AIRCRAFT MAINTENANCE ENGINEERING

(R22A2142)

DIGITAL NOTES

B.TECH

(IV Year – I SEM)

(2025-2026)

Prepared By

Mrs. L SUSHMA

DEPARTMENT OF AERONAUTICAL ENGINEERING

MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY

(Autonomous Institution – UGC, Govt. of India)

Affiliated to JNTU, Hyderabad, Approved by AICTE - Accredited by NBA & NAAC – 'A' Grade - ISO 9001:2015 Certified)

Maisammaguda, Dhulapally (Post Via. Kompally), Secunderabad – 500100, Telangana State, India.

MRCET VISION

- To become a model institution in the fields of Engineering, Technology and Management.
- To have a perfect synchronization of the ideologies of MRCET with challenging demands of International Pioneering Organizations.

MRCET MISSION

- To establish a pedestal for the integral innovation, team spirit, originality and competence in the students, expose them to face the global challenges and become pioneers of Indian vision of modern society

MRCET QUALITY POLICY.

- To pursue continual improvement of teaching learning process of Undergraduate and Post Graduate programs in Engineering & Management vigorously.
- To provide state of art infrastructure and expertise to impart the quality education

PROGRAM OUTCOMES
(PO's)

Engineering Graduates will be able to:

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design / development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multi disciplinary environments.
12. **Life- long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

DEPARTMENT OF AERONAUTICAL ENGINEERING

VISION

Department of Aeronautical Engineering aims to be indispensable source in Aeronautical Engineering which has a zeal to provide the value driven platform for the students to acquire knowledge and empower themselves to shoulder higher responsibility in building a strong nation.

MISSION

The primary mission of the department is to promote engineering education and research. To strive consistently to provide quality education, keeping in pace with time and technology. Department passions to integrate the intellectual, spiritual, ethical and social development of the students for shaping them into dynamic engineers.

QUALITY POLICY STATEMENT

Impart up-to-date knowledge to the students in Aeronautical area to make them quality engineers. Make the students experience the applications on quality equipment and tools. Provide systems, resources and training opportunities to achieve continuous improvement. Maintain global standards in education, training and services.

PROGRAM EDUCATIONAL OBJECTIVES – Aeronautical Engineering

1. **PEO1 (PROFESSIONALISM & CITIZENSHIP):** To create and sustain a community of learning in which students acquire knowledge and learn to apply it professionally with due consideration for ethical, ecological and economic issues.
2. **PEO2 (TECHNICAL ACCOMPLISHMENTS):** To provide knowledge based services to satisfy the needs of society and the industry by providing hands on experience in various technologies in core field.
3. **PEO3 (INVENTION, INNOVATION AND CREATIVITY):** To make the students to design, experiment, analyze, and interpret in the core field with the help of other multi disciplinary concepts wherever applicable.
4. **PEO4 (PROFESSIONAL DEVELOPMENT):** To educate the students to disseminate research findings with good soft skills and become a successful entrepreneur.
5. **PEO5 (HUMAN RESOURCE DEVELOPMENT):** To graduate the students in building national capabilities in technology, education and research

PROGRAM SPECIFIC OUTCOMES – Aeronautical Engineering

1. To mould students to become a professional with all necessary skills, personality and sound knowledge in basic and advance technological areas.
2. To promote understanding of concepts and develop ability in design manufacture and maintenance of aircraft, aerospace vehicles and associated equipment and develop application capability of the concepts sciences to engineering design and processes.
3. Understanding the current scenario in the field of aeronautics and acquire ability to apply knowledge of engineering, science and mathematics to design and conduct experiments in the field of Aeronautical Engineering.
4. To develop leadership skills in our students necessary to shape the social, intellectual, business and technical worlds.

MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY

IV Year B. Tech, ANE-I Sem

L	T/P/D	C
4	-/-/-	3

(R22A2142) AIRCRAFT MAINTENANCE ENGINEERING

Objectives:

- To introduce the knowledge of the maintenance and repair procedures followed for overhaul of aero engines.
- To impart the standards of FAA for documentation.

UNIT – I

NECESAITY & DEVELOPMENT OF MAINTENANCE PROGRAMS

Definition of maintenance, role of the engineer, role of the mechanic, two types of maintenance, reliability, establishing a maintenance program. Goals and objectives of maintenance. Maintenance steering group(MSG) Approach, process – Oriented maintenance, task- oriented maintenance, current MSG process – MSG – 3, maintenance program documents.

UNIT – II

AVIATION CERTIFICATION REQUIREMENTS AND DOCUMENTATION FOR MAINTENANCE & ENGINEERING

Aircraft certification, delivery inspection, operator certification, certification of personnel, aviation industry interaction; types of documentation. Manufacturer`s documentation, regulatory documentation. Airline generated documentation. ATA document standards. Objectives of a maintenance program, outline of aviation maintenance program, summary of FAA requirements, additional maintenance program requirements; organization of maintenance and engineering, organization structure, M&E organization chart, general groupings, managerial level functions- technical services, aircraft maintence, overhaul shops, material.

UNIT – III

TECHNICAL SERVICES

Engineering: makeup of engineering, mechanics and engineers, engineering department functions, engineering order preparation; production planning & control – forecasting, production planning, production control , Organization of PP&C; technical publications- functions of technical publications, airline libraries, control of publications,; Technical Training-organization, training for aviation maintenance, airframe manufacturer`s training courses,

UNIT – IV

MAINTENANCE AND MATERIAL SUPPORT

Line maintenance(on – aircraft), functions that control maintenance, MCC responsibilities, general line maintenance operations, aircraft logbook, ramp and terminal operations, maintenance crew requirement, morning meeting; Hangar Maintenance (on-aircraft)-organization of hangar maintenance, problem areas in hangar maintenance, maintenance support shops, ground support equipment, typical C – check: Shop data collection; Material support –organization and function of material. Material directorate, M&E support functions

UNIT – V

OVERSIGHT FUNCTIONS, ART & SCIENCE OF TROUBLE SHOOTING

Quality Assurance , quality audits, ISO 9000 quality standard, technical records, Quality control-quality control organization, FAA and JAA QC inspector qualifications. Basic inspection policies,; Reliability – definition and types of reliability, elements of a reliability program, Maintenance safety – safety regulations, maintenance safety program, general safety rules, accident and injury reporting . Human factors in maintenance, Trouble shooting, knowledge of malfunctions, Basic concepts of trouble shooting.

Text Books:

1. Kinnison, H.A , Aviation Maintenance Manageent, Mc Graw – Hill – 2004.
2. Mc Kinley, J.L. Bent, R.D ., Maintenance and Repair of Aerospace Vehicles, Northrop Institute of Technology, Mc Graw Hill, 1967.

Reference Books:

1. Friend, C.H., Aircraft maintence Management . Longman, 1992.
2. Kroes, M., Watkins. W., and Delp. F. Aircraft Maintenance and Repair, Tata Mc Graw – Hill. 2010

Outcomes:

- Ability to maintain and repair the areo engines.
- Ability to prepare aircraft maintenance manuals.
- Ability to know the standards of quality, FAA

MALLAREDDY COLLEGE OF ENGINEERING AND TECHNOLOGY
DEPARTMENT OF AERONAUTICAL ENGINEERING
SESSION PLAN

SUB: AIRCRAFT MAINTENANCE ENGINEERING **IV YEAR – II SEMESTER**

UNIT – NO	TOPIC	NO OF CLASSES REQUIRED
UNIT – I	**NECESAITY & DEVELOPMENT OF MAINTENANCE PROGRAMS** Definition of maintenance, role of the engineer ,role of the mechanic	2
	,two types of maintenance, reliability, establishing a maintenance program	2
	Goals and objectives of maintenance. Maintenance steering group(MSG) Approach, process	2
	maintenance, task- oriented maintenance, current MSG process	2
	MSG – 3, maintenance program documents.	1
UNIT – II	**AVIATION CERTIFICATION REQUIREMENTS AND DOCUMENTATION FOR MAINTENANCE & ENGINEERING** Aircraft certification, delivery inspection,	1
	operator certification, certification of personnel, aviation industry interaction; types of documentation	2
	Manufacturer`s documentation, regulatory documentation. Airline generated documentation.	2
	ATA document standards. Objectives of a maintenance program, outline of aviation maintenance program, summary of FAA requirements, additional maintenance program requirements;	3
	organization of maintenance and engineering, organization structure, M&E organization chart, general groupings	2
	managerial level functions- technical services, aircraft maintenance, overhaul shops, material.	2
UNIT - III	**TECHNICAL SERVICES** Engineering: makeup of engineering, mechanics and engineers,	2
	engineering department functions, engineering order preparation;	2
	production planning & control – forecasting, production planning, production control , Organization of PP&C;	3
	technical publications- functions of technical publications, airline libraries, control of publications	2
	Technical Training-organization, training for aviation maintenance, airframe manufacturer`s training courses,	2

UNIT –IV	**MAINTENANCE AND MATERIAL SUPPORT** Line maintenance(on – aircraft), functions that control maintenance	**2**
	MCC responsibilities, general line maintenance operations, aircraft logbook, ramp and terminal operations	**2**
	maintenance crew requirement, morning meeting; Hangar Maintenance (on-aircraft)-organization of hangar maintenance,	**2**
	problem areas in hangar maintenance, maintenance support shops, ground support equipment, typical C – check: Shop data collection;	**3**
	; Material support –organization and function of material. Material directorate, M&E support functions	**2**
UNIT – V	**OVERSIGHT FUNCTIONS, ART & SCIENCE OF TROUBLE SHOOTING** Quality Assurance , quality audits, ISO 9000 quality standard, technical records	**2**
	Quality control-quality control organization, FAA and JAA QC inspector qualifications. Basic inspection policies	**3**
	Reliability – definition and types of reliability, elements of a reliability program,	**2**
	Maintenance safety – safety regulations, maintenance safety program, general safety rules, accident and injury reporting .	**3**
	Human factors in maintenance, Trouble shooting	**1**
	Knowledge of malfunctions, Basic concepts of trouble shooting.	**2**
	TOTAL NUMBER OF CLASSES	**56**

Text Books:

1. Kinnison, H.A , Aviation Maintenance Manageent, Mc Graw – Hill – 2004.
2. Mc Kinley, J.L. Bent, R.D ., Maintenance and Repair of Aerospace Vehicles, Northrop Institute of Technology, Mc Graw Hill, 1967.

UNIT – I

NECESAITY & DEVELOPMENT OF MAINTENANCE PROGRAMS

Definition of maintenance

- We have talked about maintenance and how the approach to maintenance has evolved over the years; but just what is it that we mean when we use the term *maintenance*? Definition of maintenance by Lindley R. Higgins, defining maintenance as art, science, and philosophy. In this text, however, we will address the subject in less poetic and more practical terms.

Typical airline definition of maintenance

- This definition was taken from the text of a "typical" airline's technical policies and procedures manual (TPPM).
- **Maintenance** is defined as "those actions required for restoring or maintaining an item in a serviceable condition, including servicing, repair, modification, overhaul, inspection, and
- determination of condition."
- This is not incorrect. However, it merely describes what maintenance people do; it is not descriptive of the intent or the result of maintenance activity.

FAA definition of maintenance

- In the Federal Aviation Regulations, FAR part 1, *maintenance* is defined as "… inspection, overhaul, repair, preservation, and replacement of parts". Again, this describes what maintenance people do, but it is not a definitive description of what maintenance is intended to accomplish
- "The maintenance of an aircraft provides assurance of flight safety reliability, and airworthiness."The aircraft maintenance department is responsible for accomplishing all maintenance tasks as per the aircraft manufacturer and the company's requirements .The goal is a safe, reliable, and airworthy aircraft.
- The aircraft maintenance department provides maintenance and preventive maintenance to ensure reliability, which translates into aircraft availability. These functions do not preclude a random failure or degradation of any part or system, but routine maintenance and checks will keep from happening and keep the aircraft in good flying condition.

Role of the engineer

- The design of systems or components is not only limited by the imperfections of the physical world (i.e., the "natural frequency" of the system) it is also limited by a number of other constraints which we could refer to as "man – made entropy."
- A design engineer may be limited from making the perfect design by the technology or the state of the art within any facet of the design effort. He or she may be limited by ability or technique or, more often than not, the designer may be limited by economics: i.e., there just is not enough money to build that nearly perfect system that is on the drawing board or in the designer's mind.

Although the designer is limited by many factors, in the tradition of good engineering practice, the designer is obliged to build the best system possible within the constraints given.

- Another common situation in design occurs when the designer has produced what he or she believes is the optimum system when the boss, who is responsible for budget asks, "How much will it cost to build this?" The designer has meticulously calculated that these widgets can be mass produced for $1200 each."Great," says the boss."Now redesign it so we can build it for under a thousand dollars." That means redesign, usually with reduced tolerances, cheaper, materials, and, unfortunately, more entropy. More entropy sometimes translates into more maintenance required .The design engineer's primary concern, then, is to minimize (not eliminate) the entropy of the system he or she is designing while staying within the required constraints.

Typical duties

- Carries out assignments of daily aircraft maintenance and overhaul programs.
- Checks condition of aircraft and engine, make 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.
- Through 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 equipments.

Role of the mechanic

- The mechanic (aircraft maintenance technician (AMT), repairer, or maintainer), on the other hand, has a different problem .Let us, once again, refer to the field of thermodynamics.
- One important point to understand is that entropy not only exists in every system, but that the entropy of a system is always increasing. That means that the designed –in level of perfection (imperfection?) will not be permanent. Some components or systems will deteriorate from use, and some will deteriorate from lack of use (time or environment related).Misuse by an operator or user may also cause some premature deterioration or degradation of the system or even outright damage. This deterioration or degradation of the system represents an increase in the total entropy of the system. Therefore, while the engineer's job is to minimize the entropy of a system during design, the mechanic's job is to combat the natural, continual increase in the entropy of the system during its operational life time.
- To summarize, it is the engineer's responsibility to design the system with as high degree of perfection (low entropy) as possible within reasonable limits.
- The mechanic's responsibility is to remove and replace parts, troubleshoot systems, isolate faults in systems by following the fault isolation manual (FIM).

- 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 prevention systems, aircraft ice and rain protection systems and their components.
- 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.

Mechanics, Technicians, Maintainers, Engineers

- The terminology used by the world's airlines to identify maintenance personnel varies. The terms mechanic, technician, and maintainer are often used to identify those who perform the scheduled and unscheduled maintenance tasks of the unit's aircraft.
- In some organizations, however, these same people are called engineers, while in others; the term engineer is reserved for those personnel who have college degrees in one of the engineering fields. These people usually perform duties quite different from those of the line, hangar, and shop maintenance people.

