applicable:

1. For Large Aeroplanes and Category A Large Rotorcraft where the EASA is the Primary Type Certifying Authority or for Large Aeroplanes and Category A Large Rotorcraft for which an applicant has applied for EASA type approval. The TC applicant is required, in respect of new or derivative Large Aeroplanes above 13000 kg maximum take off weight and Category A Large Rotorcraft above 9072kg to make application for a Maintenance Review Board (MRB) to the EASA Flight Standards MRB Section unless an alternative process has been agreed (see note below).
2. For aircraft between 5700 KG and 13000 KG maximum take off weight the TC applicant may make application to the EASA Flight Standards MRB Section for an MRB.

–Contains the initial scheduled maintenance program for US certificated operators

–Includes the systems and power plant maintenance program, the structural inspection program, and the zonal inspection program

–Also includes aircraft zone diagrams, a glossary, and list of abbreviations and acronyms

Maintenance Planning Document (MPD)

The Industry Steering Committee (ISC) comprises operators, manufacturers, and regulators who follow the guidance outlined in Advisory Circular AC 121-22A , based on use of ATA MSG 3 methodology to develop the scheduled maintenance program for a given aircraft systems structure and engines which results in the maintenance Review Board Report (MRBR). The MRBR is used as the source document for the MPD.

The ISC, are tasked with developing and establishing the policy for the development of the MRBR proposal and participate in the review and approval process of the ISC. The document is termed the Policy and Procedures Handbook PPH.

The Maintenance Planning Document (MPD) contains all the MRB requirements together with the mandatory scheduled maintenance requirements.

After –proof of concept‖ with the accumulation of reliability data it is quite common for MRBR tasks to receive interval escalation. (Note that –Mandatory‖ Airworthiness Limitation Section (ALS) may only be escalated with the permission and concurrence of the applicable airworthiness authority.)

Maintenance Review Board Report (MRBR) tasks are all derived from the ATA Airline/Manufacture Maintenance Program Planning Document using MSG-3 analysis also listing their MSG-3 Failure effect categories and intervals.

Supplemental inspection tasks derived outside of the MRB process are detailed in the aircraft's Certification Maintenance Requirement (CMR) and Airworthiness Limitation (AWL) documents.

The MPD has all the tasks from the MRBR, plus other tasks over the years which the airframe and engine manufactures suggest or recommend that an operator should carry out.

The MPD will also include SB inspections and some AD tasks if there is no terminating action for the AD. The MPD will also include tasks from the CMP (ETOPS manual).

Section 9 (Boeing) and Section 5 (Airbus) of the MPD has all the mandatory inspections for systems and structure together with the new fuel AWLs listed.

The MPD contains additional planning information for example man hours.

Development of the MPD continues unabated as long as the aircraft remains in service.

The Airframe, Engine and Component Manufacturers work with an Industry Steering Committee to improve the cost efficiency and effectiveness of the maintenance tasks based on accumulation and analysis of maintenance data by the operators.

Operators are responsible for the effectiveness of their maintenance program and welcome opportunities to escalate their scheduled maintenance programs based on MRBR source data .

Typically improvements are developed to optimize the content and interval of maintenance tasks whilst maintaining inherent safety and reliability and delivering cost inefficiencies. Improvements are based on Manufactures analysis of in-service data collected from the worldwide fleet. All improvements are reviewed and approved through an industry process involving TCH, operators, and regulatory agencies.

- Contains all the maintenance task information from the MRBR report plus additional tasks by the airframe manufacturer
- At Boeing, Maintenance Planning Data (MPD)
- At McDonnell-Douglas, On Air Maintenance Planning (OAMP)
- At Airbus, Maintenance Planning Document (MPD)
- Includes diagrams showing locations and numbering of access doors and panels, aircraft

dimensions, planning for maintenance checks – to include man-hour requirements

Maintenance review board(US)

In the United States, initial aircraft maintenance requirements are proposed in a Maintenance Review Board (MRB) report based on Air Transport Association (ATA) publication MSG-3 (Maintenance Steering Group – 3rd Task Force).

Modern transport category airplanes with MSG-3-derived maintenance programs employ usage parameters for each maintenance requirement such as flight hours, calendar time, or flight cycles. Maintenance intervals based on usage parameters allow more flexibility in scheduling the maintenance program to optimize aircraft utilization and minimize aircraft downtime.

Maintenance Intervals

- Most intervals are standard but airlines can create own intervals as long as the integrity of the original task is maintained or receive FAA approval
- Transit Check – pre-flight and turn
- Visual, open/loose panels, fluid leaks
- 48 hour Checks – ―daily‖
- Wheels, brakes, fluid levels, hydraulic fluid
- Hourly limit Checks – (100, 200, 250 etc.)
- Engines, flight control systems
- Operating cycle limit Checks
- Tires, brakes, landing gear, airframe structures
- Letter Checks – (A, B, C, and D)
- Development of 777, MSG-3 eliminated checks
- Changing Intervals
- Hot, humid climates – more CC
- Dry, desert climates – check for sand and dust
- As aircraft age, intervals for some items may shorten while others may lengthen

Aircraft maintenance checks are periodic inspections that have to be done on all commercial/civil aircraft after a certain amount of time or usage; military aircraft normally follow specific maintenance programmes which may or may not be similar to those of commercial/civil operators. Airlines and other commercial operators of large or turbine- powered aircraft follow a continuous inspection program approved by the Federal Aviation Administration (FAA) in the United States, or by other airworthiness authorities such as Transport Canada or the European Aviation Safety Agency (EASA). Under FAA oversight, each operator prepares a Continuous Airworthiness Maintenance Program (CAMP) under its Operations Specifications or "OpSpecs". The CAMP includes both routine and detailed inspections. Airlines and airworthiness authorities casually refer to the detailed inspections as "checks", commonly one of the following: A check, B check, C check, or D check. A and B checks are lighter checks, while C and D are considered heavier checks.

A check

This is performed approximately every 400-600 flight hours or 200–300 cycles (takeoff and landing is considered an aircraft "cycle"), depending on aircraft type.[3] It needs about 150-180 man-hours and is usually on the ground in a hangar for a minimum of 10 hours. The actual occurrence of this check varies by aircraft type, the cycle count, or the number of hours flown since the last check. The occurrence can be delayed by the airline if certain predetermined conditions are met.

B check

This is performed approximately every 6-8 months. It needs about 160-180 man-hours, depending on the aircraft, and is usually completed within 1–3 days at an airport hangar. A similar occurrence schedule applies to the B check as to the A check. However, B checks may also be incorporated into successive A checks, i.e.: Checks A-1 through A-10 complete all the B check items.

C check

This is performed approximately every 20–24 months or a specific amount of actual flight hours (FH) or as defined by the manufacturer. This maintenance check is much more extensive than a B check, requiring a large majority of the aircraft's components to be inspected. This check puts the aircraft out of service and until it is completed, the aircraft must not leave the maintenance site. It also requires more space than A and B checks.

It is, therefore, usually carried out in a hangar at a maintenance base. The time needed to complete such a check is generally 1–2 weeks and the effort involved can require up to 6,000 man-hours. The schedule of occurrence has many factors and components as has been described, and thus varies by aircraft category and type.

D check

This is by far the most comprehensive and demanding check for an airplane. It is also known as an IL or "heavy maintenance visit" (HMV). This check occurs approximately every 6 years.[4] It is a check that more or less takes the entire airplane apart for inspection and overhaul. Even the paint may need to be completely removed for further inspection on the fuselage metal skin. Such a check can generally take up to 50,000 man-hours and 2 months to complete, depending on the aircraft and the number of technicians involved. It also requires the most space of all maintenance checks, and as such must be performed at a suitable maintenance base. The requirements and the tremendous effort involved in this maintenance check make it by far the most expensive, with total costs for a single visit ending up well within the million-dollar range.

Because of the nature and the cost of such a check, most airlines especially those with a large fleet have to plan D checks for their aircraft years in advance. Often, older aircraft being phased out of a particular airline's fleet are either stored or scrapped upon reaching their next D check, due to the high costs involved in comparison to the aircraft's value. On average, a commercial aircraft undergoes three D checks before being retired. Many maintenance, repair and overhaul (MRO) shops claim that it is virtually impossible to perform a D check profitably at a shop located within the United States. As such, only a few of these shops offer D checks.

Given the time requirements of this check, many airlines use the opportunity in order to also make major cabin modifications on the aircraft, which would otherwise require an amount of time that would have to put the aircraft out of service without the need for an inspection. This may include new seats, entertainment systems, carpeting, etc.

UNIT - 3
TECHNICAL SERVICES

3.1 Engineering department

- High degree of expertise, any and all specialties within the aircraft's technical realm: power plant, structures, avionics, aircraft performance, and systems (hydraulic, pneumatic, etc.)
- Development of the maintenance program (tasks, intervals, schedules, blocking, etc.,)
- Establishing the technical policies and procedures of M&E Units
- Evaluation of A/C and facilities (new aircraft, used A/C, new hangars, maintenance shops, storage facilities, buildings, etc.)
- Oversight and evaluate of the incorporation of SBs and SLs
- Assistance in Troubleshooting difficult problem
- Evaluation of maintenance problems determined by the reliability program and for problems
- Issuance of EO

3.2 Production planning and control

- Planning activities related to maintenance and engineering (short, medium, and long term)
- Establishment of standards for man-hours, materiel, facilities, tools, and equipment
- Work scheduling
- Control of hangars
- On-airplane maintenance;
- Monitoring of work progress in the support shops

Production planning and control (PPC) is most essential for any organisation. Planning process within an organisation is dynamic and continuous. In this unit we are going to discuss how production process is planned and scheduled and ultimately implemented in a production unit. For production purpose, all the facilities should be arranged and the factory itself has to be properly set up. PPC involves the planning of production, a decision on the sequence of operations to achieve what has been planned , the setting of starting and finishing time for production, proper dispatching of the material, and follow up action to check the progress of operations.

Planning and control generally involve the planning of manufacturing process. Especially it consists of the planning of routing, scheduling, dispatching, inspection, and coordination, control of materials, methods, machines, tools and operating times etc. The ultimate objective of PPC is to organize the supply and movement of materials and labour, machines utilization and related activities, in order to bring about the desired manufacturing results in terms of quality, quantity, time and place.

Production control regulates and stimulates the orderly show of materials in the manufacturing process from the beginning to the end.

Production planning may be defined as the technique of foreseeing every step in a long series of separate operations, each step to be taken at the right time and in the right place and each operation to be performed in maximum efficiency.

Planning and control are the two most important and dynamic process of management. Managers plan for different activities in their organization and through control mechanism they take corrective actions where ever required.

Production planning consists of the evaluation and determination of production inputs such as labour, machinery and equipment, materials and utilities to achieve the desired goal. The productivity of an organization can be improved by better planning efforts.

Production planning and control can be defined as ―the process of planning or deciding on the resources the firm will require for its future manufacturing operations and of allocating and time scheduling these resources to produce the desired products on time at the least total cost.‖

Generally PPC is used in manufacturing organisations. But it can also be used in different non manufacturing units also. For example, we can use PPC in any restaurant to provide customer service more efficiently.

There are basically four elements in PPC, which are stared as below:
1.Routing
2.Scheduling
3.Dispatching
4.Follow up

Routing is the planning process, which is undertaken to find the best possible path for manufacturing a certain product. It determines what work will be done on a product and how it will be done. It establishes the operations, their path and sequence, and the proper class of machines that require performing specific operations. Routing prescribes the flow of work in the plant and it is related to the considerations of layout, temporary location for raw materials and components and material handling system.

The main aim of routing is to determine the best and cheapest Production Planning and control Routing procedure involves the following different activities:
(1) An analysis of the article to determine what to make and what to buy.
(2) To determine the quality and type of material
(3) Determining the manufacturing operations and their sequence.
(4) A determination of lot sizes
(5) Determination of scrap factors
(6) An analysis of cost of the article

The next step after routing is scheduling. Scheduling is the allocation of resources applying the limiting factors of time and cost to perform a collection of tasks. It involves the assignment of starting and completion times for the various operations to be performed. Therefore scheduling can bring productivity in shop floor by providing a schedule/ routine for processing a set of jobs. Scheduling finds the total time needed for manufacturing of a product. It also finds the time required in each machines to perform each task. The purpose of scheduling is to execute a customer‘s order well in time. For example, if we order for a car, the manufacturer will estimate the time required for its production and then will give us the delivery date. Scheduling is that phase of production and control, which rates the work in order of its priority and then provide for its release to the plant at the proper time and in correct sequence. Thus, scheduling is concerned with when the work shall be performed on a product. Routing and scheduling activities are complementary to each other. One cannot route properly without having previously designed schedule and scheduling is impossible without the knowledge of required routing.

The essence of scheduling is to make allocation decisions pertaining to the starting and finishing times for tasks. Scheduling can be classified into Single machine scheduling, Flow shop scheduling and Job shop scheduling.

Production schedule: The main aim is to schedule that amount of work which can easily be handled by plant and equipment without interference.

Master Schedule: Scheduling usually starts with the preparation of the master schedule which is weekly or monthly break-down of the production requirement for each product for a definite time period. This would enable the production manager to shift the production from one product to another as per the changed production requirements. This forms a base for all subsequent scheduling acclivities. A master schedule is followed by operator schedule which fixes total time required to do a piece of work with a given machine or which shows the time required to do each detailed operation of a given job with a given machine or process.

Best scheduling is not always possible because of the following conditions:

Physical plant facilities of the type required to process the material being scheduled. Personnel who possess the desired skill and experience to operate the equipment and perform the type of work involved and, necessary materials and purchased parts.

While preparing schedules, the types of orders and their promised delivery dates must be taken into consideration. Some orders may call for overtime work because they have to be delivered soon. Such rush orders should receive priority over repeat orders, which can be scheduled for completion in the normal course.

Dispatching is the transition from planning phase to action phase. In this phase, the worker is ordered to start manufacturing the product. Dispatching involves the actual granting of permission to proceed according to plans already laid down. In dispatching, orders are issued in terms of their priority.

The dispatch section of the PPC is responsible for the following task:

- ✓ Checking the availability of material and then taking appropriate action to have it transferred from the main stores to the point at which it is needed
- ✓ Ensuring that all production aid is ready when needed and then having them issued to manufacturing departments.
- ✓ Obtaining specific drawings from the drawing office.
- ✓ Informing the process section that production is commencing.
- ✓ At the conclusion of the manufacturing, ensure that all the drawings, layout and tools are withdrawn and returned to their correct location.
- ✓ Dispatching is an important step as it translates production plans into actual production.

Production control is the process of planning production in advance of operations, establishing the exact route of each individual item part or assembly, setting, starting and finishing for each important item, assembly or the finishing production and releasing the necessary orders as well as initiating the necessary follow-up to have the smooth function of the enterprise. The production control is of complicated nature in small industries. The production planning and control department can function at its best in small scale unit only when the work manager, the purchase manager, the personnel manager and the financial controller assist in planning production activities. The production controller directly reports to the works manager but in small scale unit, all the three functions namely material control, planning and control are often performed by the entrepreneur himself..

Production technique is an updating and revising procedure, through which the requirements of implementation, the labour assignments, the machine assignments, the job priorities, the production routes etc may be revised. It is a correcting mechanism which goes on through out the implementation process of the already drawn out production plan and schedule. In order to perform the function of PPC properly, managers require some techniques to control any deviations. Following are the some of the technical tools used by the managers:

1. Control Charts and Graphs
2. Control Board
3. Communication systems
4. Quantitative techniques

Following are the advantages of using PPC in any plant:
· PPC forecasts sales orders and makes sales order more economical in production.
· It co-ordinates the operations of several departments.
· It ensures better service to customers by delivering quality goods within the specified time period.
· Reduces production costs through orderly scheduling of work activities and reducing wastages.
· Reduces employee idle time.
· Ensures a better control of material and contributes to efficient buying.

3.3 Characteristics of Production Planning and Control:

The forgoing discussion brings out the following traits of production planning and control:
1. It is the planning and control of manufacturing process in an enterprise.
2. All types of inputs like materials, men, machines are efficiently used for maintaining efficiency of the manufacturing process.
3. Various factors of production are integrated to use them efficiently and economically.
4. The manufacturing process is organized in such a way that none of the work centres is either overworked or under worked. The division of work is undertaken very carefully so that every available element is properly utilized.
5. The work is regulated from the first stage of procuring raw materials to the stage of finished goods.

Objectives of Production Planning and Control:

Planning of production precedes control. Whatever is planned needs to be controlled. The ultimate objective of both planning and control is to use various inputs in an efficient way and to have a proper control over various targets and schedules fixed earlier.

The following details will bring out the objectives of production planning and production control:

Production Planning:

1. To determine the requirements for men, materials and equipment.
2. Production of various inputs at a right time and in right quantity.
3. Making most economical use of various inputs.
4. Arranging production schedules according to the needs of marketing department.
5. Providing for adequate stocks for meeting contingencies.
6. Keeping up-to-date information processes.

Production Control:

1. Making efforts to adhere to the production schedules.
2. Issuing necessary instructions to the staff for making the plans realistic.
3. To ensure that goods produced according to the prescribed standards and quality norms.
4. To ensure that various inputs are made available in right quantity and at proper time.
5. To ensure that work progresses according to the predecided plans.

3.4 Heavy Maintenance and Repairs

Aviation Repair Technologies (ART) is an aircraft maintenance company based in Blytheville, Arkansas (one hour north of Memphis, TN). It performs aircraft heavy maintenance, aircraft component repair, aircraft line maintenance, aircraft storage, and aircraft disassembly. The company was founded in 1998 and currently has 5 line maintenance locations in addition to its headquarters in Arkansas. The company has approximately 200 employees.

Services

Aviation Repair Technologies offers a variety of aircraft maintenance services, including heavy aircraft maintenance, component repair, flight structure repair, line maintenance, aircraft disassembly, and short-term aircraft storage.