Types of maintenance

Two types of maintenance

- Fig -1 is a graph showing the level of perfection of a typical system .One hundred percent perfection is at the very top of the y-axis. The x- axis depicts time.
- There are no numbers on the scales on either axis since actual values have no meaning in these theoretical discussions .The left end of the curve shows the level of perfection attained by the designers of our real world system. Note that the curve begins to turn downward with time. This is a representation of the natural increase in entropy of the system- the natural deterioration of the system- over time. When the system deteriorates to some lower (arbitrarily set) level of performance, we perform some corrective action: adjusting, tweaking, servicing, or some other form of maintenance to restore the system to its designed – in level of perfection. That is, we reduce the entropy to its original level. This is called preventive maintenance and is usually performed at regular intervals. This is done to prevent deterioration of the system to an unusable level and to keep it in operational condition. It is sometimes referred to as scheduled

maintenance. This scheduled could be daily, every flight, every 200 flight hours, or every 100 cycles (a cycle is a takeoff and a landing).

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.
- Fig -2 shows the system restored to its normal level (curves a and b).There are times, of course, when the system deteriorates rather rapidly in service to a low level of perfection (curve c). At other times the system breaks down completely (curve d).In these cases, the maintenance actions necessary to restore the system are more definitive, often requiring extensive testing, troubleshooting, adjusting, and very often, the replacement, restoration, or complete overhaul of parts or subsystems. Since these breakdowns occur at various, unpredictable intervals, the maintenance actions employed to correct the problem are referred to as unscheduled maintenance.

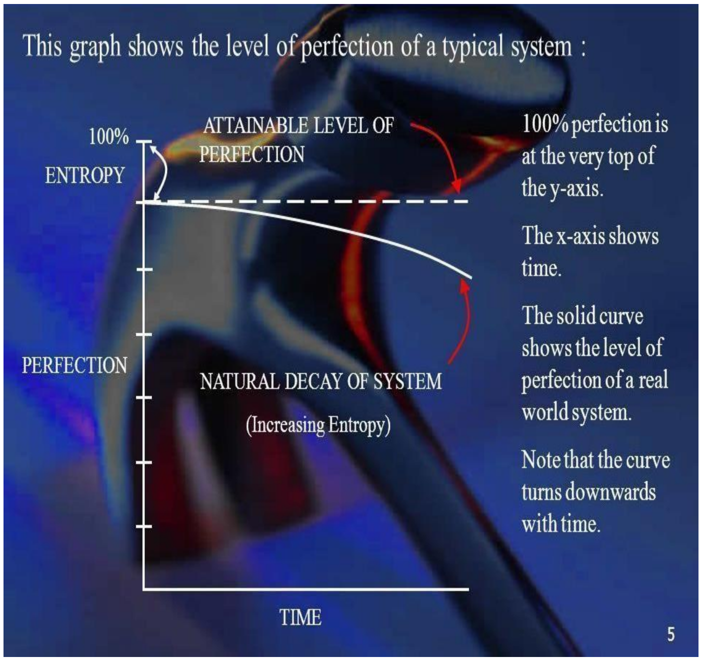


Fig -1 -The difference between theory and practice

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's 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.

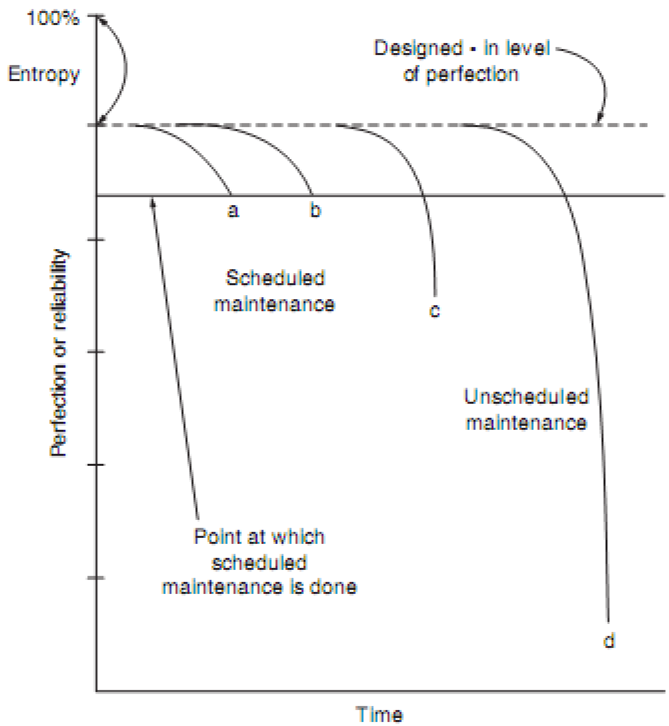


Fig – 2 - Restoration of system perfection

➢ Reliability

- The level of perfection we have been talking about can also be referred to as the reliability of the system. The designed - in level of perfection is known as the inherent reliability of that system .This is as good as the system gets during real world operation. No amount of maintenance can increase system reliability any higher than this inherent level. However , it is desirable for the operator to maintain this level of reliability (or this level of perfection) at all times, we will discuss reliability and maintenance in more detail .But there is one more important point to cover – redesign of the equipment.

➢ Redesign

- Fig-3- shows the original curve of our theoretical system, Curve A. The dashed line shows the system's original level of perfection. Our system however, has now been redesigned to a higher level of perfection: that is, a higher level of reliability with a corresponding decrease in total entropy. During this redesign, new components , new materials , or new techniques may have been used to reduce the natural entropy of the system .In some cases , a reduction in man-

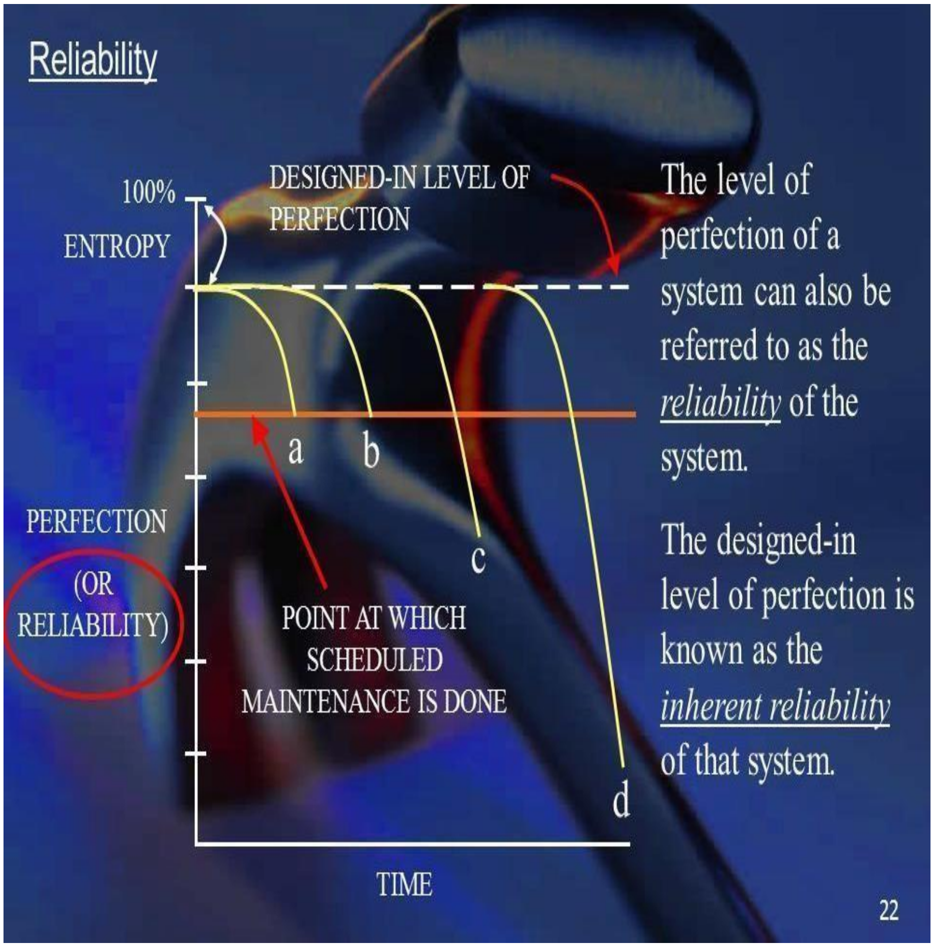


Fig -3 – Effects of redesign on system reliability

Made entropy may result because the designer applied tighter tolerances, attained improved design skills, or changed the design philosophy.

- Although the designers have reduced the entropy of the system, the system will still deteriorate. It is quite possible that the rate of deterioration will change from the original design depending upon numerous factors; thus, the slope of the curve may increase , decrease , or stay the same .Whichever is the case, the maintenance requirements of the system could be affected in some way.
- If the decay is steeper, as in (B) in fig -3, the point at which preventive maintenance needs to be performed might occur sooner, and the interval between subsequent actions would be shorter. The result is that maintenance will be needed more often. In this case, the inherent reliability is increased, but more maintenance is required to maintain that level of reliability (level of perfection), unless the performance characteristics of the system have been improved, this redesign may not be acceptable. A decision must be made to determine if the performance improvement justifies more maintenance and thus an increase in maintenance costs.

- Conversely if the decay rate is the same as before, as shown in curve C of fig-3, or less steep, as shown in curve D, then the maintenance interval would be increased and the overall amount of preventive maintenance might be reduced. The question to be considered then is this; does the reduction of maintenance justify the cost of the redesign? This question, of course, is a matter for the designers to ponder, not the maintenance people.
- One of the major factors in redesign is cost .Fig – 4 shows the graphs of two familiar and opposing relationships. The upper curve is logarithmic. It represents the increasing perfection attained with more sophisticated design efforts. The closer we get to perfection (top of the illustration) the harder it is to make a substantial increase. (We will never get 100 percent).The lower curve depicts the cost of those ongoing efforts to improve the system. This, unfortunately, is an exponential curve. The more we try to approach perfection, the more it is going to cost us. It is obvious, then, that the designers are limited in their goal of perfection, not just by entropy but also by costs .The combination of these two limitations is basically responsible for our profession of maintenance.

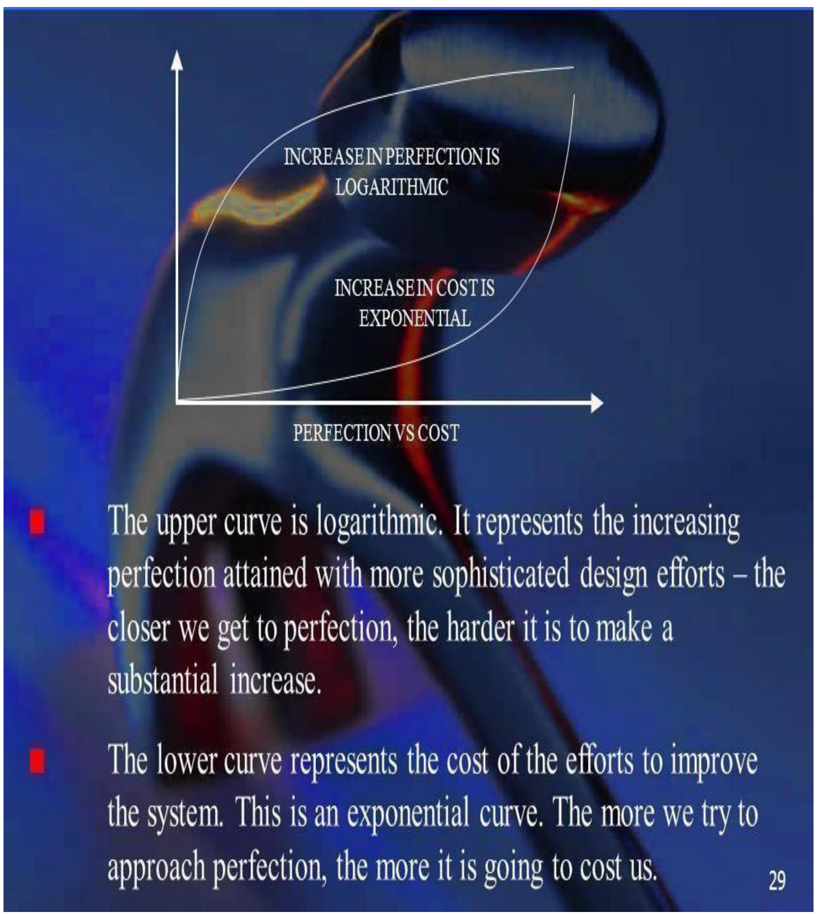


Fig – 4 – perfection Vs cost

➢ Failure Rate Patterns

- Maintenance, of course, is not as simple as one might conclude from the above discussion of entropy. There is one important fact that must be acknowledged not all systems or components fail at the same rate nor do they all exhibit the same pattern of wear out and failure .As you might except, the nature of the maintenance performed on these components and systems is related to those failure rates and failure patterns.

- United Airlines did some studies on lifetime failure rates and found six basic patterns.
- These are shown in table in below .The vertical axes show failure rates and the horizontal axes indicate time.
- No values are shown on the scales since these are not really important to the discussion.

- Curve A shows when is commonly referred to as the "bath tub" curve, for obvious reasons .This failure rate pattern exhibits a high rate of failure during the early portion of the component's life, known as infant mortality. This is one of the bugaboos of engineering. Some components exhibit early failures for several reasons; poor design, improper parts, or incorrect usage .Once the bugs are works out and the equipment settles into its pattern, the failure rate levels off or rises only slightly overt time. That is, until the later stages of the component's life .The rapid rise shown in curve A near the end of its life is an indication of wear out. The physical limit of the component's materials has been reached.

- Curve B exhibits no infant mortality but shows a level , or slightly rising failure rate characteristic throughout the component's life until a definite wear – out period is exhibited toward the end.

- Curve C depicts components with a slightly increasing failure rate with no infant mortality and no discernible wear – out period, but at some point, it becomes unusable.

- Curve D shows a low failure rate when new (or just out of the shop), which rises to some steady level and holds throughout most of the component's life.

- Curve E is an ideal component no infant mortality and no wear –out period just steady (or slightly rising) failure rate throughout its life.

- Curve F Shows components with an infant mortality followed by a level or slightly rising failure rate and no wear – out period.