Heavy aircraft maintenance

Aviation Repair Technologies provides heavy maintenance, including C-checks, cargo conversions, aircraft modifications, and engineering services, for narrowbody commercial aircraft as well as turboprops and regional jets. The company specializes in repairs to the following aircraft types:

- ATR 42, ATR 72
- Dash 8, Q400
- Canadair CRJ-200/700/900
- ERJ 135, ERJ 145, ERJ 175, ERJ 190
- MD80, 737

Line maintenance

ART has a network of 5 airport locations where it provides line maintenance services to its customers. Its services include the following:

- Overnight checks
- A-Checks
- On call repairs and troubleshooting
- GSE maintenance and repair
- Aircraft cleaning

The company's locations include the following:

- BNA: Nashville, TN
- BYH: Blytheville, AR
- CHA: Chattanooga, TN
- CVG: Cincinnati, OH
- TLH: Tallahassee, FL

Aircraft storage and disassembly: Aviation Repair Technologies also offers short-term aircraft storage and aircraft disassembly.

Jet engine test cell: Also located at the airport is an aircraft jet engine test cell that was constructed in 1991 by the US Air Force and is capable of testing engines that produce up to 56,000 lbs of thrust, including CFM56, CF34, and other popular engine types. Aviation Repair Technologies holds an exclusive lease on the test cell through 2019.

Authorization to perform

The holder of an FAA mechanic certificate with airframe or power plant rating(s), or both, or an LSA Repairman maintenance that has received additional task specific training for the function to be performed is generally considered the minimum level of certification to perform heavy maintenance of TL Ultralight, sro LSA aircraft.

Typical Tasks Considered as Heavy Maintenance include:

1. Removal and replacement of components for which instructions are provided in the maintenance manual or service directive instructions, such as:

2. Complete engine removal and reinstallation in support of an engine overhaul or to install a new engine,

3. Remove and replacement of engine cylinders, pistons, or valve assemblies, or a combination thereof,

4. Primary flight control cables/components,

5. Landing gear assemblies.

6. Repair of components for which instructions are provided in the maintenance manual or service directive instructions,

7. Structural repairs of components or aircraft structure, or both, for which instructions are provided in the maintenance manual or service directive instructions.

3.5 Training

- ➢ Responsible for curriculum, course development, administration, and training records for all formal training attended by the M&E unit's employees.
- ➢ Coordinates any training required outside (vendor training)
- ➢ Coordinates with line and hangar maintenance personnel for the development of on- the-job training and remedial or one-time training activities
- ➢ Establish new and special training courses to meet the needs of the airline (problem investigation by reliability, new equipment or modifications, or the addition of aircraft types to the fleet)

3.6 Technical publications

- ➢ Responsible for all technical publications used by the M&E organization
- ➢ Keeps a current list of all documents received from manufacturers and vendors as well as those produced in-house by the airline
- ➢ Ensuring that appropriate documents and revisions are distributed to these various work centers
- ➢ Responsible for maintaining the main technical library and any satellite libraries within the airline's system, including those at out stations.

Publications Aeronautical publications are the sources of information for guiding aviation mechanics in the operation and maintenance of aircraft and related equipment. The proper use of these publications will greatly aid in the efficient operation and maintenance of all aircraft. These include manufacturers‘ service bulletins, manuals, and catalogs; FAA regulations; airworthiness directives; advisory circulars; and aircraft, engine and propeller specifications. Manufacturers‘ Service Bulletins/Instructions Service bulletins or service instructions are two of several types of publications issued by airframe, engine, and component manufacturers.

The bulletins may include:

(1) Purpose for issuing the publication,
(2) Name of the applicable airframe, engine, or component,
(3) Detailed instructions for service, adjustment, modification or inspection, and source of parts, if required and
(4) Estimated number of man hours required to accomplish the job.

Computing services

- Responsible for the definition of the M&E organization's computing requirements
- Selection of software and hardware to be used, with usage information and requirements inputs from the individual units
- Training of maintenance, inspection, and management personnel on computer usage
- Provide continuing support to the using organizations

UNIT - 4

MAINTENANCE AND MATERIEL SUPPORT ORGANIZATION STRUCTURE

4.1 Aircraft Maintenance Operations

Hangar maintenance

Responsible for compliance with the airline's policies and procedures relative to all work done on the aircraft in the hangar,

- ❖ Modifications
- ❖ Engine changes
- ❖ "C" checks (and higher)
- ❖ Corrosion control
- ❖ Painting
- ❖ Various support shops (welding, seat and interior fabric, composites, etc.)
- ❖ Ground support equipment.

Fig:4.1 **Hangar maintenance**

4.2 Line Maintenance

Responsible for compliance with the airline's policies and procedures relative to the work done on the aircraft on the flight line while the aircraft is in service

- Turnaround maintenance and servicing
- Daily checks
- Short interval checks (less than "A" check interval), and "A" checks. Sometimes
- Simple modifications
- Perform line maintenance activities for other airlines under contract.

Line Maintenance and Repairs Authorization to Perform - The holder of an LSA repairman certificate with either an inspection or maintenance rating is generally considered the minimum level of certification to perform line maintenance of TL Ultralight LSA aircraft. The examples listed below are not considered as restrictions against the performance of such tasks by an owner who is authorized to perform said task by the FAA.

Fig:4.2 Typical Tasks Considered as Line Maintenance

1. 100-hour inspection,
2. Annual condition inspection,
3. Servicing of fluids,
4. Removal and replacement of components for which instructions are provided in the maintenance manual.
5. Repair of components and structure for which instructions are provided in the maintenance manual and which do not require additional specialized training.
6. Compliance with a TL Ultralight, sro service directive when the repairman is listed as an authorized person to accomplish the work described.

4.3 Maintenance Control Center - MCC

1. Responsible for keeps track of all aircraft in flight and at outstations.
2. All maintenance needs of these vehicles are coordinated through the MCC
3. MCC also coordinates downtime and schedule change with the flight department.

Fig:4.3 Overhaul Authorization

Overhaul Authorization to Perform—Only TL Ultralight, sro or the component to be overhauled on an LSA may perform or authorize to be performed the overhaul of an LSA component. In the U.S., no FAA certification is required to be an LSA approved overhaul facility.

Overhaul Manual—A separate overhaul manual in addition to the TL Ultralight, sro maintenance manual is required to perform the overhaul of an LSA aircraft or LSA aircraft component.

Typical components that are overhauled include:
1. Engines,
2. Carburetors/fuel systems,
3. Starters/alternators/generators,
4. Instruments,
5. Propellers,
6. Ballistic parachute systems.

Mechanical component shops - Mechanical components: actuators, hydraulic systems and components, aircraft surfaces (flaps, slats, spoilers), fuel systems, oxygen. pneumatics, etc.

Structures - Maintenance and repair of all aircraft structural components, includes composite material as well as sheet metal and other structural elements.

Inventory control - Ensuring that the parts and supplies on hand are sufficient without tying up excessive funds in nonmoving items and without running out of stock too soon or too often for commonly used items.

Stores - Storage, handling, and distribution of parts and supplies used by the maintenance personnel in line, hangar, and shop maintenance activities

UNIT - 5
MAINTENANCE DOCUMENTATION AND QUALITY ASSURANCE

5.1 Function Quality program

- Quality Assurance
  - –Covers everything from raw materials and GMP verification through finished- product release
  - –HACCP is part of QA
- Quality Control
  - –Actual manufacturing process

Quality Assurance

- Written definition or policy
- Reporting pathways
- Authority
- Product standards

Quality can be described in a number of different ways depending on the perspective and the product or process involved. Quality is defined as "an inherent feature, a degree of excellence, having certain properties and grade." Webster's Dictionary defines quality control as "an aggregate of activities (as design analysis and statistical sampling with inspection for defects) designed to ensure adequate quality especially in manufactured products." While quality means different things to different people, AMTs should define quality as a collection of processes designed and implemented to ensure adequate quality exists in both aviation maintenance processes and products.

Let's go back a few years to the time when Quality Control (QC) was introduced as a product- oriented concept. Picture an inspector sitting at the end of an assembly line looking at each widget as it came down the chute. Inspectors looked for obvious defects and checked dimensions with some sort of "go/ no-go" gauge. The aviation equivalent would be a team of inspectors in a large operation, or an IA inspecting an aircraft after a major repair or phase inspection. This type of inspection looked at the finished product with little emphasis on the process that produced that product. Depending on the "product," this system worked quite well for a long time, but as manufacturing complexity evolved, end of assembly line inspection was not sufficient. Into that equation was also thrown cost, economies of scale, new materials, and new manufacturing processes.
One component of a quality management system is Quality Assurance (QA), and is most closely identified with ISO-9000, Six Sigma, and its successors. It is a process-based system that places more emphasis on how something is made rather than the final product. The rapid evolution of computers and their widespread use in manufacturing has allowed the process to become the focus of quality assurance, because computers can perform the same function many times with little or no error. One example is the modern CNC milling machine. Not only can these machines make parts

with tolerances down to the fifth decimal place (.0000X), but they are smart enough to sense when the cutting tool starts to become dull.

Statistical process control has become the standard for manufacturing operations that use high technology machinery, and this quality process has been applied to the balance of quality programs in many different industries.

5.2 Quality Control Issues

Most respondents stated that they audit their vendors or suppliers at least once a year. In one instance, one respondent reported that they audit their primary vendors once every other year. This was dependent upon the scale and scope of work performed by the vendor. In most cases, if the vendor was considered one which was primary and performed substantial work, an audit was done on-site by a representative of the respondent. If the work was not considered substantial, aquestionnaire was mailed out to be completed by the vendor. Internal audits were reported as being completed daily by the quality assurance department at each repair station interviewed. A quality assurance department existed at all repair stations in the sample. FAA audits were performed regularly on each of the repair stations in the sample. The frequency of these audits varied from once a month to once a year. The reasons for this difference in frequency depended upon the size of the facility and the relationship with the cognizant PMI. Variability was also reported as to the frequency of audits by clients, which ranged from never to once every few years. In some cases, the inspector was from CASE on behalf of the client. Three respondents stated that a new client usually inspected the facility. Occupational Safety and Health Administration (OSHA) was reported as another government agency that performed inspections, but none of the respondents claimed they did so frequently. Two respondents reported that they were audited by the JAA once every 1 to 2 years. There was some variability as to the responsibility of returning the aircraft or component to service. Two repair stations reported that the airline for which they were performing work was involved in this process. A similar situation existed at one repair station for supplying parts. In this case, it was the responsibility of the client to determine part sourcing.

❖ Support
- Top management must buy into what QA is doing
- QA manager must report to CEO or direct link
- Corporate support does not always make one popular with local managers but is critical for maintaining high quality standards

❖ Safety
- Conflicts may exist between optimum quality and food safety
- Manufacturers must recognize that many processes that ensure food safety do not enhance product quality
- Any time a process change occurs to improve quality, product safety requires reverification
- Responsibility may fall to QA

❖ Supervision

- Person with basic educational knowledge
- Desire to do the job

–The job is relentless and does not go away over the weekend. The quality manager must address the issues as they arise. If one leaves an issue on Friday without making a decision, then on Monday, one is already two days behind. The consensus is that the good supervisors have a fire in their belly that keeps them on top of things and does not allow them to become complacent. One cannot ride along hoping that things will get better without some type of intervention.‖ Dean Tjornehoj, director of quality assurance, Land O'Lakes, Inc.,

❖ What is Quality

- The ability to make the same thing the same way, over and over again
- Customer buys today is same as what they bought last week or will buy next week
- Product meets customer's expectations 100% of the time

❖ Reliability

- Definition (in statistical term):
- ‗the probability of failure free operation of an item in a specified environment for a specified amount of time'

Examples:

If eight delays and cancellations are experienced in 200 flights, that means 96% of flights dispatched on time for the airline.

Effective February 15, 2007, the FAA ruled that US-registered ETOPS-207 operators can fly over most of the world provided that the IFSD rate is 1 in 100,000 engine hours. This limit is more stringent than ETOPS-180 (2 in 100,000 engine hours).

5.3 Two main approaches of reliability in the aviation industry

- First approach is the overall airline reliability, essential means the dispatch reliability, that is, how often the airline achieves an on-time departure of its scheduled flights. The reasons of delay are categorized as maintenance, procedures, personnel, flight operations, air traffic control (ATC). etc.

- Second approach is to consider reliability as programs specifically designed to address the problems of maintenance-whether or not they cause delays and provide analysis of and corrective actions for those items to provide the overall reliability of equipment. This contributes to the dispatch reliability as well as the overall operation.

5.3.1 Reliability Program (for maintenance)

A set of rules and practices for managing and controlling a maintenance program. The main function is to monitor the performance of the vehicles and their associated equipment and call attention to any need for corrective action.

Additional functions:

- Monitor the effectiveness of those corrective actions

Provide data to justify adjusting the maintenance interval or maintenance program procedure as appropriate

Aircraft Reliability Programme

The reliability programme of aircraft in operation and maintenance is a combination of statistic monitoring and recording of the events associated with the airworthiness of an aircraft. The results obtained by monitoring reliability in operation may serve as a basis for supplementing or modifying the aircraft maintenance programme; such changes would indicate the malfunction of components or systems manifesting lacks and the need for early control, or replacement during utilization.
On the basis of the reports on reliability monitoring of air carriers‘ maintenance services, the aircraft manufacturer collects and analyses the data for a large number of aircraft, thus being able to establish which are the systems and respectively components of the aircraft that cause problems in aircraft operation in most cases. In this article the methodology of calculating the indicators of reliability monitoring is described and the results of reliability monitoring presented on the example of one type of aircraft.

In the aircraft industry maintenance is considered to be one of the key segments in the business successfulness of an air carrier. By this, efforts are made to achieve maximal aircraft utilization with a security level as high as possible and minimal operative and ecological costs. As a result, aiming to increase profitability, and monitoring the reliability of an aircraft, its components and systems is of great benefit to aircraft carriers.

The primary purpose of any aircraft reliability programme is the collection of data and information and their statistic analysis to get valuable feedback with the data on irregularities developed in operation for an air carrier and a manufacturer. The programme of reliability monitoring serves as a supplement to the standard maintenance programme of a particular aircraft in order to maintain its continuous airworthiness.

In the first part of the article the methodology of calculating the parameters for aircraft reliability monitoring in operation and the interpretation of monitoring results are presented. Further on, a report of the manufacturer of one aircraft type is given, together with the presentation of the components with the highest number of unscheduled removals on the aircraft. At the end some concluding remarks are brought.

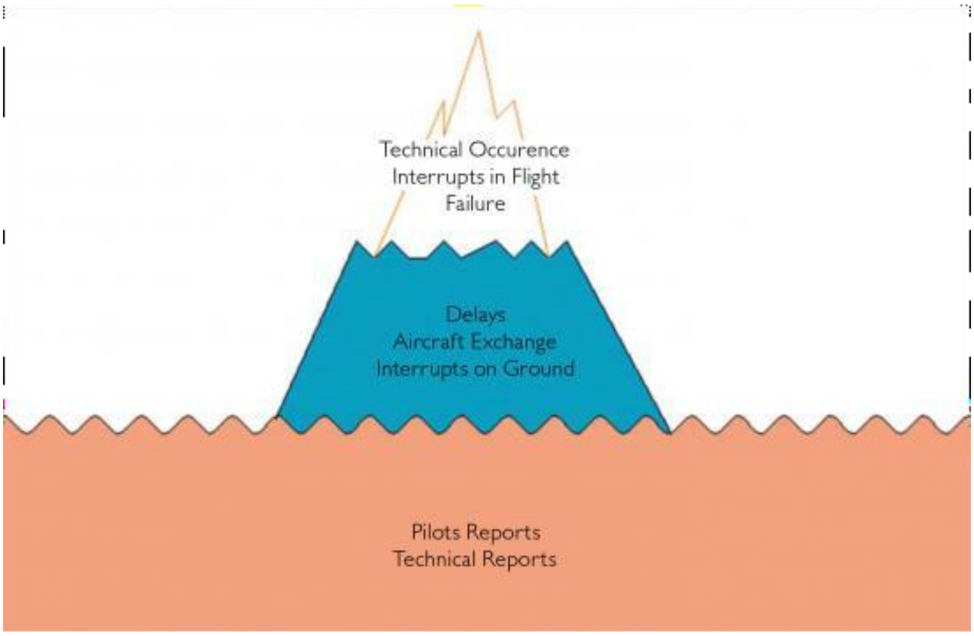


Fig:5.1 reliability technical data

FIGURE 1. THE “ICEBERG” OF PARAMETERS FOR MONITORING AIRCRAFT RELIABILITY.

For monitoring the aircraft reliability technical data obtained in operation as well as regular and extra inspections of an aircraft, its systems and components are evidenced. The data collected in that way are the basis for each reliability monitoring and the conclusions obtained and based on them depend on their accuracy and so the total result. The obligation of collecting the data lies on the air carrier according to the requirements of aviation regulations for keeping continuous airworthiness of aircrafts EASA PART M*, item M.A.302 (d) and acceptable ways of meeting the requirements AMC** M.A.708 (c). The parameters monitored for aircraft reliability in operation are the following:

- flight hours
- flight cycles
- technical delays
- technical cancellation
- pilot reports
- technical staff reports
- unscheduled component removals
- component removals
- in-flight shut down
- unscheduled engine removals
- shop visits.

To facilitate comparisons between air carriers for the same type of aircraft the reliability indicators may be classified in four main groups:

- general aircraft reliability indicators
- structure reliability indicators
- aircraft components reliability indicators
- power plant reliability indicators.

After collecting the data for a given month, they are statistically analysed and the data of aircraft availability and reliability obtained. The parameters are to be monitored as a large whole, so that the reliability programme would be as effective as possible. This may be well illustrated by an ―iceberg‖, **Figure 1**.

In Figure 1 it is evident that the reports and complaints (of pilot/technical staff) themselves do not indicate which problem has the largest effect on aircraft operations and that operative interruptions (technical occurrence, interrupts in flight, failures) show only the tip of the –iceberg‖ and not the cause of the problem.

Interpretation of the Results of Reliability Monitoring

When all the data for a given month are collected, calculations follow showing the reliability level of the aircraft, its components and systems. The systems and the components of an aircraft are classified according to ATA-100 specification, which is a standard documentation for all commercial aircraft. According to ATA-100 specification, an aircraft is divided into systems and subsystems. The systems are constituted of a power plant, structure, electric systems and similar. Subsystems include particular parts, which together make one system. They are all specified by a multi-digit ATA number, where the subsystems of one system have the same two digits as the ATA number of the system they form.