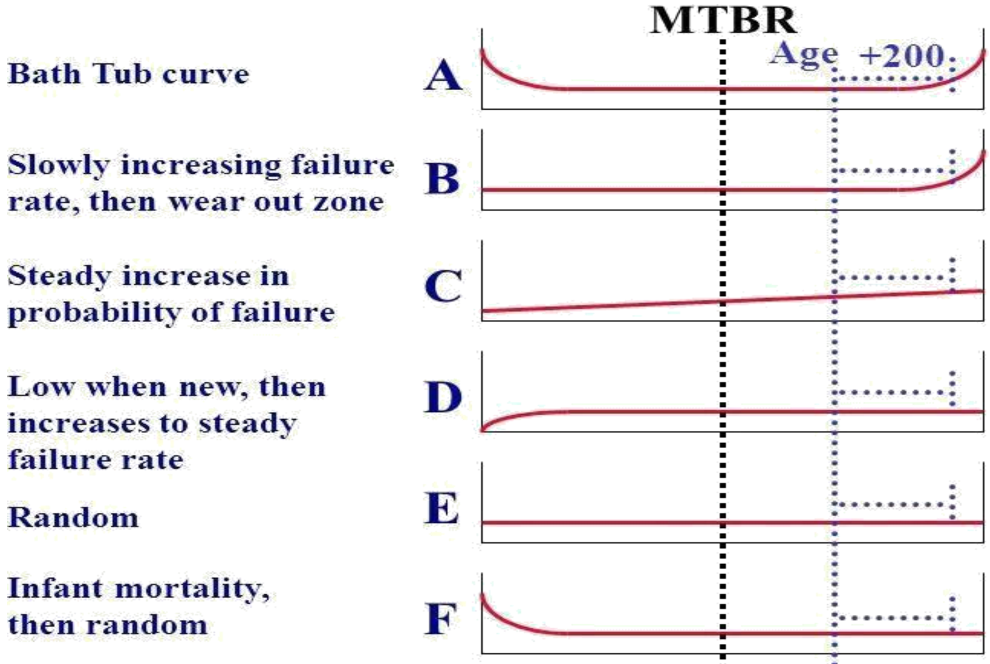


Table-1- failure rate patterns

- The other 89 percent (depicted by curves D,E, and F of table) would require some other approach. The implication of this variation is that the components with definite life limits and /or wear out periods will benefit from scheduled maintenance. They will not all come due for maintenance or replacement at the same time, however, but they can be scheduled; and the required maintenance activity can be spread out over the available time, thus avoiding peaks and valleys in the workload. The other 89 percent, unfortunately, will have to be operated to failure before replacement or repair is done. This, being unpredictable, would result in the need for maintenance at odd times and at various intervals; i.e., unscheduled maintenance.

- These characteristics of failure make it necessary to approach maintenance in a systematic manner, to reduce peak periods of unscheduled maintenance .the industry has taken this into consideration and has employed several techniques in the design and manufacturing of aircraft and systems to accommodate the problem.

Other maintenance considerations

- The aviation industry has developed three management techniques for addressing the in service interruptions created by the items that must be operated to failure before maintenance can be done .These are equipment redundancy , line replaceable units, and minimum aircraft dispatch requirements

- The concept of redundancy of certain components or systems is quite common in engineering design of systems where a high reliability is desirable. In the case of redundant units- usually called primary and backup units-if one unit fails, the other is available to take over the function .For example, in aviation most commercial jets have two high – frequency (HF) radios. Only one is needed for communications, but the second one is there for backup in case the first one fails.

- A unique feature of redundant units also affects the maintenance requirements .If both primary and back –up units are instrumented such that the flight crew is aware of any malfunction, no prior maintenance check is required to indicate that incapability. On the other hand, if neither system is so instrumented, maintenance personnel would need to perform some check on both primary and backup systems to determine serviceability.

- Another common concept used in aviation is the line replaceable unit (LRU) .An LRU is a component or system that has been designed in such a manner that the parts that most commonly fail can be quickly removed and replaced on the vehicle. This allows the vehicle to be returned to scheduled service without undue delay for maintenance .The failed part, then, can either be discarded or repaired in the shop as necessary without further delaying the flight.

- The third concept for minimizing delays for maintenance in aviation is known as the minimum equipment list (MEL).This list allows a vehicle to be dispatched into service with certain items inoperative provided that the loss of function does not affect the safety and operation of the flight .These items are carefully determined by the manufacturer and sanctioned by the regulatory authority during the early stages of vehicle design and test. The manufacturer issues a master minimum equipment list (MMEL) which includes all equipment and accessories available for the aircraft model. The airline then tailors the document to its own configuration to produce the MEL .Many of these MEL items are associated with redundant systems. The concept of the MEL allows deferral of maintenance without upsetting the mission requirements .The maintenance , however , must be performed within certain prescribed periods , commonly 1,3,10,or,30 days , depending on the operational requirements for the system.

- The items are identified in the MMEL , by flight crew personnel during the later stages of new aircraft development .Thus flight personnel determine what systems they can safely fly the mission without or in a degraded condition.

- These flight crew personnel also determine how long (1, 3, 10,or 30 days) they can tolerate this condition. Although this is determined in general terms prior to delivering the airplane, the flight crew on board makes the final decision based on actual conditions at the time of dispatch. The pilot in command (PIC) can, based on existing circumstances, decide not to dispatch until repairs are made or can elect to defer maintenance per the airline's MEL. Maintenance must abide by that decision.

- Associated with the MEL, is a dispatch deviation guide (DDG) that contains instructions for the line maintenance crew when the deviation requires some maintenance action that is not necessarily obvious to the mechanic. A DDG is published by the airplane manufacturer to instruct the mechanic on these deviations.

- The DDG contains such information as tying up cables and capping connectors from removed units, opening and placarding circuit breakers to prevent inadvertent power – up of certain equipment during flight, and any other maintenance action that needs to be taken for precautionary reasons.

- Similar to the MEL is a configuration deviation list (CDL). This list provides information on dispatch of the airplane in the event that certain panels are missing or when other configuration differences not affecting safety are noted. The nonessential equipment and furnishing (NEF) items list contains the most commonly deferred items that do not affect airworthiness or safety of the flight of the aircraft .This is also a part of the MEL system.

- Although failures on these complex aircraft can occur at random and can come at inopportune time; these three management actions – redundancy of design, line replaceable units, and minimum dispatch requirements – can help to smooth out the workload and reduce service interruptions.

Establishing a maintenance program

- Although there has been a considerable amount of improvement in the quality and reliability of components and systems, as well as in materials and procedures, over the 100 – year life of aviation, we still have not reached total perfection. Aviation equipment, no matter how good or how reliable, still needs attention from time to time.
- Scheduled maintenance and servicing are needed to ensure the designed – in level of perfection (reliability).Due to the nature of the real world , some of these components and systems will , sooner or later , deteriorate beyond a tolerable level or will fail completely .In other instances , users , operators , or even maintenance people who interface with these components and systems can misuse or even abuse the equipment to the extent of damage or deterioration that will require the need for some sort of maintenance action.
- We have seen that components and systems fail in different ways and at different rates .This results in a requirement for unscheduled maintenance that is somewhat erratic and uncertain. There are often waves of work and no – work periods that need to be managed to smooth out the workload and stabilize the manpower requirements.
- Those components exhibiting life limits or measurable wear – out characteristics can be part of a systematic, scheduled maintenance program. Design redundancy, line replaceable units, and minimum dispatch requirements have been established as management efforts to smooth out maintenance workload. But these are numerous components and systems on an aircraft that do not lend themselves to such adjustments for convenience. Occasionally, inspections and /or modifications of equipment are dictated - within specified time limits – by aviation regulators as well as by manufacturers. It is necessary, then, that the maintenance and engineering

organization of an airline be prepared to address the maintenance of aircraft and aircraft systems with a well – thought –out and well executed program.

- The program discussed herein has been created over the years by concentrated and integrated efforts by pilots, airlines, maintenance people, manufacturers, component and system suppliers, regulatory authorities, and professional and business organizations within the aviation industry. Not every airline will need to be organized and operated in the same manner or style, but the programs and activities discussed in this text will apply to all operators.

Goals and objectives of maintenance

- A goal is a point in time or space where you want to be; a level of accomplishment you want to achieve.

- An objective is the action or activity you employ in order to help you achieve a specific goal.

- In other words, a goal is where you want to be; an objective is how you plan to get there.

- The maintenance programs currently in use in commercial aviation were developed by the industry using two basic approaches: the process – oriented approach and the task – oriented approach. The differences in these two methods are twofold
- (a)The attitude toward maintenance actions and
- (b) The manner in which maintenance actions are determined and assigned to components and systems.
- Although the commercial aviation industry has recently gone to the task oriented approach for the most recent airplane models, there are many older airplanes still in service whose maintenance programs were developed by the process – oriented approach.

- In recent years, McDonnell-Douglas and Boeing have developed new task – oriented maintenance programs for some of these older model aircraft .the operator can purchase these new programs from the manufacturer.

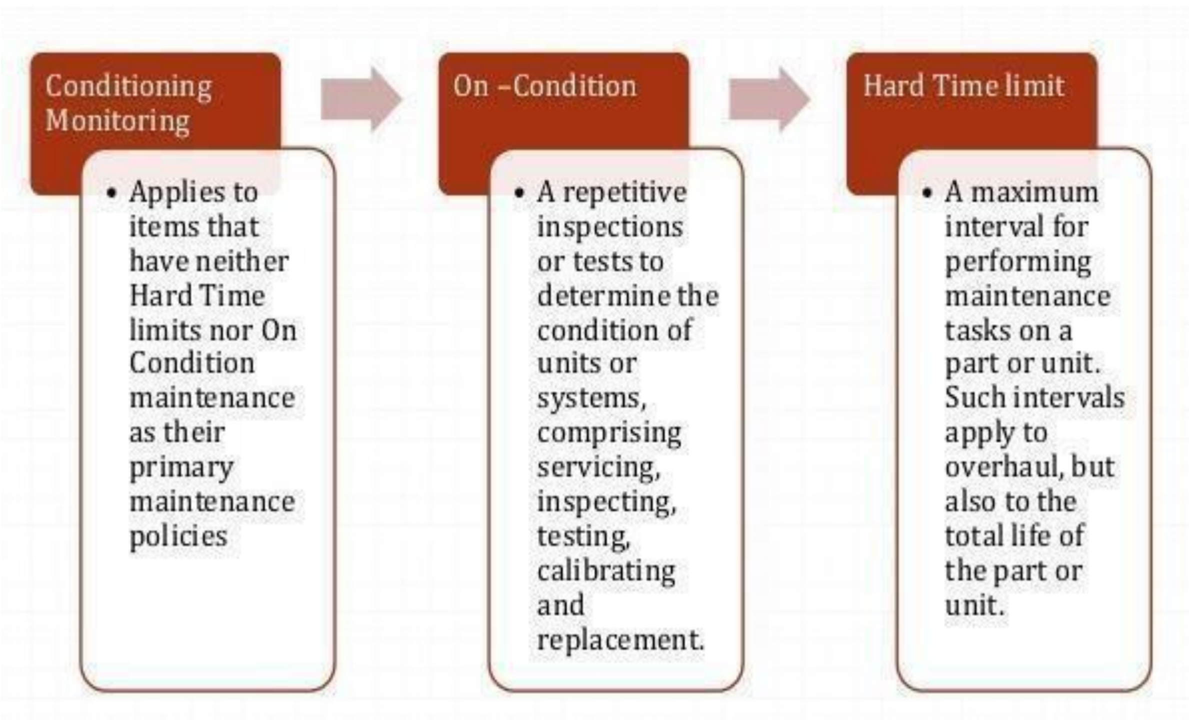
- The process-oriented approach to maintenance uses three primary maintenance processes to accomplish the scheduled maintenance actions. These processes are called hard time (HT), on-condition (OC), and condition monitoring (CM).

- The hard time and on-condition processes are used for components or systems that, respectively, have definite life limits or detectable wear-out periods

- . These are the items in categories A, B, and C discussed above and illustrated in Table I.

- The condition monitoring process is used to monitor systems and components that cannot utilize either the HT or OC processes. These CM items are operated to failure, and failure rates are tracked to aid in failure prediction or failure prevention efforts. These are the "operate to failure" items in categories D, E, and F of Table I.

- The task oriented approach to maintenance uses predetermined maintenance tasks to avoid in service failures .Equipments redundancies are sometimes used to allow in-service failures to occur without adversely affecting safety and operation. A reliability program is usually employed (similar to, but more elaborate than, the CM process) for those components or systems whose failure rates are not predictable and for those that have no scheduled maintenance tasks.
- Both of these maintenance philosophies—the process oriented and the task oriented—are discussed in general below along with the basic method of generating the program. How the maintenance tasks and task intervals are determined will be discussed in detail.



- Maintenance must ensure that the flight department has vehicles available to carry out the flight schedule, and this schedule should be met with all required maintenance completed. Therefore, the goals of an airline maintenance program can be stated as follows:
- To deliver airworthy vehicles to the flight department in time to meet the flight schedule
- To deliver these vehicles with all necessary maintenance actions com-pleted or properly deferred

- The objectives of an airline in-service maintenance program are as follows:

1) To ensure the realization of the inherent safety and reliability levels of the equipment
2) To restore safety and reliability to their inherent levels when deterioration has occurred

3) To obtain the information necessary for adjustment and optimization of the maintenance program when these inherent levels are not met
4) To obtain the information necessary for design improvement of those items whose inherent reliability proves inadequate
5) To accomplish these objectives at a minimum total cost, including the costs of maintenance and the cost of residual failures

➢ Maintenance steering group (MSG) Approach

- The Boeing Company started the modern approach to maintenance program development in 1968 with the Boeing 747 airplane, then the largest commercial airplane. It was the start of a new era in aviation, the era of the jumbo jets, and the company felt that this new era should begin with a more sophisticated approach to maintenance program development. They organized teams of representatives from the Boeing Company's design and maintenance program groups along with representatives from the suppliers and the airlines who were interested in buying the airplane. The FAA was also included to ensure that regulatory requirements were properly addressed.

- The process used involved six industry working groups (IWGs):
- (a) Structures; (b) mechanical systems; (c) engine and auxiliary power plant (APU); (d) electrical and avionics systems; (e) flight controls and hydraulics; and (f) zonal.
- Each group addressed their specific systems in the same way to develop an adequate initial maintenance program. Armed with information on system operation, maintenance significant items (MSIs) and their associated functions, failure modes, failure effects, and failure causes, the group analyzed each item using a logic tree to determine requirements.
- This approach to maintenance program development was called a "bottom-up" approach because it looked at the components as the most likely causes of equipment malfunction. The purpose of the analysis was to determine which of three processes would be required to repair the item and return it to service. The three processes were identified as HT, OC, and CM as defined above.
- This maintenance steering group (MSG) approach to maintenance program development was so successful on the 747 that it was modified slightly for use with other aircraft. The specific references to the 747 airplane were removed, and the new generalized process could be used on all aircraft. It was renamed MSG-2 and applied to the development of maintenance programs for the Lockheed L-1011 and the McDonnell-Douglas DC-10 airplanes. Other slight modifications were made to the process in 1972 by European manufacturers, and the resulting procedure used in Europe became known as EMSG.
- The MSG-2 process was slightly different for the three maintenance areas studied: (*a*) systems and components; (*b*) structures; and (*c*) engines. Table 2 summarizes the steps for each:

Step number for			
System/comp	Structure	Engine	Analysis activity
1		1	Identify the systems and their significant items
	1		Identify significant structural items
2			Identify their functions, failure modes, and failure reliability
	2		Identify failure modes and failure effects
		2	Identify their functions, failure modes, and failure effects
3		3	Define scheduled maintenance tasks having potential effectiveness relative to the control of operational reliability
	3		Assess the potential effectiveness of scheduled inspections of structure
4		4	Assess the desirability of scheduling those tasks having potential effectiveness
	4		Assess the desirability of those inspections of structure which do have potential effectiveness
	5		Determine that initial sampling thresholds were appropriate

TABLE -2 -MSG-2 Process Steps

- 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.
- The process flow diagram in the MSG-2 document is too complex to repeat here, especially since the MSG-2 process is no longer used. It is important, however, to understand how the maintenance processes were assigned to the tasks selected.
- Figure 2 is a simplified diagram of that process. Briefly, if failure of the unit is safety related (block 1) and there is maintenance check available to detect a reduction in failure resistance (block 4), then the item in question is identified as on-condition. If no such check is available, then the item is classified as hard time. The student can follow the logic of Fig. 2 for the other conditions.

- Once the maintenance action was determined, it was necessary to define how often such maintenance should be done. Available data on failure rates, removal rates, etc. of the item were then used to determine how often the maintenance should be performed.

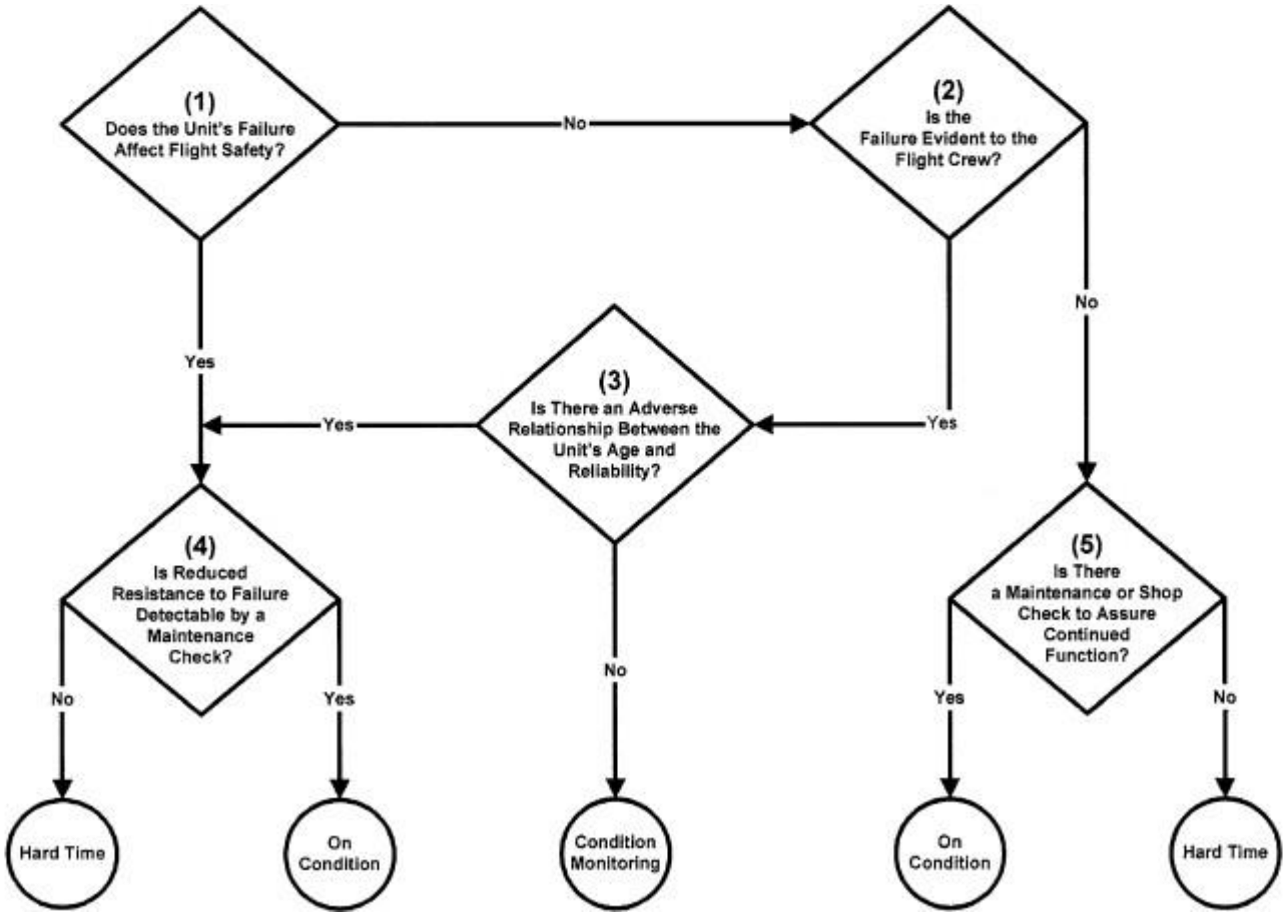


Figure -4-Simplified MSG-2 flow chart.

➢ Process – Oriented maintenance

- Process-oriented maintenance programs are developed for aviation using decision logic procedures developed by the Air Transport Association of America (ATA). The MSG-2 process is a bottom-up approach whereby each unit (system, component, or appliance) on the aircraft is analyzed and assigned to one of the primary maintenance processes, HT, OC, or CM.

- In general, hard time means the removal of an item at a predetermined interval, usually specified in either so many flight hours or so many flight cycles. In some cases the hard time interval may be in calendar time. On-condition means that the item will be checked at specified intervals (in hours, cycles, or calendar time) to determine its remaining serviceability. Condition monitoring involves the monitoring of failure rates, removal rates, etc. to facilitate maintenance planning. Let us look at each process in more detail.

The hard time (HT) process

- Hard time is a failure preventive process which requires that the item be removed from the vehicle and either completely overhauled, partially overhauled (restored), or discarded before exceeding the specified interval. The hard time interval may be specified by calendar time, by engine or airplane check interval (engine change, “C” check, etc.), by landing or operating cycles, by flight hours, by block hours, by specified flights (over water, terminating, etc.), or in conjunction with another process (OC for instance).

- When HT is specified, the component will be removed from the vehicle and overhauled, restored, or discarded, whichever is appropriate. This will be done before the component has exceeded the specified time interval. The component overhaul or restoration will restore the component to a condition that will give reasonable assurance of satisfactory operation until the next scheduled removal.
- Ideally, hard time would be applied to a component that always fails at *X* hours of operation. This component would then be replaced at the last scheduled maintenance period prior to the accumulation of *X* hours; thus, the operator would get maximum hours out of the component and the component would never fail in service (ideally).
- Hard time is also applied to items having a direct adverse effect on safety and items subject to reliability degradation with age but having no possible maintenance check for that condition.
- As an example, structural inspection, landing gear overhaul, and replacement of life-limited engine parts are all controlled by hard time. Frequently, mechanical linkages and actuators, hydraulic pumps and motors, electric motors and generators, and similar items subject to a definite wear-out cycle will also be identified as hard time. For items having clearly defined wear-out periods, hard time is probably the most economical process. However, these items can also be OC or CM, depending on the operator, as long as they are not safety related.

The on-condition (OC) process

- On-condition is a failure preventive process that requires that the item be periodically inspected or tested against some appropriate physical standard (wear or deterioration limits) to determine whether or not the item can continue in service.
- After failing an OC check, the component must be overhauled or restored to the extent of at least replacing out-of-tolerance parts. Overhaul or repair must restore the unit to a condition that will give reasonable assurance of satisfactory operation for at least one additional OC check interval. If the item cannot be overhauled or restored, or if it cannot be restored to a condition where it can operate one more OC check period, then it should be discarded.
- On-condition must be restricted to components, equipment, or systems on which a determination of continued airworthiness may be made by measurements, tests, or other means without doing a tear-down inspection. These on-condition checks are to be performed within the time limits (intervals) prescribed for each OC check.
- The periodically scheduled OC checks must constitute meaningful determination of suitability for continued operation for another scheduled OC check interval. If the check performed provides enough information regarding the condition and failure resistance of the item to give reasonable assurance of its continued airworthiness during the next check period, the item is properly categorized as on-condition.

- If the check constitutes merely a maintenance task—servicing, adjustment, or a go/no-go determination—and is not making a meaningful disclosure of actual condition, the item is, in fact, operating as a condition monitored item. It should be classified as CM and not OC.
- In some cases, it could even be classified as HT. A simple operational check is *not* an acceptable requisite for the on-condition process. On-condition checks must measure or evaluate the wear and/or deterioration condition of the item.
- The on-condition process also encompasses periodic collection of data that will reveal the physical condition of a component, system, or engine. Through analysis and evaluation, OC data must be able to ascertain continued airworthiness and/or deterioration of failure resistance and imminence of failure. On-condition data must be directed to an individual component, system, or engine (by serial number). It is a priori (before the fact) failure data that can be used to measure decreasing life expectancy and/or predict failure imminence.
- Examples of OC checks are as follows: (*a*) tire tread and brake linings, (*b*) scheduled bore scope inspections of engines, (*c*) engine oil analysis, and (*d*) in-flight engine performance analysis (i.e., engine condition monitoring or ECM). In each of the above stated cases, one can measure degradation and determine, from established norms, how much life or serviceability remains.

- Two points to remember about the on-condition process:
  (a) if a satisfactory on-condition check can be accomplished to ensure serviceability with reasonable probability until the next OC check, or if evaluation of the OC data collected will predict failure imminence, then the OC process will achieve close to maximum life on components and engines; and
  (b) on-condition applicability is limited by the requirement for a satisfactory condition measurement or pertinent failure predicting data.

- Examples of components susceptible to the on-condition process are as follows
  1. Brake wear indicator pins: Compare brake wear condition against a specified standard or limit. Brake wear will vary considerably among operators due to operational conditions and crew habits, but the wear indicator pin OC check will help attain near maximum usage out of each set of brakes.

  2. *Control cables*: Measure these for diameter, tension, and broken strands.

  3. Linkages, control rods, pulleys, rollers tracks, jack screws, etc.: Measure these for wear, end or side play, or backlash.

The condition monitoring (CM) process

- The condition monitoring process is applied when neither the hard time nor the on-condition process can be applied.
- The CM process involves the monitoring of the failure rates, removals, etc. of individual components or systems that do not have a definite lifetime or a noticeable wear-out period. Condition monitoring is not a failure preventive process as are HT and OC. There are no

maintenance tasks suitable for evaluating the life expectancy of the CM item and there is no requirement to replace the item before it fails. Neither time nor condition standards can be used to control CM items because these components do not have such attributes. Therefore, CM components are operated until failure occurs and replacement of CM items is an unscheduled maintenance action.

- Since CM items are operated to failure, the ATA states that these items must comply with the following conditions:

    1. A CM item has no direct, adverse effect on safety when it fails; i.e., the air-craft continues to fly to a safe landing. Generally, CM items have only this indirect, non adverse effect on safety due to system redundancy.
    2. A CM item must not have any hidden function (i.e., a malfunction that is not evident to the crew) whose failure may have a direct adverse effect on safety. However, if there is a hidden function and the availability or operation of that hidden function is verified by a scheduled operational test or other non measurement test made by the flight crew or maintenance crew, CM can still be used.
    3. A CM item must be included in the operator's condition monitoring or reliability program; i.e., there must be some sort of data collection and analysis for those items for maintenance to get a better understanding of the nature of failure for those components or systems.

- In addition to the above ATA stipulations, CM items usually have no adverse relationship between age and reliability (i.e., no predictable life expectancy). They exhibit a random failure pattern.
- The most appropriate application of the condition monitoring process is to complex systems, such as avionics and electronics components, and to any other components or systems for which there is no way to predict failures. Typical components and systems suitable for CM include navigation and communications equipment, lights, instruments, and other items where test or replacement will not predict approaching failure nor result in improved life expectancy. In aviation, CM is frequently applied to components where failure has no serious effect on safety or air-worthiness, due to redundancy, and to items not affecting airworthiness at all, such as coffee makers, lavatories, passenger entertainment systems, etc.
- Condition monitoring systems consist of data collection and data analysis procedures that will portray information upon which judgments relative to the safe condition of the vehicle can be made.
- Condition monitoring, which is primarily a data collection and analysis pro-gram, can also be used on HT and OC components for verifying or adjusting the HT and OC intervals.
- For example, if a hard time item is removed just prior to its expiration date and overhaul activities reveal that little or nothing needs to be done to restore the component, then perhaps the HT interval can be extended. Likewise, if OC checks reveal little or no maintenance requirement or that the lifetime of the component is longer than originally expected, the OC check interval can be changed.

- However, without the collection of data over a period of time (several HT periods or OC intervals), there would not be any solid justification to change the intervals. By the same token, CM data collection may indicate that the HT or OC intervals need to be shortened for some components. The CM pro-gram also provides data to indicate whether or not components are being monitored under the most appropriate process.

➢ Task- oriented maintenance

- Task-oriented maintenance programs are created for aviation using decision logic procedures developed by the Air Transport Association of America. The process called MSG-3 is a modification of and an improvement on the MSG-2 approach.

- The MSG-3 technique is a top-down consequence of failure approach whereby failure analysis is conducted at the highest management level of air-plane systems instead of the component level as in MSG-2. The MSG-3 logic is **used** to identify suitable scheduled maintenance tasks to prevent failures and to maintain the inherent level of reliability of the system. There are three categories of tasks developed by the MSG-3 approach:
    1. Airframe system tasks
    2. Structural item tasks
    3. Zonal tasks

Maintenance tasks for airframe systems

- Under the MSG-3 approach, eight maintenance tasks have been defined for airframe systems. These tasks are assigned in accordance with the decision analysis results and the specific requirements of the system, component, etc. under consideration. These eight tasks are listed and defined below:

1. Lubrication. An act of replenishing oil, grease, or other substances that maintains the inherent design capabilities by reducing friction and/or conducting away heat.
2. Servicing. An act of attending to basic needs of components and/or systems for the purpose of maintaining the inherent design capabilities.
3. Inspection. An examination of an item and comparison against a specific standard.
4. Functional check. Aquantitative check to determine if each function of an item performs within specified limits. This check may require use of additional equipment.
5. Operational check. A task to determine if an item is fulfilling its intended pur-pose. This is a failure-finding task and does not require quantitative tolerances or any equipment other than the item itself.
6. Visual check. An observation to determine if an item is fulfilling its intended pur-pose. This is a failure-finding task and does not require quantitative tolerances.
7. Restoration. That work necessary to return the item to a specific standard. Restoration may vary from cleaning the unit or replacing a single part up to and including a complete overhaul.
8. Discard. The removal from service of any item at a specified life limit.

Maintenance tasks for structural items

- Airplanes are subjected to three sources of structural deterioration as discussed below.

1. Environmental deterioration. The physical deterioration of an item's strength or resistance to failure as a result of chemical interaction with its climate or environment. Environmental deteriorations may be time dependent
2. Accidental damage. The physical deterioration of an item caused by contact or impact with an object or influence that is not a part of the airplane, or damage as a result of human error that occurred during manufacture, operation of the vehicle, or performance of maintenance.
3. Fatigue damage. The initiation of a crack or cracks due to cyclic loading and subsequent propagation of such cracks

- Inspection of airplane structures to determine if deterioration due to the above has occurred requires varying degrees of detail. The MSG-3 process defines three types of structural inspection techniques as follows:

    1. General visual inspection. A visual examination that will detect obvious, unsatisfactory conditions or discrepancies. This type of inspection may require removal of fillets or opening or removal of access doors or panels. Work stands and ladders may be required to facilitate access to some components.
    2. Detailed inspection. An intensive visual inspection of a specified detail, assembly, or installation. It is a search for evidence of irregularity using adequate lighting and, where necessary, inspection aids, such as mirrors, hand lenses, etc. Surface cleaning and detailed access procedures may also be required.
    3. Special detailed inspection. An intensive examination of a specific location. It is similar to the detailed inspection but with the addition of special techniques. This examination may require such techniques as nondestructive inspections (NDIs): dye penetrant, high-powered magnification, magnetic particle, eddy current, etc.