Aircraft Availability

For aircraft availability assessment as an indicator –an average number of available aircraft of a fleet in an observed period‖ is usually used. The observation period of one month is considered. The aim is to get the data on the average number of available aircraft in the period observed. The total possible capacity of the fleet of one aircraft type expressed in hours is:

$huk = hm \cdot iuk$

where:

hm – is the number of hours in the period observed, e.g. one month

iuk – is the total number of aircraft of the observed type.

Due to maintenance, the aircraft were not operatively available for hs hours, and available for use $uk \;\; s$ $h = h - h$ hours, respectively. Accordingly, the number of available aircraft during the observed period of time equals:

$ia = huk - hs / huk \times iuk$

Aircraft Despatch Reliability

Aircraft despatch reliability is the probability that the aircraft will take off on scheduled time. Here the delays occurred due only to technical reasons, i.e. due to carrying out maintenance services are considered. The despatch reliability is defined by:

$Rd = 1 - nd + nc / n$

where:

nd – is the number of delays in the observed period being larger than some default time due to technical reasons (5 to 15 minutes)

nc – is the number of flight cancellations due to technical reasons

n – is the total number of cycles (of takeoffs) in the observed period.

As an indicator, instead of –despatch reliability‖, –despatch reliability rate‖ is usually which expresses the despatch reliability in percentages. This may also be interpreted as an indicator of successful aircraft despatches in relation to a hundred take-offs.

Aircraft System Reliability

Aircraft systems are monitored according to ATA 100 specification. To assess reliability the malfunction of particular aircraft systems is monitored, due to which some components are to be removed in an unscheduled manner. Also in this case this indicator is in practice presented in somehow modified form and called –the system reliability rate‖, and it shows an average number of unscheduled removals of particular components of a system to a thousand hours of flight.

$iur = nur / nks \cdot h \times 1000$

where:

nur – is the total number of unscheduled component removals in the observed period *nks* – is the number of components in a system *h* – is the total aircraft flight hours in the observed period.

Number of Pilots and Technical Staff Reports

Reliability indicators may be defined on the basis of pilot reports or on the basis of observations of technical staff. For example, ―the level of reliability on the basis of pilot reports in the observed period in relation to a hundred take-offs‖ can be defined:

ip = np / nto x 100

where:

np – is the number of pilot reports in the observed period

nTO – is the number of take-offs – number or cycles in the observed period.

Indicators of Structural Reliability

Aircraft structural reliability is obtained by the methods of non-destructive testing – NDT. Structural health monitoring – SHM represents a concept of a system for continuous monitoring technical health of aircraft structure. The basic principle is the creation of reliable non-destructive technology, which would be an integral part of aircraft structure. Sensors would be built into the aircraft to detect failure (material fatigue, erosion, etc.) in time and by its reporting enable the carrying out of further actions.

Indicators of Aircraft Components Reliability

All contemporary transport aircraft are equipped with an onboard maintenance system. For mechanical components, this means that sensors permanently measuring certain parameters of a system are installed, and on which bases technical health may be estimated. These are, for example, the sensors measuring pressure, temperature, vibration and movements.

These systems called BITE (Built In Test Equipment) enable the detection of malfunction during operation. ECAM (Electronic Centralized Aircraft Monitoring) controls all the parameters of an aircraft and informs and alerts the crew of the aircraft over displays.

DFDRS (Digital Flight Data Recording System) i.e. ―the black box‖ is an obligatory device in an aircraft. It stores aircraft parameters serving also for the analysis of a possible incident. The failures or breakdowns of a particular system are diagnosed and memorized by CFDS (Centralized Fault Display System).

Power System Reliability

For measuring power system reliability, the technology enabling these data to be automatically collected during flight and stored in a portable medium is used. The analysis is carried out on a computer in a technical base. Further development of this data analysis system tends to send certain data to a technical base already during flight, so that technical service could be prepared for carrying out the possibly needed actions of maintenance even before landing of the aircraft.

For a power plant the following is usually monitored:

- in-flight shutdowns
- unscheduled removals
- shop visits.

Alert Level

For each mentioned parameter of measuring aircraft reliability the alert level should be determined. It is used to recognize and react to every significant deviation from statistically acceptable levels of reliability. The state of the system on the basis of reliability indicators can be assessed by three values: stable, unstable and critical. The stable state presumes that reliability indicator ranges between some control levels; in an unstable state the parameter gets out and returns within the control levels or gets into a critical zone and gets back under it. For some indicators control levels are defined in relation to an average value of a parameter. According to this criterion the upper control level (GKG) and lower control level (DKG) equals:

$GKG = x + k \cdot \sigma$

$DKG = x - k \cdot \sigma$

$x = \Sigma\, x / N$
$\sigma = \Sigma\, (x2) - (\Sigma x / N)2 / N - 1$
where:
x – is the mean value of the indicator
s – is standard derivation
k – is the factor of deviation, number 1 to 3 (usually between 2 and 3)
N – is the number of months considered.
The upper control level, which may also be called the alert level, is an indicator for carrying out certain actions in maintenance, planning and similar. It is based on statistical calculations of standard derivations in the period of twelve months. It may be increased or decreased by up to 10 % in relation to previous level. Exceptionally, larger deviations may also be allowed.

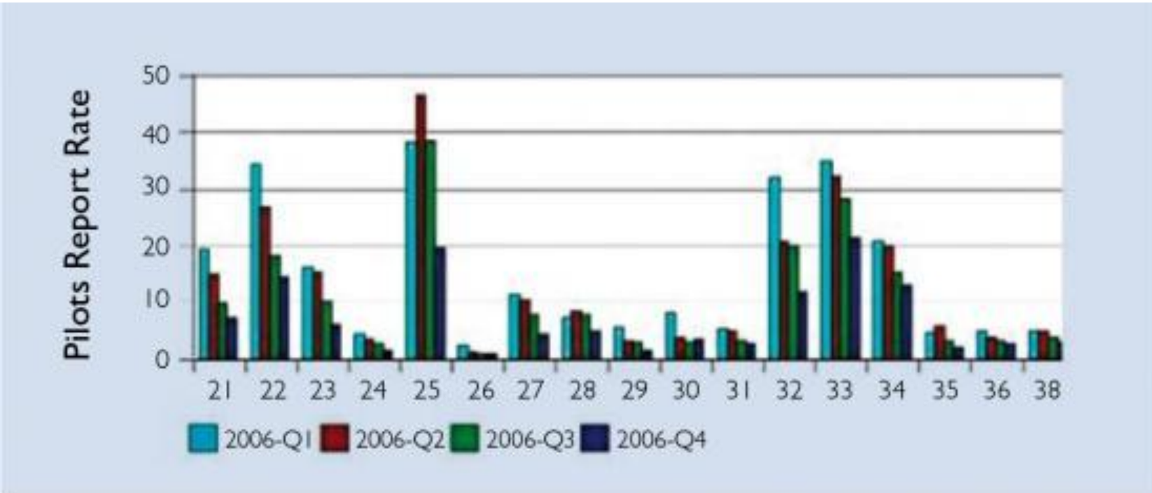


Fig:5.2 pilots report rate

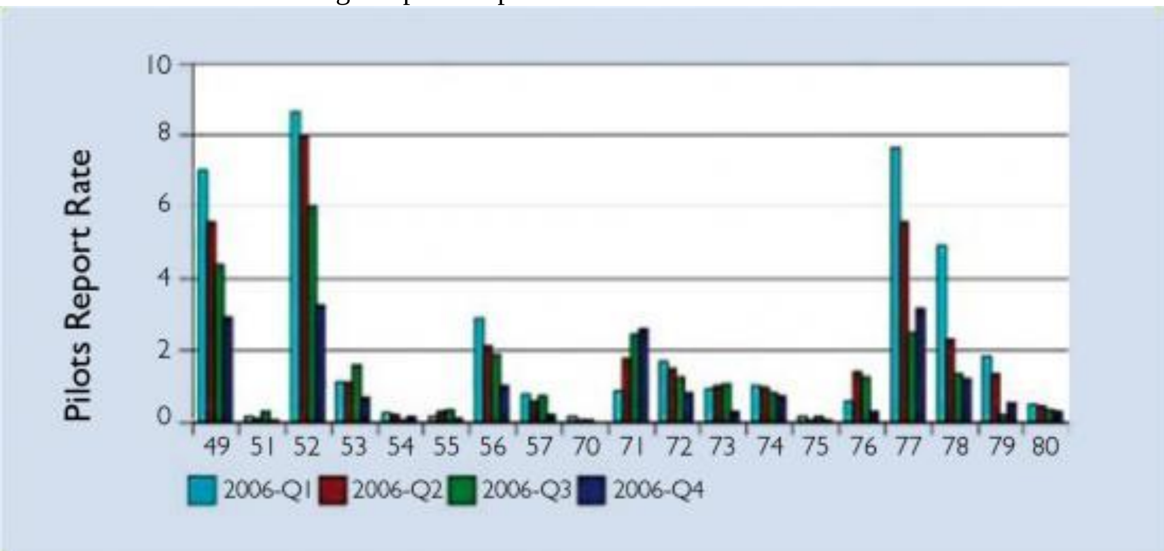


Fig:5.3 pilots report rate

FIGURES 2 AND 3. PILOT REPORTS RATE FOR ATA CHAPTERS 21–38 AND 49–80.
Analysis of Reliability Monitoring by Manufacturer of One Aircraft Type

The air carrier will monitor the reliability of aircraft in operation and send the collected data to the aircraft manufacturer. Four times a year, on the basis of the collected data received from air carriers, the manufacturer issues a report on the reliability for a certain aircraft type available to all air carriers having that type of aircraft in their fleet. In the relevant report, collected and analysed data indicating reliability of aircraft components and system are presented. This is of great importance to the air carrier, since this can draw attention to an increased trend of failures of particular components, the

untimely checking of which and, as needed, possible early service or replacement could cause non-airworthiness of aircraft due to technical malfunction. Each of the cases influences the safety of operations and represents high costs – hence, it is in the interest of the air carrier to prevent them.
The systematized and analysed results of one aircraft type manufacturer are presented below. The data presented are the result of monitoring the reliability of a fleet of 34 air carriers in one year, whose total flight hours amounted to 8 072 951 flight hours and 7 173 857 flight cycles.