Zonal maintenance tasks

- The zonal maintenance program ensures that all systems, wiring, mechanical controls, components, and the installation contained within the specified zone on the aircraft receive adequate surveillance to determine the security of installation and general condition. The logical process is normally used by type certificate (TC) and supplement type certificate (STC) holder for developing their maintenance and inspection for zonal maintenance by using MSG-3 logic to develop a series of inspections, and a numerical reference is assigned to each zone when it is analyzed. Due to aging aircraft, the FAA has established specific damage tolerance criteria based on inspection of an aircraft operator's continued airworthiness program. The AC 120-93 provides for detailed damage tolerance inspection (DTI) for repair and alterations that affect fatigue-critical structure of the aircraft. The DTI process includes the area to be inspected, the inspection methods and techniques, and the inspection procedures.

- The program packages a number for general visual inspection tasks, generated against the item in the system's maintenance program, into one or more zonal surveillance tasks. Zonal maintenance and inspection level techniques are performed in two types as in the following list.
    1. General visual inspection
    2. Detailed visual inspection

➢ The Current MSG Process—MSG-3

- The MSG-2 process was modified in 1980 in a document released by the Air Transport Association of America.
- The document states "MSG-3 did not constitute a fundamental departure from the previous version, but was built upon the existing framework of MSG-2 which had been validated by 10 years of reliable aircraft operation using the maintenance programs based thereon."
- The MSG-3 program adjusted the decision logic to provide a more straight-forward and linear progression through the logic.
- The MSG-3 process is a top-down approach or consequence of failure approach. In other words, how does the failure affect the operation? It does not matter whether a system, subsystem, or component fails or deteriorates. What matters is how the failure affects the aircraft operation. The failure is assigned one of two basic categories: safety and economic. Figure 5 is a simplified diagram of the first step in the MSG-3 logic process.

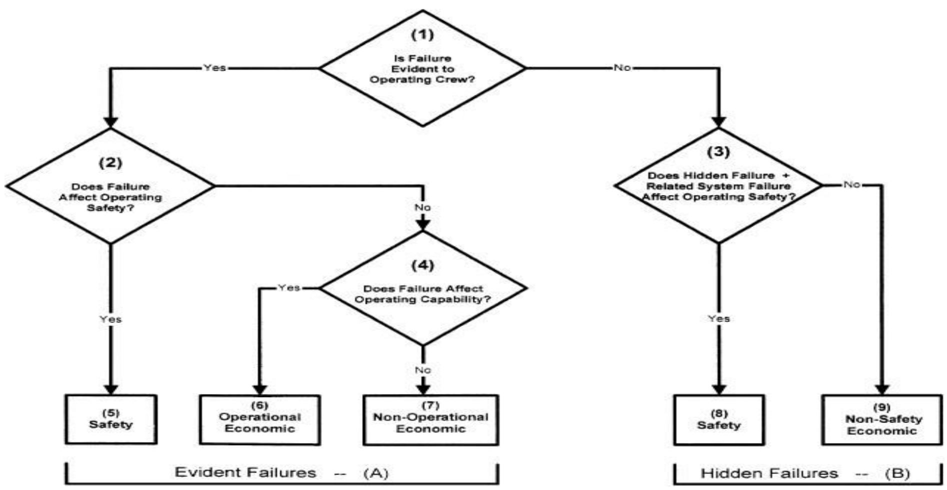


Fig – 5- MSG-3—level I analysis—failure categories

- The maintenance tasks resulting from the MSG-3 approach may include hard time, on-condition, and condition monitoring tasks similar to those of MSG-2, but they are not referred to by those terms.
- The MSG-3 approach is more flexible in developing the overall maintenance program.
- The flow chart of Fig. 5 is used to determine if the failure is evident to the flight crew or hidden from them (level I analysis). Those failures that are evident are further separated into safety related and operationally related with the latter split into those that are of economic significance and those that are not. These types are numbered 5, 6, and 7. The significance of these categories will be addressed later. Those failures that are determined to be hidden from the crew

are divided into safety related and non safety related items. These are designated as categories 8 and 9.

- Figures 6 and 7 (level II analysis) are used to determine the maintenance tasks required to accommodate the functional failure. Although the questions are similar, there is a slight difference in the way evident and hidden failures are addressed. Note that some of the flow lines in Figs. 2-3 and 2-4 are identified as Cat 5 or Cat 8 only. This requires some explanation.

- The first question in each chart, regarding lubrication or servicing, must be asked for all functional failures (categories 5 through 9). Regardless of the answer to this question (Yes or No), the analyst must ask the next question. For categories 6 and 7 in Fig. 6 and category 9 in Fig. 7, the questions are asked in sequence until a Yes answer is obtained. At that point the analysis stops. For categories 5 and 8 (safety related), however, all questions must be answered regardless of
- the Yes or No response to any of them.
- The last block of Figs 6 and 7 also requires some explanation. These flow charts are used for the development of a maintenance program for a new aircraft or derivative. If progression through the chart ends up in this block for categories 6, 7, and 9, then a redesign on the equipment involved may be considered by the design engineers. However, if the item is safety related—categories 5 or 8—then a redesign is mandatory. Once the initial maintenance program is developed, the airline mechanics will use that program.
- The MSG-3 process can be best understood through a step-by-step explanation of what the working groups would do for a given analysis. Each working group will receive information about the systems and components within their respective groups:
- (*a*) the theory of operation; (*b*) a description of the operation of each mode (if there is more than one mode); (*c*) the failure modes of each operational mode; and (*d*) any data available (actual or estimated) on the failure rates, removal rates, etc. [such as mean time between failures (MTBF) and mean time between unscheduled removals (MTBUR) for repairable parts; and mean time to removal (MTTR) for non repairable parts].

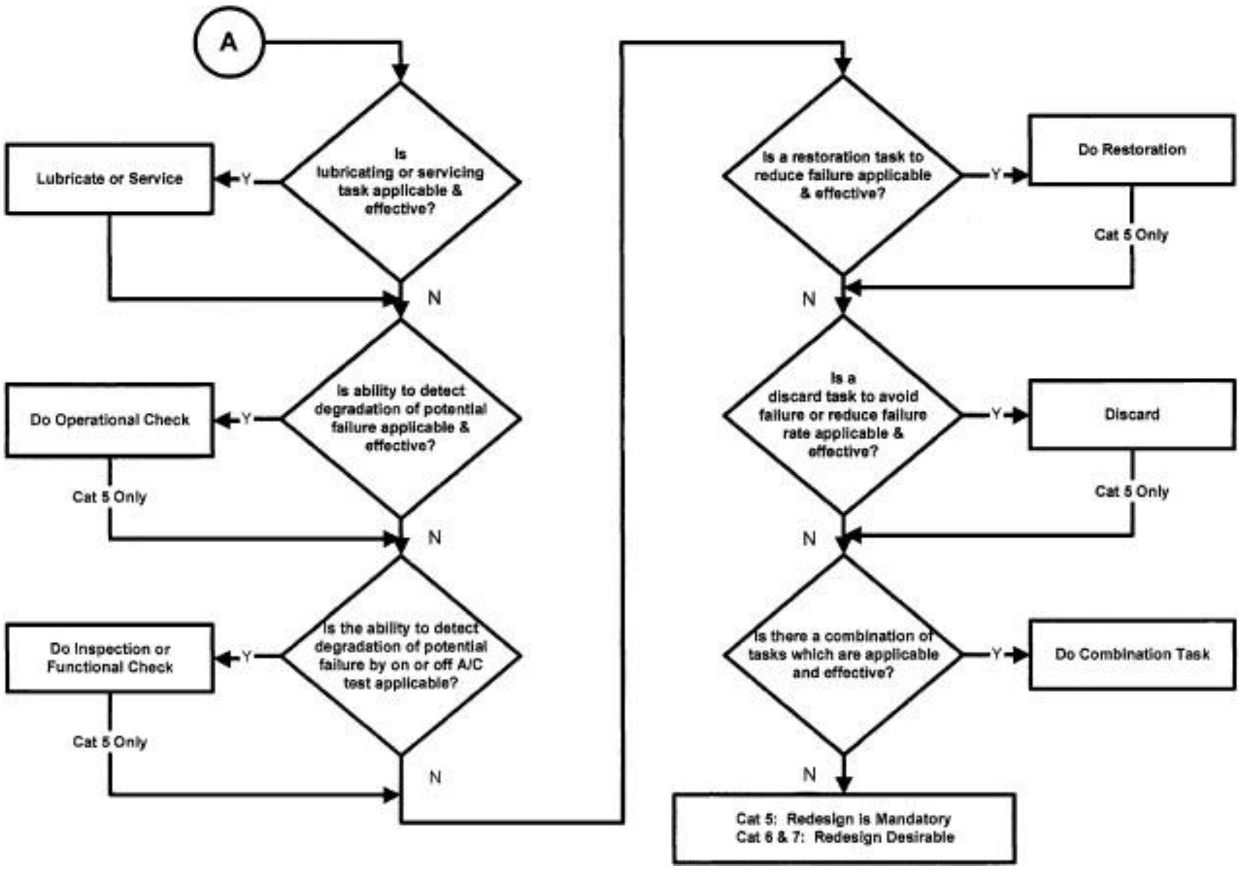


Fig – 6 - MSG-3—level II analysis—evident failures

- If the system is the same as, or similar to, that used on an existing model aircraft , the group members only need refresher training on the operation and on the failure modes. If the equipment is new, or has been extensively modified for the new model aircraft, the learning process may take a little more time. The airframe manufacturer is responsible for providing this training to the working groups. The manufacturer is also responsible for furnishing any available performance and failure rate data to the working groups.

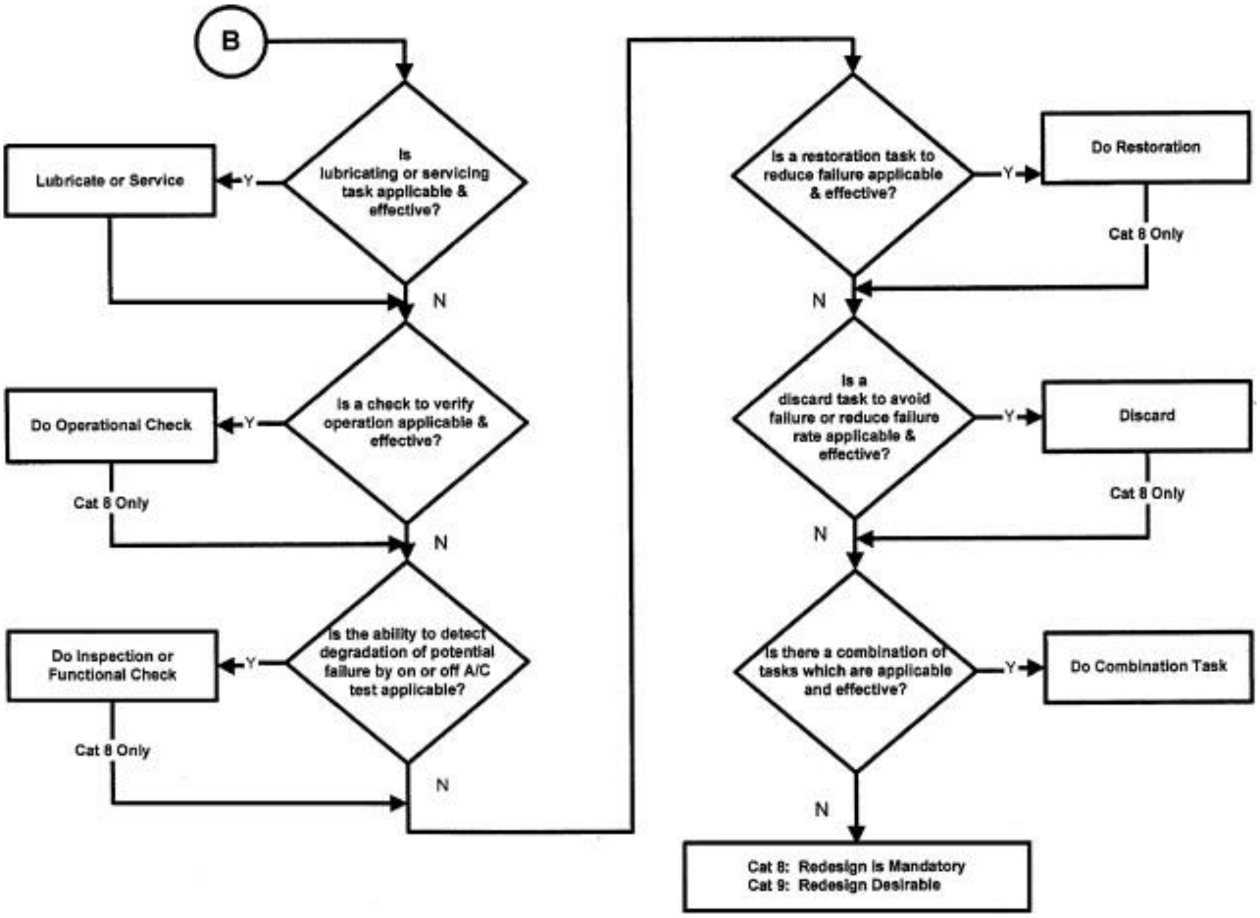


Fig – 7 - MSG-3—level II analysis—hidden failures

➢ Maintenance program documents

- The result of the MSG-3 analysis constitutes the original maintenance program for the new model aircraft and the program that is to be used by a new opera-tor of that model. The tasks selected in the MSG process are published by the airframe manufacturer in an FAA approved document called the Maintenance Review Board Report (MRBR). This report contains the initial scheduled maintenance program for U.S. certificated operators. It is used by those operators to establish their own FAA approved maintenance program as identified by their operations specifications.
- The MRBR includes the systems and power plant maintenance program, the structural inspection program, and the zonal inspection program. It also contains aircraft zone diagrams, a glossary, and a list of abbreviations and acronyms.
- In addition to the MRBR, the manufacturer publishes its own document for maintenance planning.
- At Boeing, this document is called the maintenance planning data (MPD) document. McDonnell-Douglas called it the on aircraft maintenance planning (OAMP) document.

- At Airbus Industries, it is called the maintenance planning document (MPD). We will use the acronym MPD/OAMP to refer to all such documents.
- These documents contain all the maintenance task information from the MRBR plus additional tasks suggested by the air-frame manufacturer.
- The MPD/OAMP also sorts the tasks in various ways to aid in planning. This document often groups by letter check and by hours, cycles, and calendar time.
- These manufacturer's documents also contain diagrams showing the location and numbering of access doors and panels, aircraft dimensions, and other information to aid the development of maintenance programs and the planning of maintenance checks. The latter includes man-hour requirements for each task. These are only estimates of the time required to do the actual work prescribed. They do not include the time required to open and close doors or panels, position work stands, to analyze or troubleshoot problems, or to correct any discrepancies found during conduct of the task. These estimated times must be altered by the operator to accommodate the actual task requirements when planning any given check activity.