In **Figures 2** and **3** the pilot reports rates for certain ATA chapters are presented. The pilot reports are suspicions or confirmed malfunctions of aircraft components and system entered in a technical logbook and they demand inspection by technical staff. The pilot reports rate is calculated as the ratio of the number of pilot reports and the number of aircraft flight hours in a certain period, most often in a thousand hours of flight.

Despatch reliability is presented by graph in **Figure 4**, while **Figure 5** presents the delay rate due to technical reasons and cancelled flights.

The delay and cancellations rate may also be classified by systems according to ATA specification, enabling the monitoring of components and systems most often failing, **Figures 6**and **7**.
According to the results of monitoring, it is evident that aircraft components are the biggest cause of delay and cancellation. The reliability of particular components is presented in the report on reliability only if the component was registered as faulty. The histogram in **Figure 8**presents **10** components which, after processing of all the data received, proved as being replaced most often.

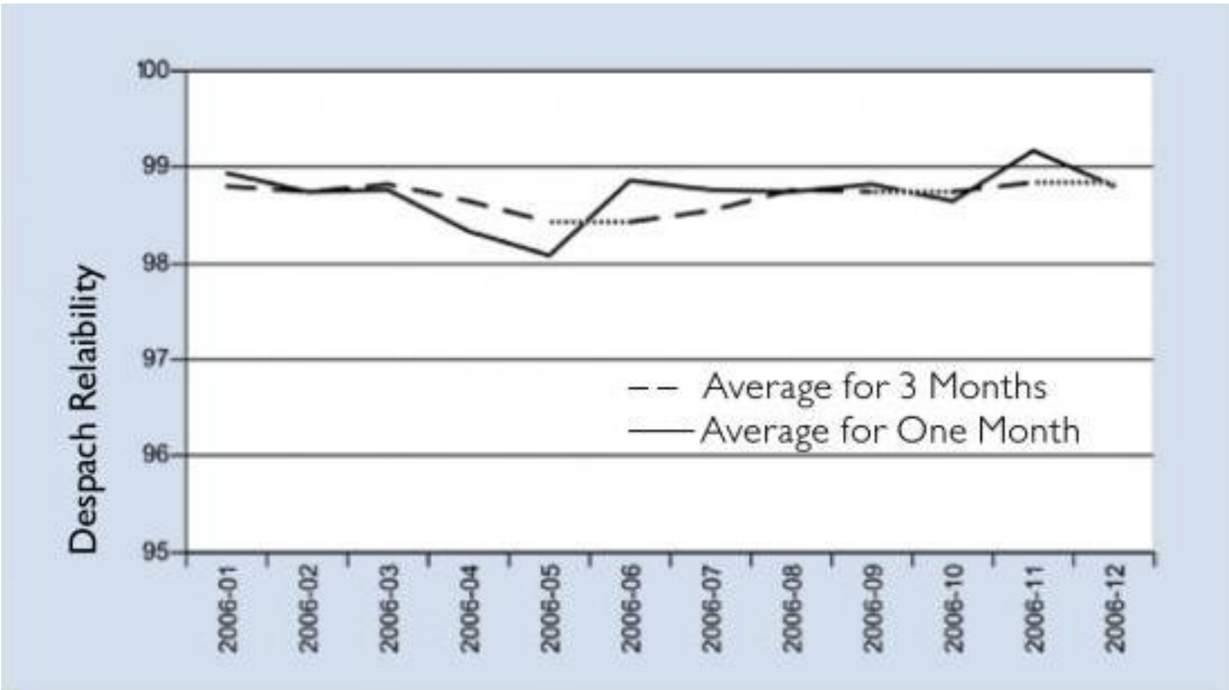


FIGURE 5.4 AIRCRAFT FLEET DESPATCH RELIABILITY.

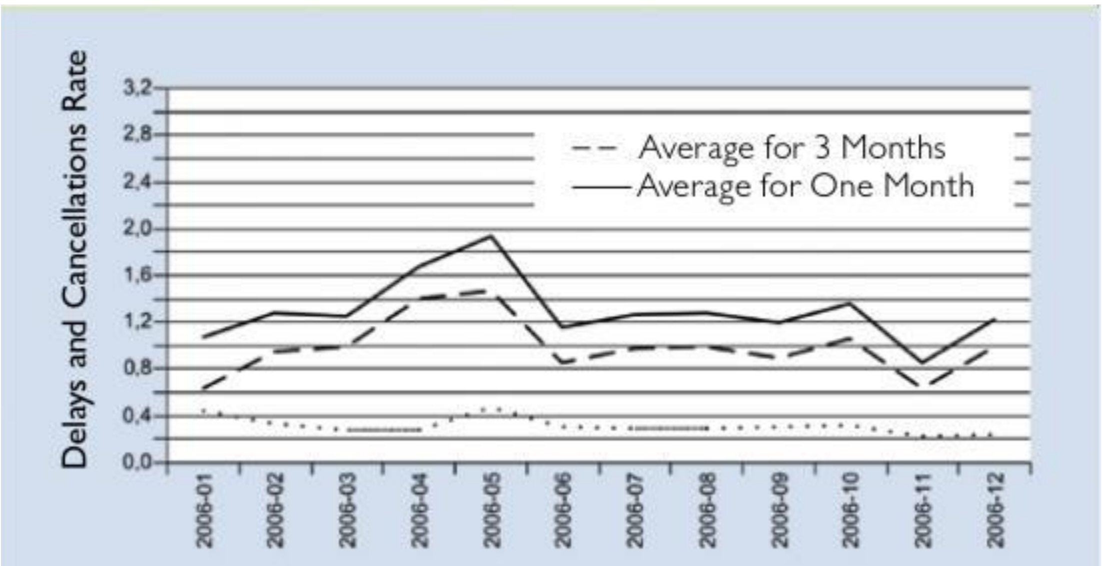
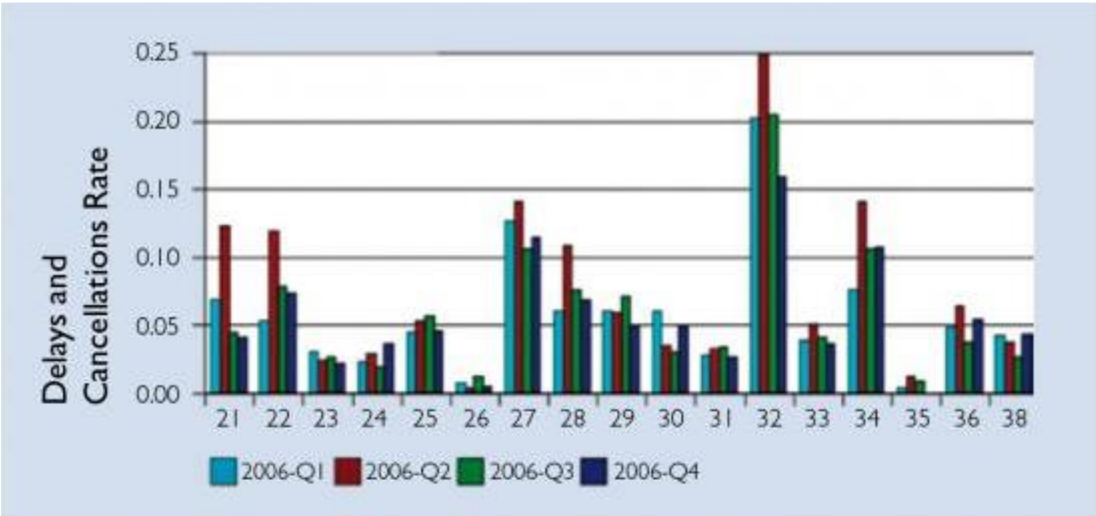
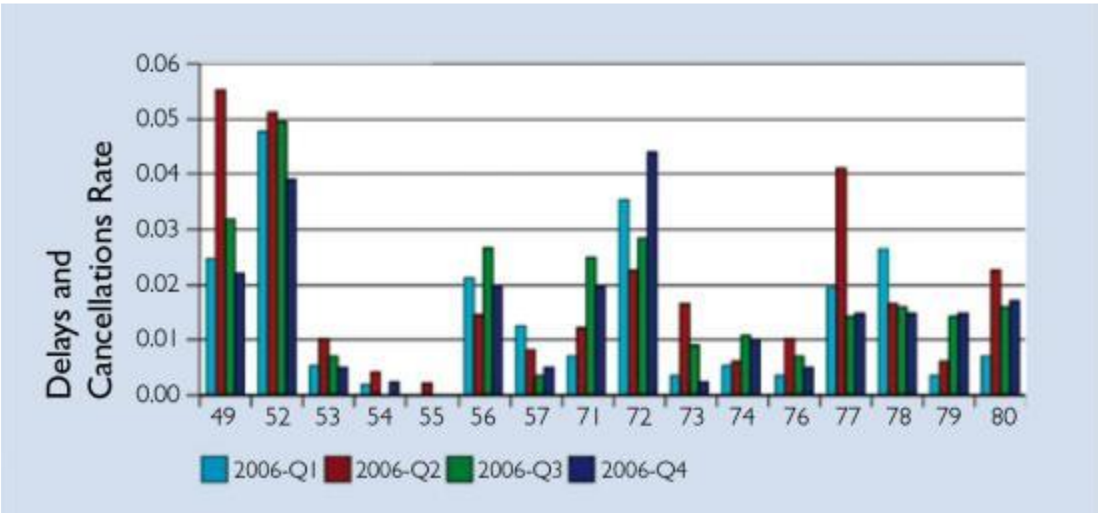


FIGURE 5. DELAYS DUE TO TECHNICAL REASONS AND CANCELLED FLIGHTS.





FIGURES 6 AND 7. DELAYS AND CANCELLATIONS RATE CLASSIFIED according to ATA chapters for 21–38 and 49–80.

A feedback on functionality, i.e. on the problems occurred during aircraft operation plays a big role and is of high importance in aircraft maintenance. Information that the air carrier can and must deliver to the aircraft manufacturer gives the manufacturer a possibility to collect and process data for a large number of aircraft seen as a fleet. On the basis of these data the manufacturer may identify the systems and/or components due to which problems in aircraft operation most often arise. If a defect in manufacture is established, modifications and installation of new components are introduced by the aircraft manufacturer, which should provide an increase of reliability in maintenance and operation. Also, an air carrier is obliged to deliver reports on reliability monitoring to aviation authorities as a proof that aircraft structure, power plant, its components and other systems are capable of achieving and maintaining reliability levels high enough, which is the basis for safety of carrying out aircraft operations.

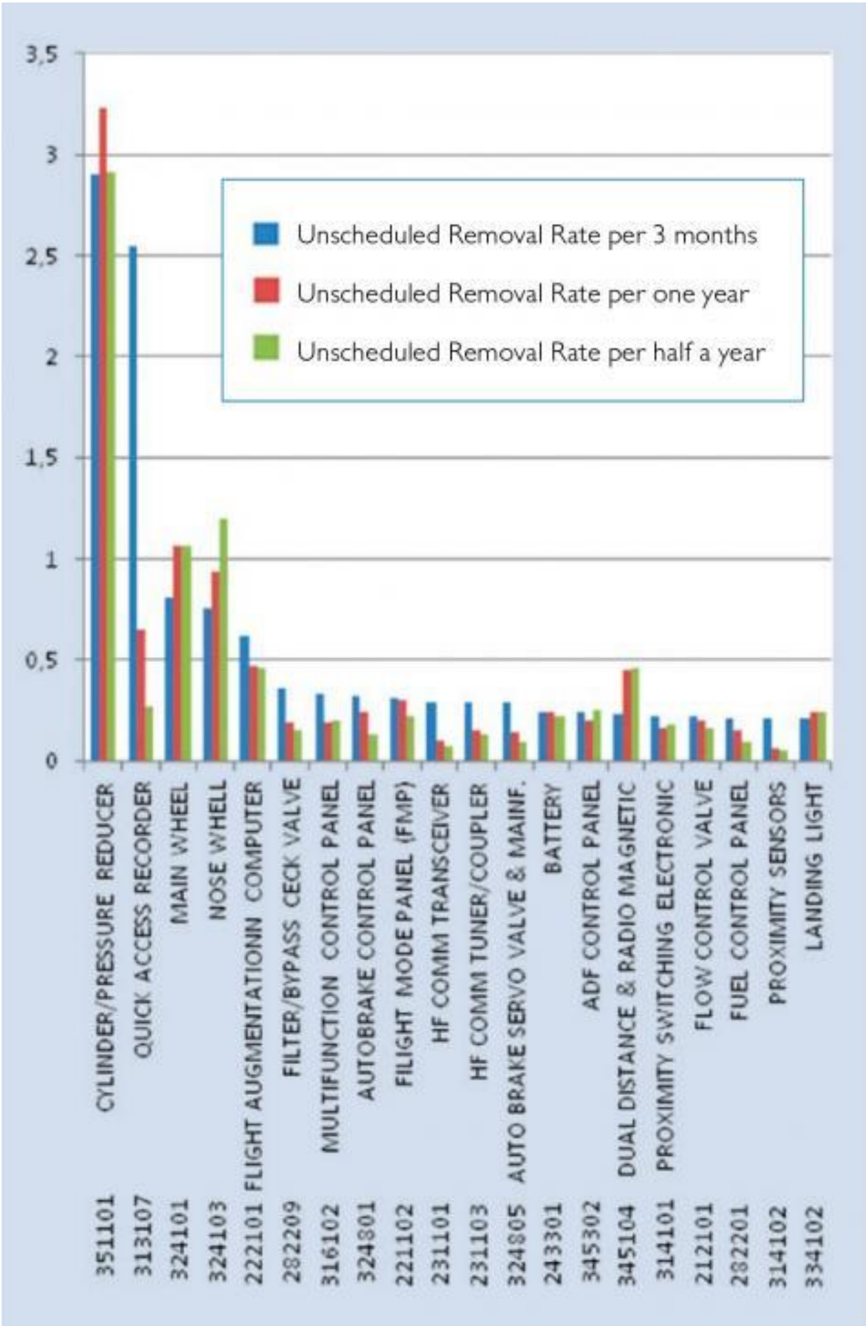


FIGURE 8. COMPONENTS WITH LARGEST NUMBER OF UNSCHEDULED removals.

5.3.2 Maintenance programs have four types of reliability

- Statistical reliability
- Historical reliability
- Event-oriented reliability
- Dispatch reliability

Statistical reliability

Based upon collection and analysis of ‗events' such as failure, removal, and repair rates of systems or components.

Historical reliability

Comparison of current event rates with those of past experience. Commonly used when new equipment is introduced and no established statistic is available.

Event-oriented reliability

Events like bird strikes, hard landing, in-flight shutdowns (IFSD), lighting strikes or other accidents that do not occur on a regular basis and therefore produce no useable statistical or historical data. In ETOPS, FAA designated certain events to be tracked as ‗event-oriented reliability program'. Each occurrence of the events must be investigated to determinate the cause to prevent recurrence.
IFSD causes; for example: due to flameout, internal failure, crew-initiated shutoff, foreign object ingestion, icing, inability to obtain and/or control desired thrust.

Dispatch reliability

Measurement of an airline operation respect to on-line departure. It receives considerable attention from regulatory authorities(e.g. FAA), airlines and passengers. Actually, it is just a special form of the event-oriented reliability approach.

5.4 Danger of misinterpreted reliability data

A pilot experienced a rudder control problem and called in two hours from arriving an airport. He writes up the problem in the aircraft logbook and reports it by radio to the flight operation unit at the airport. Upon arrival, the maintenance crew check the log and find the write-up and begin troubleshooting. The repair actions take a little longer then scheduled turnaround time and cause delay. Since maintenance is at work and rudder is the problem, the delay is charged to the maintenance department.

If the pilot and the flight operation unit knew the problem and informed the maintenance two hours before landing, the maintenance people can spent the time prior to landing to perform troubleshooting analysis and the delay could have been prevented. So, an alter in airline procedure can avoid the delay.

A good reliability program should avoided same delay in the future by altering the procedure, not regardless of who or what is to blame.

If there were 12 write-ups of rudder problems during the month and only one of them caused a delay, there is actually two problems to investigate.

6 The delay, which may/or may not be caused by rudder the problems

7 The 12 rudder write-ups that may ,in fact, be related to an underlying maintenance problem.

Dispatch delay constitutes one problem and the rudder system malfunction constitutes another.
They may overlap but they are two different problems. Delay is a event-oriented reliability that must be investigated on its own; the 12 rudder problems should be addressed by the statistical (or historical) reliability problem separately.