Maintenance Intervals Defined

- The maintenance work interval depends on the aircraft manufacturer with the cooperation of the airline's operator discretion.
- Various maintenance checks have been named and defined in the MSG-3 process and are to be considered standard.
- However, many airlines have defined their own named intervals, but as long as the integrity is maintained of the original maintenance required task or an approved FAA deviation.
- Aircraft maintenance checks are normally driven by total air time (TAT), the number of hours an aircraft has flown, and total landing cycles (CYC), which translates into each time aircraft lands it generates one cycle. Under FAA oversight, airlines and aircraft operators must prepare a continuous airworthiness maintenance program (CAMP) under their operations specification.
- The CAMP program outlines routine and detailed inspection.
- Airlines and aircraft operators and airworthiness authorities commonly refer to these types of inspections as checks. These checks are known as A, B, C, D checks

- The following are the examples of standard intervals:

Daily checks

- Daily checks consist of the oil level check. The oil level on the aircraft engine must be checked between 15 and 30 minutes after engine shutdown to obtain an accurate reading. This means that the oil level cannot be checked and replenished prior to the first flight of the day. It can only be done soon after landing. (If one must check the oil level prior to first departure, the engine must be run for 2 minutes or more to warm up the oil. Fifteen minutes after shutting down, the oil level can be checked. This is not a normal procedure, but it is necessary in some cases.)

- The daily checks also include any time-deferred maintenance items, such as an aircraft engine being on oil watch. ETOPS-type aircraft also receive a pre-departure service check, which is also part of the daily checks.

48- hour checks

- A 48-hour check, for most aircraft models, replaces what used to be called a daily check.
- The 48-hour check is performed every 48 hours depending on airline operations specifications. This check may include tasks that are more detailed than the daily checks;
- For example, items such as wheel and brake inspection, replenishment of fluids such as engine oil and hydraulic, auxiliary power unit oil replenishment and inspection, general visual inspection of the fuselage, wings, interior, and flight deck.

Hourly limit checks

- Certain checks determined by the MSG analysis have maintenance tasks assigned by the number of hours the unit or system has been operating: 100, 200, 250 hours, etc.
- This approach is used for engines, airplane flight controls, and numerous other systems that are operating on a continual basis during the flight or on the ground.

Operating cycle limit checks

- Other airplane systems are maintained on a schedule determined by the number of operating cycles they have endured.
- For example, landing gear is used only during takeoffs and landings, and the number of those operations will vary with the flight schedule. Airframe structures, power plant/engine components, such as LP and HP impellors and HP turbine blades and some other components are also subject to cyclic stresses and will have numerous tasks in this category.

Letter checks

- Until the development of the Boeing 777, all aircraft utilizing the MSG-3 processes for maintenance program development had various letter checks identified in the maintenance program.
- These checks were identified as A, B, C, and D checks. The Boeing 777, using a modified MSG-3 process (called MSG-3, Revision 2) eliminated the letter checks. Every task that was not on the transit check was identified by hours or cycles only, and these tasks were not grouped into letter checks as was done for previous model aircraft.
- This produced an optimum maintenance program in that it allowed maintenance to be done at the most appropriate time for the equipment or system. For the operator, it makes the program more adaptable to their needs. Some operators, however, still schedule this maintenance in blocks at specific time or cycle intervals.

Changing Basic Maintenance Intervals

- Operational conditions will often require that an operator change the basic maintenance program to better address the organizational needs and to accommodate the fifth objective of a maintenance program.
- For example, operation in hot humid climates may require that corrosion control tasks be performed more often than the MRB report indicates while operating the same vehicles in a dry, desert climate may reduce the needed frequency for these tasks. In the latter situation, however, items sensitive to sand and dust will need increased attention in the maintenance program
- It is expected that an operator will change the original maintenance intervals for certain tasks or for entire letter checks whenever in-service experience dictates. However, to do this, the operator must have proof that a change is warranted. The accepted proof for such maintenance interval changes is in the form of data collected through the operator's condition monitoring program or reliability program. As aircraft get older, task intervals for certain items may have to be shortened while others may be lengthened. Maintenance is a dynamic process.

UNIT – II
AVIATION CERTIFICATION REQUIREMENTS AND DOCUMENTATION FOR MAINTENANCE & ENGINEERING

➢ Aircraft certification

- There are three certificates necessary for full certification of the airplane. These documents—the type certificate, the production certificate, and the airworthiness certificate—certify, respectively, the aircraft design, the manufacturing process, and the aircraft itself.

Type certificate (FAA form 8110.9)

- To begin with, each aircraft designed and built for commercial as well as private operation must have an approved type certificate (TC). This certificate is applied for by the designers of the vehicle once the basic design has been deter-mined. The TC defines the vehicle, engines and/or propellers, and the various instruments, systems, and equipment that make up the model.
- If more than one engine type (i.e., derivatives of existing engines or engines from different manufacturers) is offered for the same vehicle, the TC must cover the characteristics and limitations of all of them. The same is true on other equipment, systems, and accessories. The TC also defines the capabilities and limitations of the vehicle, such as passenger and cargo carrying limits, altitude limits, fuel capacity, and top speed as well as cruising speed.
- All of these parameters combined, which define the airframe/engine combination, must be identified on a data sheet attached to the certificate. The aircraft/engine combination is designed to exacting safety and airworthiness standards set by the FAA, and this design must be proven to the FAA by means of inspections and test flights. A final FAA proving flight is conducted before the TC is awarded.
- The TC is applied for early in the design stages but is not awarded until the aircraft is actually built, tested in flight, and proven to meet the standards of safety and airworthiness.
- For example, the Boeing Company applied for the TC for the 757-200 airplane in 1978; it was awarded by the FAA's Aircraft Certification Office (ACO) in 1982.

- A sample of the TC is shown in Fig-1.
- This is the first page showing the air-planes covered.
- Additional information concerning the design is given in the data sheets (not shown) attached to the TC.
- The TC remains in effect until superseded revoked, or a termination date is established by the FAA. Figure -2 shows an STC.

The United States of America

Department of Transportation

Federal Aviation Administration

①

Type Certificate

②

Number ________ ③

This certificate issued to ④
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 ⑤ of the Federal Aviation Regulations.

⑥

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: ⑦

Date of issuance: ⑧

By Direction of the Administrator

(Signature)____________________________

⑨

(Title) ______________________________

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 not exceeding $1,000, or imprisonment not exceeding 3 years, or both.

FAA FORM 8110-9 (2-82)(Representation)

Fig-I- FAA type certificate (sample)

(1) Type of product (airplane, engine, propeller); (2) "IMPORT" if applicable; (3) TC number as assigned; (4) applicant's name; (5) applicable Federal Aviation Regulation; (6) product type designation: "Airplane Model 120." Additional models if applicable; (7) date of original application; (8) date TC is issued. When later models are added, retain original date and add new date; (9) signature of manager, FAA accountable directorate.

United States of America

Department of Transporation-Federal Aviation Administration

Supplemental Type Certificate

Number

This certificate, issued to

certifies that the change in the type design for the following product with the limitations and conditions therefor as specified hereon meets the airworthiness requirements of Part of the Regulations.

Original Product-Type Certificate Number:

Make:

Model:

Description of Type Design Change:

Limitations and Conditions:

This certificate and the supporting data which is the basis for approval shall remain in affect until surrendered, suspended, revoked, or termination date is otherwise established by the administrator of the Federal Aviation Administration.

Date of application:

Date of issuance:

Date reissued:

Date amended:

FEDERAL AVIATION ADMINISTRATION

By Direction of the Administrator

(Signature)

(Title)

Any alteration of this certificate is punishable by a fine not exceeding $1,000, or imprisonment not exceeding 3 years, or both.

This certificate may be transferred in accordance with FAR 21.47.

FAA FORM 8110-2 (10-68)(Representation)

Fig- 2- FAA supplemental type certificate (sample)

Production certificate (FAA form 8120-4)

- Once the TC is awarded, the manufacturer applies for the production certificate (PC) by submitting application form 8110.12 to the FAA's Manufacturing Inspection District Office (MIDO).
- The production certificate is awarded after the FAA is satisfied with the quality control system that also consists of necessary manufacturing and production facilities, effective quality system for compliance as per requirements of 14 CFR part 21, and approved design data of each unit(aircraft) built to the TC standards.
- In other industries, it is possible to build a hand-made prototype of a product which often differs from the mass-produced units. This is then used to demonstrate the unit's capabilities.
- This is not the case in aviation. Each copy of the aircraft must be built to the type certificate standards.
- A manufacturer usually gets one production certificate.
- Each subsequent air-craft manufactured by that company will be added to the original PC by the FAA.
- Figure -3 shows the first page of a typical production certificate
- A production certificate may have a production limitation record (PLR), shown in Fig. - 4, which lists all the TCs and STCs issued to that manufacturer as well as any limitations. The PC is effective for as long as the manufacturer complies with the requirements of the original issuance. For new technology, or for derivative or new aircraft, the FAA may conduct additional inspections of the manufacturer's facilities and processes if it deems that to be necessary. The FAA may cancel, suspend, supersede, or revoke the PC for just cause at any time.

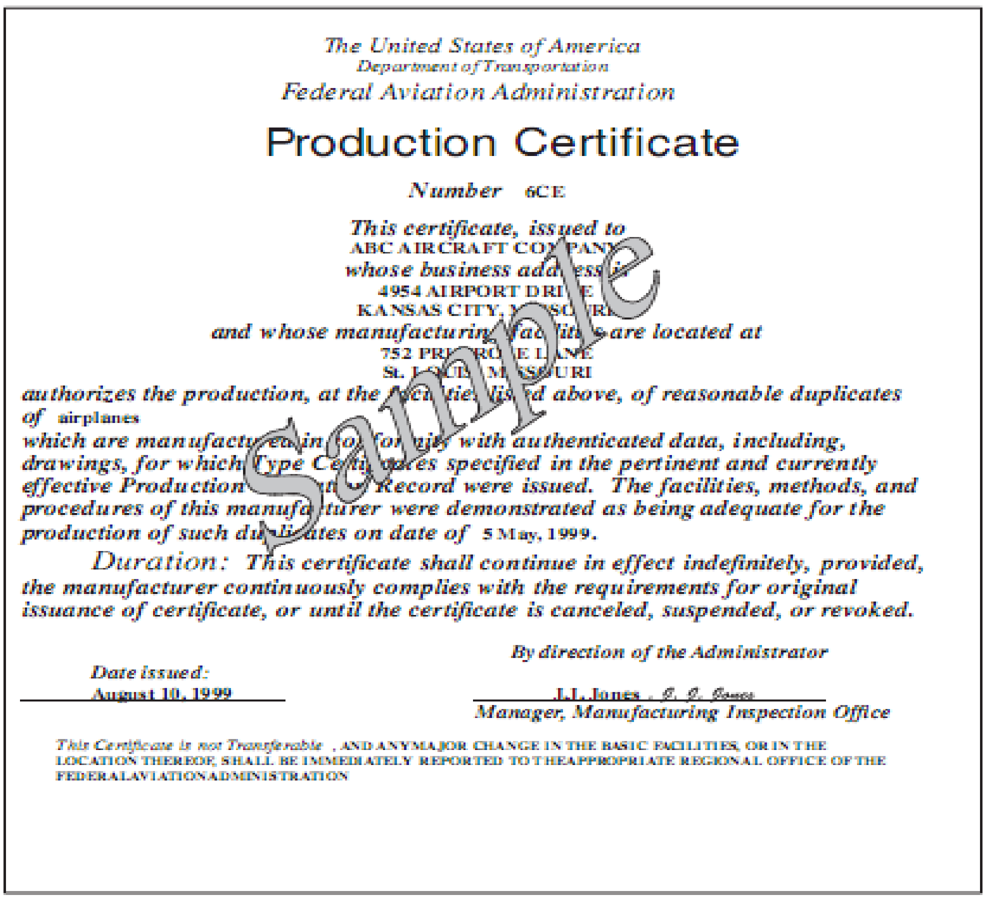
Airworthiness certificate (FAA form 8100-2)

- The third certificate, the airworthiness certificate (AC), is awarded by the FAA's MIDO to each aircraft produced by a manufacturer. This certificate confirms that the aircraft to which it is awarded has been inspected and found to conform with its type certificate and to be in airworthy condition.
- This airworthiness certificate is applied for by the manufacturer and awarded by the FAA after the aircraft has passed all inspections and a successful flight test—when the aircraft "rolls out the door"—just prior to delivery to the customer. The airworthiness certificate contains the aircraft's unique serial (tail) number.
- The standard AC remains in effect as long as the following conditions are met: (*a*) the aircraft meets its type design; (*b*) the aircraft is in a condition for safe operation; (*c*) all applicable airworthiness directives (ADs) have been incorporated; and (*d*) maintenance and alterations are performed in accordance with applicable FARs. The FAA can cancel, suspend, supersede, or revoke the AC if, in its opinion, any of the above have been violated.

- Figure-5 shows a typical airworthiness certificate.

- FAA rules require that this certificate be prominently displayed in the aircraft. In passenger airliners, it is usually posted by the main entry door. Look for it the next time you board a commercial aircraft. If you do not see it, ask a crew member where it is.
- The FAA form 8100-2 is also allowed for the following categories of vehicles, including normal, utility, acrobatic, transport, and special classes. Special air-worthiness certificate FAA Form 8130-7 is not used for commercial aircraft/ airline use.
- The FAA authorization is required to operate any type of aerial vehicle in U.S. airspace. The following are the examples of categories

- Primary. Aircraft flown for pleasure and personal use
- Restricted. Agriculture, forest, and wildlife, surveying, patrolling, weather use
- Light-Sport. Light sport aircraft, ultra light vehicle use
- Experimental. R&D, air racing, crew training, unmanned aircraft system use



The United States of America
Department of Transportation
Federal Aviation Administration

Production Certificate

Number 6CE

This certificate, issued to
ABC AIRCRAFT COMPANY
whose business address is
4954 AIRPORT DRIVE
KANSAS CITY, MISSOURI
and whose manufacturing facilities are located at
752 PRIMROSE LANE
St. LOUIS, MISSOURI
authorizes the production, at the facilities listed above, of reasonable duplicates of airplanes
which are manufactured in conformity with authenticated data, including, drawings, for which Type Certificates specified in the pertinent and currently effective Production Limitation Record were issued. The facilities, methods, and procedures of this manufacturer were demonstrated as being adequate for the production of such duplicates on date of 5 May, 1999.

Duration: This certificate shall continue in effect indefinitely, provided, the manufacturer continuously complies with the requirements for original issuance of certificate, or until the certificate is canceled, suspended, or revoked.

By direction of the Administrator

Date issued:
August 10, 1999

J.L. Jones , *J. L. Jones*
Manager, Manufacturing Inspection Office

This Certificate is not Transferable , AND ANYMAJOR CHANGE IN THE BASIC FACILITIES, OR IN THE LOCATION THEREOF, SHALL BE IMMEDIATELY REPORTED TO THEAPPROPRIATE REGIONAL OFFICE OF THE FEDERALAVIATIONADMINISTRATION

Fig – 3 - FAA production certificate (sample).