❖ **Elements of a Reliability Program**

1. Data collection
2. Problem area alerting
3. Data display
4. Data analysis
5. Corrective actions
6. Follow-up analysis
7. Monthly report

5.5 Data Collection:

Allows operator to compare present performance with the past, typical data type are:

1. Flight time and cycle for each aircraft
2. Cancellations and delays over 15 minutes
3. Unscheduled component removals
4. Unscheduled engine removals
5. In-flight shutdowns of engines
6. Pilot reports or logbook write-ups
7. Cabin logbook write-up
8. Component failures (shop maintenance)
9. Maintenance check package findings
10. Critical failures

Maintenance Safety

Aviation Safety Organization (AVS) Approach

Incorporate SMS into our internal FAA Aviation Safety processes ***first*** and study requirements for industry

➢ FAA Aviation Safety SMS Requirements Order contains both ***FAA Aviation Safety*** and ***industry*** requirements

- FAA Aviation Safety SMS Program Office

  –Supports the development and implementation of an integrated SMS for FAA Aviation Safety
  –Manages the plan, technical products, and overall progress in the implementation of the FAA Aviation Safety SMS
  –Ensures implementation of the service/office safety management systems are coordinated and accomplished in a timely manner
  –Encourages commonality in the implementation of the constituent product/service provider SMS requirements
  –Leads the FAA SMS efforts
  –Obtains and shares lessons learned
  –Harmonize and collaborate with the international community

- Aviation Industry Interaction
- Aviation Maintenance Certifications
- Certification of Personnel
- Operator Certification Delivery Inspection
- Aircraft Certification Introduction
- Aviation Industry Certification Requirements

Standard Airworthiness Certificate

A standard airworthiness certificate (FAA form 8100-2 displayed in the aircraft) is the FAA's official authorization allowing for the operation of type certificated aircraft in the following categories:

- Normal
- Utility
- Acrobatic
- Commuter
- Transport
- Manned free balloons
- Special classes

A standard airworthiness certificate remains valid as long as the aircraft meets its approved type design, is in a condition for safe operation and maintenance, preventative maintenance, and alterations are performed in accordance with 14 CFR parts 21, 43, and 91.

Airworthiness Certification Process
The FAA requires several basic steps to obtain an airworthiness certificate in either the Standard or Special class.

The FAA may issue an applicant an airworthiness certificate when:

- Registered owner or operator/agent registers aircraft,
- Applicant submits application to the local FAA office, and
- FAA determines the aircraft is eligible and in a condition for safe operation

The United State of America

Department of Transportation

Federal Aviation Administration

AIRCRAFT

Type Certificate

IMPORT
Number A55CE

This certificate issued to BERIEV AIRCRAFT COMPANY certifies that the type design for the following product with the operating limitations and conditions therefor as specified in the Federal Aviation Regulations and the Type Certificate Data Sheet, meets the airworthiness requirements of Part 21.29 of the Federal Aviation Regulations.

Model: Be-103

This certificate, and the Type Certificate Data Sheet which is a part hereof, shall remain in effect until surrendered, suspended, revoked, or a termination date is otherwise established by the Administrator of the Federal Aviation Administration.

Date of application: 8 October 2001

Date of issuance: 11 July 2003

By direction of the Administrator.

(Signature) Michael Gallagher

Michael Gallagher

(Title) Manager, Small Airplane Directorate

This certificate may be transferred if endorsed as provided on the reverse hereof.

Any alteration of this certificate and/or the Type Certificate Data Sheet is punishable by a fine of not exceeding $1,000, or imprisonment not exceeding 3 years, or both.

FAA FORM 8110-9 (2-82)

European Aviation Safety Agency

SUPPLEMENTAL TYPE CERTIFICATE

10037862

This Supplemental Type Certificate is issued by EASA, acting in accordance with Regulation (EC) No. 216/2008 on behalf of the European Community, its Member States and of the European third countries that participate in the activities of EASA under Article 66 of that Regulation and in accordance with Commission Regulation (EC) No. 1702/2003 to

DUGAN KINETICS, L.L.C.

8900 STATE HIGHWAY 3SW, SUITE 201
BREMERTON WA 98367
USA

and certifies that the change in the type design for the product listed below with the limitations and conditions specified meets the applicable Type Certification Basis and environmental protection requirements when operated within the conditions and limitations specified below:

Original Product TC Number : FAA A6WE
TC Holder : BOEING
Model : DC-9-81/-82/-83/-87, MD-88
Original STC Number : FAA STC ST02127SE

Description of Design Change:
Thrust Reverser/Installation of ejector thrust reverser on Pratt & Whitney Turbofan JT8D-217, -217A, 217C or -219 Engines as per FAA STC ST02127SE dated 08 Apr. 2011.

EASA Certification Basis:
The Certification Basis for the original product remains applicable to this certificate/ approval.
The requirements for environmental protection and the associated certificated noise and/ or emissions levels of the original product are unchanged and remain applicable to this certificate/ approval.

See Continuation Sheet(s)

For the European Aviation Safety Agency,

Date of issue: 03.01.2012

Armin KAISER
Project Certification Manager
Large Aeroplanes

Kaiser

Note:
The following numbers are listed on the certificate:
EASA current Project Number: 0010012252-001

UNITED STATES OF AMERICA

DEPARTMENT OF TRANSPORTATION—FEDERAL AVIATION ADMINISTRATION

STANDARD AIRWORTHINESS CERTIFICATE

1. NATIONALITY AND REGISTRATION MARKS	2. MANUFACTURER AND MODEL	3. AIRCRAFT SERIAL NUMBER	4. CATEGORY
N12345	CESSNA C-150L	6969	NORMAL

5. AUTHORITY AND BASIS FOR ISSUANCE

This airworthiness certificate is issued pursuant to the Federal Aviation Act of 1958 and certifies that, as of the date of issuance, the aircraft to which issued has been inspected and found to conform to the type certificate therefor, to be in condition for safe operation, and has been shown to meet the requirements of the applicable comprehensive and detailed airworthiness code as provided by Annex 8 to the Convention on International Civil Aviation, except as noted herein.

Exceptions:

NONE

6. TERMS AND CONDITIONS

Unless sooner surrendered, suspended, revoked, or a termination date is otherwise established by the Administrator, this airworthiness certificate is effective as long as the maintenance, preventative maintenance, and alterations are performed in accordance with Parts 21, 43, and 91 of the Federal Aviation Regulations, as appropriate, and the aircraft is registered in the United States.

DATE OF ISSUANCE	FAA REPRESENTATIVE	DESIGNATION NUMBER
1/29/96	R.E. BARO	AEA-FSDO-03

Any alteration, reproduction, or misuse of this certificate may be punishable by a fine not exceeding $1,000 or imprisonment not exceeding 3 years, or both. THIS CERTIFICATE MUST BE DISPLAYED IN THE AIRCRAFT IN ACCORDANCE WITH APPLICABLE FEDERAL AVIATION REGULATIONS.

FAA FORM 8100-2 (8-82) GPO 892-804

Production Certificate

THE BOEING COMPANY

EAST MARGINAL WAY SOUTH

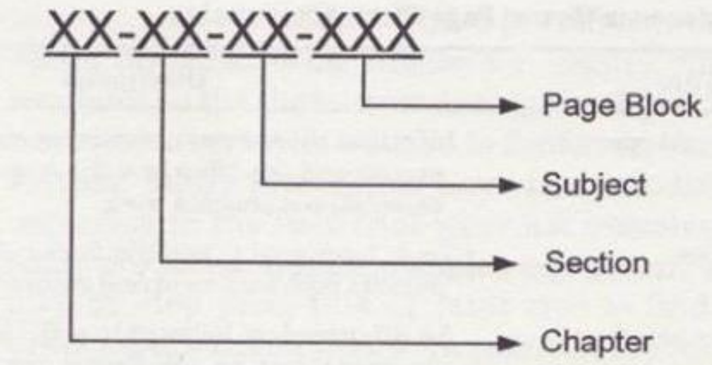
SEATTLE, WASHINGTON

ATA Document Standards

TABLE 5-4 ATA Standard Chapter Numbers

ATA	Subject	ATA	Subject
5	Time limits, maintenance checks	37	Vacuum
6	Dimensions and access panels	38	Water/waste
7	Lifting and shoring	45	Central maintenance syste[illegible]
8	Leveling and weighing	49	Airborne auxiliary power
9	Towing and taxiing	51	Standard practices and structures—general
10	Parking, mooring, storage, and return to service	52	Doors
11	Placards and markings	53	Fuselage
12	Servicing	54	Nacelles/pylons
20	Standard practices—airframe	55	Stabilizers
21	Air conditioning	56	Windows
22	Auto flight	57	Wings
23	Communications	70	Standard practices—engine[illegible]
24	Electrical power	71	Power plant (package)
25	Equipment/furnishings	72	Engine (internals)
26	Fire protection	73	Engine fuel control
27	Flight controls	74	Ignition
28	Fuel	75	Air
29	Hydraulic power	76	Engine controls
30	Ice and rain protection	77	Engine indicating
31	Indicating/recording system	78	Exhaust
32	Landing gear	79	Oil
33	Lights	80	Starting
34	Navigation	82	Water injection
35	Oxygen		
36	Pneumatic	91	Charts (miscellaneous)

SOURCE: From Air Transport Association (ATA); iSpec 2200. Reprinted with permission.



Example:

52	Doors
52-11	Passenger Doors
52-11-02	Passenger Door Handle
52-11-02-401	R/I Procedure for Pax Door Handles

Figure 5-1 ATA format for maintenance manuals. (*Source*: *Air Transport Association of America (ATA); iSpec 2200. Reprinted with permission.*)