The United States of America

Department of Transportation

Federal Aviation Administration

Production Limitation Record

The holder of
Production Certificate No. 6CE
may receive the benefits incidental to the possession of such certificate with respect to

AIRCRAFT
(OR AIRCRAFT PROPELLER,
AIRCRAFT ENGINE (AS APPLICABLE)

manufactured in accordance with the data forming the basis for the following Type Certificate(s) No.

Type Certificate	Model	Date Production Authorized
A 920CE	[illegible] 2[illegible]47R	August 10, 1978
A 9CE	[illegible] 258D	August 10, 1978
STC 492CE	[illegible]awing List HC-B2YK-6	August 10, 1978

(Note: Any number of columns may be used provided the material is neat and legible. Additional PLRs may be used when necessary. Additional PLRs shall be numbered "1 of 2," "2 of 2," as appropriate to the number of pages involved.)

LIMITATIONS:

(if any)

August 10, 1999
Date of issuance

By Direction of the Administrator
J. J. Jones
J. J. Jones
Manager, Manufacturing Inspection District Office

FAA FORM 8120-3 (7-67)

Fig – 4 - FAA production limitation record (sample).

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	Boeing 747-400	197142	Transport

5 AUTHORITY AND BASIS FOR ISSUE

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:

EXEMPTION NO. 1013A FAR 25.471(b): Allows lateral displacement of C.G. from airplane centerline.

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, preventive 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
11/29/92	John Q. Publican (signed: John Q. Publican)	DMIR ANM 1234

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

Figure 4-5 FAA airworthiness certificate (sample).

Fig – 5 - FAA airworthiness certificate (sample)

➢ Delivery Inspection

- Prior to delivery to a customer, the aircraft usually undergoes an inspection by that customer to ensure that the vehicle has been built to the customer's specifications and requirements.
- This includes basic design, options, and customer-furnished equipment (if any), down to the shape, color, and positioning of the airline logo.
- This inspection by the operator may be cursory or detailed and often includes a test flight by their own flight and cabin crews. Any discrepancies found should be corrected by the manufacturer before delivery is taken. Commercial carriers will often fly the aircraft "around the flag pole" at the builder's delivery center to perform this checkout. Some may take the aircraft on a "shakedown flight" from the delivery center to the carrier's home base. Once the customer accepts the aircraft from the manufacturer, that customer is fully responsible for maintaining the

unit in airworthy condition in accordance with its own maintenance program and regulatory authority rules.

➢ Operator Certification

- An operator cannot just buy an aircraft and enter into commercial service simply by getting a license and petitioning the market for customers. In aviation, for a prospective operator to enter the business, he or she must meet the requirements of both the Department of Commerce, with respect to the business aspects of airline operation, and the Department of Transportation (DOT), primarily the FAA, with respect to the technical aspects. In short, the prospective operator must provide the necessary information to ensure that he or she understands the business of commercial aviation; understands the operational and maintenance aspects of commercial aviation operation; and has the necessary people, facilities, and processes in place needed to carry out that business.
- The secretary of the DOT issues a "certificate of public convenience and necessity" authorizing the recipient to enter into commercial transportation. The secretary determines that the applicant is "fit, willing, and able" to perform the service.
- An operating certificate (OC) is then issued by the Flight Standards District Office (FSDO) of the FAA to the airline company. This certificate authorizes the carrier to operate scheduled air transportation service under the Federal Aviation Act of 1958 as amended. The operating certificate is not transferable to another operator.
- The OC remains in effect indefinitely unless it is surrendered by the operator, superseded by another certificate, or revoked by the FAA. The OC states, in part, that the airline is authorized to operate in accordance with the Federal Aviation Act and its rules and regulations, and "the terms, conditions, and limitations contained in the operations specification."
- In part, the Federal Aviation Act of 1958 requires the airline to develop an operations specifications document (Ops Specs) for each type of aircraft to be operated in commercial service.
- The Ops Specs is a parent document; i.e., in addition to specific information listed in the document, it may identify other airline documents, by reference, that fully describes certain airline operations that apply to the model.
- The Ops Specs outlines such operational activities as (*a*) the type of service to be offered, passenger, cargo, or combination; (*b*) the type of aircraft to be used; (*c*) the routes to be flown; (*d*) the airports and alternate airports that will be used; (*e*) the navigation and communications facilities to be utilized on each route; (*f*) the way points used in navigation; and (*g*) the takeoff and approach routes, including any alternate approach routes, at each airport.
- The Ops Specs must also identify the maintenance and inspection program applicable to the model, including the scheduled and unscheduled maintenance programs; the inspection program; and the engine and equipment repair pro-gram (off-aircraft maintenance).
- Other aspects of maintenance, such as the quality assurance and reliability programs, will also be defined. If any portion of the aircraft or systems maintenance is performed by a third party, that agreement must also be addressed in the Ops Specs.

- The operations specifications document is a detailed document and is put together by the principal maintenance inspector (PMI) assigned to the airline by the FAA and by the airline personnel. It is tailored to each operation.

➢ Certification of Personnel

- The minimum requirements for airline operations under part 121 state that the airline must have sufficient full-time qualified management and technical personnel to ensure a high degree of safety in its operations.
- The basic personnel requirements are a director of safety; a director of operations, a director of maintenance, a chief pilot, and a chief inspector. This is only a suggestion, how-ever. The FAA goes on to say that they may approve any other number of positions and any other titles as long as the operator can show that it can perform the operation safely. The people in such positions must have the necessary "training, experience, and expertise" for conducting the business of aviation and must be knowledgeable of the regulatory and airline policies and procedures as they relate to their specific jobs. The airline identifies the "duties, responsibilities, and authority" of these management personnel.

Aviation Maintenance Certifications

- Training begins with someone who is interested in becoming an aircraft maintenance technician. This normally starts in high school. Some high schools have contracts with aviation maintenance training schools that allow student to take classes and graduate with Airframe and Power Plant (A&P) licenses concurrent with their high school graduation.
- Federal Aviation Regulation 119.65 (a), (b).
- Federal Aviation Regulation 119.65 (c), (d).
- Federal Aviation Regulation 119.65 (e).

- The aviation maintenance training schools must train all individuals and certify them in accordance with FAA regulations. To earn an A&P license, aviation schools must fulfill three requirements, which are the bare minimum, prior to taking the FAA's A&P exam. The Avionics/FCC license course is optional.
- General aviation course
- Airframe course
- Power plant course
- Avionics/FCC license course

➢ Aviation Industry Interaction

- The aviation industry is made up of aircraft manufacturers; manufacturers and vendors of parts, systems, and accessories for the aircraft; airline operators; third-party maintenance organizations; trade associations, such as the Air Transport Association of America (ATA) and the

International Air Transport Association (IATA); flight crew, cabin crew, and mechanics' unions; and regula-tory authorities.

- This integrated group of professionals is constantly working together to develop and improve aviation both technically and operationally. This is somewhat unique compared to other transport modes. This continuous quality improvement (CQI) concept was in effect in the commercial aviation field long before it became standard procedure in other industries.

Documentation for Maintenance

- The documentation for maintenance is required by the FAA.
- Advisory Circular AC 120-16E, Air Carrier Maintenance Programs, refers to the air carrier maintenance manual system, maintenance record/documentation keeping system, and various other requirements.
- The aircraft documentation system can be defined as "cradle to grave." When the aircraft is built, the documentation starts, and throughout its service life the documentation is gathered in the form of maintenance performed log pages, Engineering Order (EOs), Airworthiness Directive (ADs), Service Bulletins (SBs), Fleet Campaign Directives (FCDs), records of any minor or major repairs, and phase checks.
- When an aircraft is sold, decommissioned, and retired, all the paperwork must follow the aircraft.
- The main focus of this topic is to understand documentation that identifies an aircraft, its systems, and the necessary work to repair and maintain them.
- Some of the documents will be customized for the operator by the aircraft manufacture vendor to the manufacturer, while others will be generic.
- Most of these documents have standard revision cycles, and changes are distributed on a regular basis by the airframe manufacturer.
- Controlled documents are used in operation and /or maintenance of the aircraft in accordance with the FAA regulations.
- These types of documents have limited distribution within the airline and require regular revision with a list of revisions and active and rescinded page numbers.
- The operator is required to use only up-to-date documents. The written information is provided by the airframe manufacturer and the manufacturer of the systems and equipment installed on the aircraft.
- The documents provided by the regulatory authority and the documentation written by the airline itself detail the individual maintenance processes.
- We will be discussing the following documentation:

1) Manufacturer's documentation
2) Regulatory documentation
3) Airline-generated documentation
4) ATA document standard

➢ Manufacturer's Documentation

- Table below indicates the documents provided to an operator by the airframe manufacturer for the maintenance of the aircraft.
- The form and content of the documents sometimes varies from one manufacturer to another. The table identifies, basically, the type of information the airframe manufacturer makes available to its customers.
- Some of the documents can be customized for the airline or operator to only include configuration and equipment. These are called customized documents by the manufacturer and are noted at the bottom of Table below.

- **Manufacturer's Documentation**

Title	Abbreviation
Airplane maintenance manual*	AMM
Component location manual	CLM
Component maintenance manual	CMM
Vendor manuals	VM
Fault isolation manual*	FIM
Illustrated parts catalog†	IPC
Storage and recovery document‡	SRD
Structural repair manual	SRM
Maintenance planning data document	MPD
Schematic diagram manual*	SDM
Wiring diagram manual*	WDM
Master minimum equipment list	MMEL
Dispatch deviation guide	DDG
Configuration deviation list	CDL
Task cards*	TC
Service bulletins	SBs
Service letters	SLs

*Customized to contain customer configuration.
†Customized on request.
‡Information may be included in AMM for recent model aircraft.

- Other maintenance documents that normally accompany aircraft manufacturer documents are the vendor documents.
- These documents contain engine manufacturer, flight crew seats, passenger seats, aircraft galley manuals, and other suppliers' component repair manuals.

Airplane maintenance manual

- The airplane maintenance manual (AMM) is a formal document containing all the basic information on the operation and maintenance of the aircraft and its on-board equipment. It starts with an explanation of how each system and sub-system works (detailing description and operation) and describes such basic maintenance and serving actions as removal and installation of LRUs and various tests performed on the system and equipment, such as functional test, operational check, adjustments, the replenishing of various fluids, and other servicing tasks.

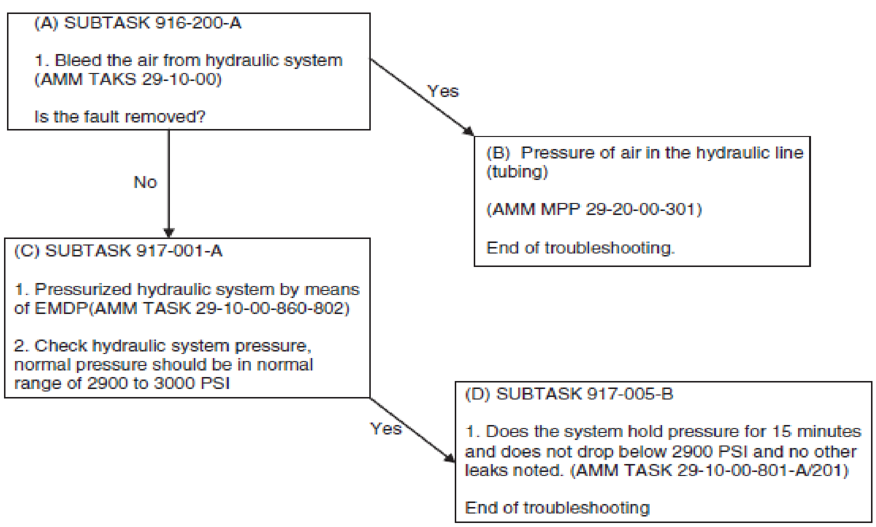
- The AMM normally excludes any type of repair which may include structures or fiberglass paneling. The AMM uses the ATA coding system. Upon completion of a discrepancy or maintenance task, a technician signs off the log book or non routine work card (NRWC) using the AMM reference associated with the ATA chapter and subchapter system.

Component and vendor manuals

- Any component built by the airframe manufacturer will be accompanied by a component maintenance manual (CMM) written by the manufacturer.
- Normally, the aircraft manufacturers make the aircraft, while other systems, such as engines, landing gears, flight crew seats, and passenger seats, are purchased from outside vendors, but when the aircraft manufacturer sells the aircraft, the other vendors' CMMs accompany these items, in case parts need to be repaired or replaced.
- The CMM shows the breakdown of all components that make a complete part. The components installed on the aircraft are chosen by the airlines and are installed during or after the aircraft is completed.

Fault isolation manual (FIM)

- The FIM contains a set of fault isolation trees provided by the aircraft manufacturer to help troubleshoot, isolate the section where the fault occurred, and identify and pinpoint problems related to various systems and components on the aircraft.
- The aircraft faults system normally shows the fault occurrence at the flight deck on the engine-indicating and crew-alerting system (EICAS) message screen. The EICAS shows faults in a yellow/amber color, which alerts the flight crew that a fault has occurred.
-



Example of FIM

- The FIM is a block diagram that provides a reference to AMM tasks and sub-tasks. At the end of each task, it will ask, "Is the fault removed?" The AMT must follow the subsequent arrows indicating Yes or No to further troubleshoot. If no further maintenance is required, the discrepancy has been resolved and no further action needs to be taken. The flow diagram is designed to locate many but not all problems within the various systems.

Component location manual (CLM)

- The CLM provides the location of all the major equipment items of the aircraft. Normally, AMTs know how to locate a component when replacing it, but the CLM is a great tool for finding the part number of the component and its location as well.
- The CLM works with four different sections within the manufacturer's manual system: (1) ATA coding system, (2) fin number system, (3) illustrated parts catalog (IPC) system, and (4) item location figures.
- The ATA system is used to find or locate the item with the ATA chapters.
- The fin number works with the illustrated parts catalog (IPC) system with item location in an alphanumeric system. This is a great tool for helping avionics technicians to find relays and other hidden items; just type in the fin number and part name, and the number and manual reference is displayed.
- The fourth item is the location figure, where each zone of the aircraft is highlighted upon selection. This presents an overview of the entire zone, including the components' pictures and part num-bers with their respective locations.

Illustrated parts catalog (IPC)

- The IPC is produced by the airframe manufacturer and includes list and location diagrams of all parts used on the aircraft. This includes all parts for all systems and is usually not customized to the airline's configuration. However, when the aircraft is customized it will show parts by figure, part number, and item number with aircraft applicability.
- Every aircraft is given a serial number, along with an aircraft registration number, which is used in the IPC for affectivity reason when searching for a part by using the ATA chapters.
- The IPC shows assemblies, subassemblies, alternate part numbers, and part inter-changeability along with any modifications if performed on parts by the service bulletin, the IPC will show these parts as pre- or post modification.

Storage and recovery document (SRD)

- The SRD contains information needed to address maintenance and servicing of aircraft that are to be out of service and stored for long periods of time.
- This includes the procedures for draining certain fluids, moving the aircraft so that tires will not go flat, and protecting components from the weather. In the older model aircraft, this document was produced separately by the airframe manufacturer.
- For more recently manufactured aircraft, this information is included in the applicable AMM.

Structural repair manual (SRM)

- The SRM is an airframe-specific manual that provides the aircraft operator with information regarding aircraft skin and other specific tolerances and procedures in the event of minor structural damage.

- The SRM gives the acceptable dimensions and limits of damage to the aircraft structure so the
- operator knows when the damage should be fixed.
- For example, when an aircraft incurs damage such as a dent, usually the dent is measured in by its depth and in relation to its surrounding area to make sure there is no damage to the ribs area and to check for any evidence of a crack. The operator then looks into the SRM for the area where the dent is located on the aircraft to see if it will be a minor or a major repair. The SRM provides the damage tolerance which will determine if the aircraft can fly with a minor dent that can be repaired later. The SRM will also indicate the number of hours the aircraft can fly with the dent.
- There are some damages beyond SRM limits, and the maintenance department will have to contact engineering in order for specific repair schemes to be issued. If the damages are beyond SRM limits, the airline engineering department is in contact with the aircraft manufacturer's engineers. The repair is usually done by using an engineering order (EO) that will guide the aircraft maintenance department and inspection department on how to repair and sign off, bringing the aircraft back to an airworthy condition.

Maintenance planning data document (MPD)

- This document (called the on aircraft maintenance program by McDonnell-Douglas) provides the airline operator with a list of maintenance and servicing tasks to be performed on the aircraft.
- It contains all items of the MRB report along with other information.
- Some of these tasks are identified as certification maintenance requirements (CMRs) and are required by the FAA in order to maintain certification of the aircraft.
- All other tasks, which were developed by the MSG process, are included along with other tasks recommended by the manufacturer.
- The tasks are divided into various groupings for older aircraft models—daily, transit, letter checks, hourly limits, and cycle limits—and are used for planning purposes by the airline.
- Later models do not group the tasks by letter checks, only by hours, cycles, and calendar time.

Schematic diagram manual (SDM)

- The SDM contains schematic diagrams of electrical, electronic, and hydraulic systems on the aircraft, as well as logic diagrams for applicable systems. The diagrams in the AMM and other manuals are usually simplified diagrams to aid in describing the system and assist in troubleshooting.
- The schematic manual, however, contains the detailed information and identifies wiring harnesses, connectors, and interfacing equipment.

Wiring diagram manual (WDM)

- The WDM is an essential tool for troubleshooting.
- The WDM provides information on the wiring runs for all systems and components containing such elements.
- Due to the complexity of the modern aircraft and its electrical system, such control devices as gauges and sensors provide and relay information to the flight deck in a complicated network of wiring runs like a network system.
- The WDM shows the wire routing from the aircraft's nose to tail and from other sections to different connectors, on-board sensors, and control devices. Normally wires that are routed in bundles from the airframe side of the aircraft are also shown in the WDM.

- The wiring harness is a type of wiring bundle as well, but when referring to the wiring harness, we usually are referring to the power side of the air-craft. The wiring harness normally is connected to a fire wall, which is a connection point from the engine wire harness to the aircraft airframe system
- Aircraft wires are normally made from standard copper, and in some cases they are coated with different alloys to prevent corrosion. Due to the large amount of current required for carrying
- longer distances, aluminum wire is frequently used. Normally it is insulated by a fiberglass braid.
- Aircraft wire is measured in the American Wire Gauge (AWG) system, which has been in use since the late 1850s. In the AWG system, the largest number represents the smallest wire. The following is an example of the AWG system found in the WDM:

  ***** K15B-25 *****

  K → Alphabet letter—System in which a wire is being used

  15 → Two-digit number—Individual wire number

  B → Alphabet letter—Wire segment/section of wire power source

  25 → Two-digit number—Wire size (AWG size)

Master minimum equipment list (MMEL)

- The MMEL is issued by the airframe manufacturer and developed by the manufacturer's flight engineering group. Prior to issuing the MMEL, the aircraft manufacturer submits a proposed master minimum equipment list (PMMEL) to the type certificate office of the aircraft manufacturing country (in the United States, FAA Flight Operation Evaluation Board). Once it is approved by the authority it becomes an MMEL.
- The MMEL is used to identify the equipment that may be degraded or inoperative at the dispatch time of the aircraft. These are the systems that the flight crew, under certain circumstances, may agree to accept at dispatch in degraded or inoperative condition, provided the system is fixed within the prescribed time limit set by the MMEL.

Dispatch deviation guide (DDG)

- Some of the MMEL items that are inoperative or degraded at dispatch require maintenance action prior to the deferral and dispatch. This may be the need to pull and placard certain circuit breakers, disconnect power, tie up loose cables for removed equipment, and various other actions to secure the aircraft and the system against inadvertent operation. The instructions necessary for these actions are provided in the DDG. This guide is written by the manufacturer's AMM staff and is coordinated with the MMEL.

Configuration deviation list (CDL)

- The CDL is similar to the DDG but involves configuration of the aircraft rather than the aircraft's system and equipment.
- The CDL identifies any external part of an aircraft's panels, gear doors, flap hinge fairings, cargo doors, and all door indication and warning systems.
- These items could have been inoperative, cracked, broken, or missing. Normally, these items are discovered during the line checks or at pre- or post flight checks of the day. The CDL items do not affect the airworthiness and safety of the aircraft, and scheduled flight operation can be resumed.

Nonessential equipment and furnishing (NEF) items

- The NEF contains the most commonly deferred items, such as paneling (flight deck, cabin), cup holders, missing paint off panel in flight deck or cabin area— cosmetic items which could be broken, cracked, chipped, or missing.
- NEF items are located throughout the aircraft and do not affect the safety or airworthiness of the aircraft.

Task cards (TC)

- Certain tasks in the AMM for removal/installation, testing, servicing, and similar maintenance items are extracted from the AMM and produced on separate cards or sheets so that the mechanic can perform the action without carrying the entire maintenance manual to the aircraft. These task cards can be used "as is" or they can be modified by the operator for reasons discussed in the section Airline-Generated Documentation.

Service bulletins, service letters, and maintenance tips

- Whenever the airframe manufacturer or the engine manufacturer has modifications or suggestions for improving maintenance and/or servicing, they issue appropriate paperwork to the affected airlines.
- A service bulletin (SB) is usually a modification of a system that will provide improved safety or operation of a system and includes a detailed description of the work and parts required.
- An SB is usually optional and the airline makes the choice, except in certain cases involving an FAA airworthiness directive (AD) discussed below in Regulatory Documentation.
- A service letter (SL) usually provides information to improve maintenance actions without equipment modification. The maintenance tip is a suggestion for maintenance personnel to assist in their work or improve conditions.

➢ Regulatory Documentation

- The FAA issues numerous documents related to maintenance of aircraft and their systems. Table lists the more significant of these documents.

Title	Abbreviation
Federal aviation regulations	FARs
Advisory circulars	ACs
Airworthiness directives	ADs
Notice of proposed rule making	NPRM

Regulatory Documents

Federal aviation regulations (FARs)

- In the United States, Federal laws are collected into a document known as the code of federal regulations or CFRs.
- Those laws related to commercial aviation are under title 14 of this code, aeronautics and space, parts 1 through 200.
- The regulations relating to certification and operation of large, commercial aircraft— part 121— would be noted as 14 CFR 121. We usually refer to this as FAR part 121. we will use the FAR terminology and form since it is so common in the industry.
- These FARs address all aspects of the aviation field, including private, commercial, and experimental aircraft; airports; navigational aids; air traffic control; training of pilots, controllers, mechanics, etc.; and other related activities.

Advisory circulars (ACs)

- An advisory circular is a document issued by the FAA to provide assistance to operators on meeting the requirements of various FARs.
- These ACs are not binding as law but are merely suggestions as to how to comply with other requirements.
- An AC often states that it is "a means, but not the only means" of complying with a regulation. The FAA allows some leeway in how its regulations are met in order to achieve the desired results without trying to micromanage the operator.

Airworthiness directives (ADs)

- The airworthiness directives are substantial regulations issued by the FAA to correct an unsafe condition that exists in a product (aircraft, aircraft engine, propeller, or appliance) and a condition that is likely to exist or develop in other, similar products.
- An AD, whose incorporation is mandatory, may be issued initially by the FAA when an unsafe condition is noted or it may result from FAA action after the airframe manufacturer has issued a service bulletin (SB) relative to some noted problem.

- Incorporation of an SB is optional but, if it is made into an AD by the FAA, incorporation becomes a mandatory requirement.
- Aircraft owners or operators are required to maintain the aircraft in compliance with all ADs.
- Typically, an AD will include (*a*) a description of the unsafe condition; (*b*) the product to which the AD applies; (*c*) the corrective action required; (*d*) date of compliance; (*e*) where to get additional information; and (*f*) information on alternative methods of compliance if applicable.

Notice of proposed rulemaking (NPRM)

- The NPRM is an FAA process that indicates the intent to change or amend an existing Federal Aviation Regulation (FAR).
- This provides an advance notice and invites public comment on proposed rules, which includes holding public hearings or specific activities, rendering a decision, and issuing a new rule, directive, or requirement in the form of an FAR.

➢ Airline-Generated Documentation

- Table lists the documentation that the airline will generate in order to carry out its maintenance activities.
- Again, these documents may vary in name and actual content from one operator to another, but the information identified here must be addressed by airline documentation.

Title	Abbreviation
Operations specifications	Ops Specs
Technical policies and procedures manual	TPPM
Inspection manual	IM
Reliability program manual	RPM
Minimum equipment list	MEL
Task cards*	TC
Engineering orders†	EOs

*May be manufacturer written, customer written, or a combination.
†Issued for maintenance not identified in standard maintenance plan.

Airline-Generated Documentation

Operations specifications

- The operations specifications (Ops Specs) document has been discussed as an FAA requirement for airline certification.
- It is written by the air-line in accordance with strict FAA requirements and usually with the help of an FAA representative.
- The Ops Specs is required for each aircraft type flown by the airline.
- It is a parent document, which refers to numerous other documents to avoid duplication and details the airline's maintenance, inspection, and operations programs.

Technical policies and procedures manual (TPPM)

- The TPPM is the primary document for the airline's M&E operation and, with other documents supplied by the airframe manufacturer, serves as the FAA requirement for a maintenance manual per AC 120-16E.
- It is usually written by engineering, to ensure technical accuracy, from inputs supplied by management of the various M&E organizations.
- It should define exactly how all M&E functions and activities will be carried out. The TPPM is a detailed document and may be several volumes. Personnel in all units of M&E must be trained on the TPPM, especially those parts that relate directly to that unit's operation, so that the operation will go smoothly..

Inspection manual (IM)

- The IM may be a separate document distributed primarily to QC personnel, Contents of the IM relate to all inspection activities within M&E: (*a*) mechanic inspection tasks from the MPD/OAMP or the MRB report; (*b*) QC inspector's tasks; (*c*) special inspections (hard landings, bird strikes, etc.); (*d*) the airline's required inspection item (RII) program; and (*e*) the paperwork, forms, and reports required to carry out these functions.
- Some IMs may indicate details on the calibration of tools and test equipment, since these are QC functions, or these may be in a separate chapter of the TPPM.

Quality assurance (QA) manual

- The QA manual could be a special manual for QA auditors only, it could be part of the inspection manual, or it could be a separate chapter in the TPPM as desired.
- The QAmanual defines the duties and responsibilities of the QAorganization and defines the processes and procedures used in the annual quality assurance audits conducted on the M&E units, suppliers, and outside contractors. Forms used and reports are also covered along with the procedures for follow-up and enforcement of QA write-ups.

Reliability program manual

- An airline's reliability program, under FAA rules, must be approved by the regulatory authority, so it is usually published as a separate document. This document defines the reliability program in detail so that the FAA can evaluate and approve all its elements at one time.

Minimum equipment list (MEL)

- The MMEL provided by the aircraft airframe manufacturer includes all equipment and aircraft configuration information available for the model to which it applies.
- The airlines pick and choose from the MMEL system the type of MEL they would rather have due to specifications, weight variants, options installed, software and hardware upgrades, retrofit

status, engines, and airframe configuration, which later in the airline's version becomes an MEL. The MEL cannot be less restrictive than the MMEL.

MEL categories may vary from operator to operator. There are four MEL categories:

- Category A MEL is normally 1 to 2 days, unless specified for such MEL where it could be a 1-day flight MEL, depending on the restrictions.
- Category B MEL is normally issued for 3 consecutive calendar days.
- Category C MELs shall be repaired within 10 days.
- Category D MEL items must be replaced in 120 calendar days. This is a part that is normally considered for replacement.

Task cards

- The task cards produced by the airframe manufacturer are usually for one action only.
- These procedures may call for the mechanic to open panels set certain circuit breakers "in" or "out," turn other equipment "on" or "off," etc., prior to the work and to reverse these processes at the completion.
- Much of the work done at an airline during an aircraft check, however, involves the combination of several tasks to be performed by the same mechanic or crew within the same area or on the same equipment.
- To avoid unnecessary duplication of certain actions, and the unnecessary opening and closing of the same panels, etc., most airlines write their own task cards to spell out exactly what to do, using the manufacturer's cards as a guide. This eliminates the duplicated or wasted efforts.

Engineering orders (EO)

- Any maintenance work not covered in the standard maintenance plan developed by engineering from the MRB report or Ops Specs data must be made official by the issuance of an EO.
- This is official paper work, issued by engineering and approved by QA, and is usually implemented through the production planning and control (PP&C) organization. In some airlines, the document may be called simply a work order.

➢ ATA Document Standards

- Line maintenance people for most airlines, especially those doing contract maintenance for other carriers, will have the opportunity to work on a wide variety of aircraft during the course of their shift or work week. Since aircraft manufacturers are independent, they each (in the past) had their own way of doing things.
- To reduce confusion on the line, the ATA stepped in and standardized the overall format of the maintenance manuals so that all manufacturers' documents would be more compatible. ATA codes are designed to help understand different systems or system types on aircraft and their subsystems and are assigned a chapter number.
- Table below shows the chapter assignment as per ATA standard.

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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 system
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—engines
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)

ATA Standard Chapter Numbers

- These ATA coding systems are uniform for all models and types of aircraft, and all aircraft manufacturers use the same coding system.
- If there are any air-craft systems that require maintenance, such as the navigation system, an A&P technician or avionics technician will know that they can find such information in ATA of the aircraft maintenance manual
- The ATA codes are further broken down into three sets of two-digit numbers followed by a three-digit number.
- This identifies the chapter, subject, section, and page block, respectively.
- Figure below shows the structure of the number.
- The first two digits (ATA Chapter) are the same for all manufacturers and are used throughout the maintenance manual system.
- The second (section) and third (subject) groups may vary from one manufacturer to another and from one model aircraft to another of the same manufacturer because of differences in the structure of the systems to which they apply.
- The last group of digits (page block) is the same for all maintenance manuals.
- The page blocks refer to specific types of information contained in the air-plane maintenance manual.

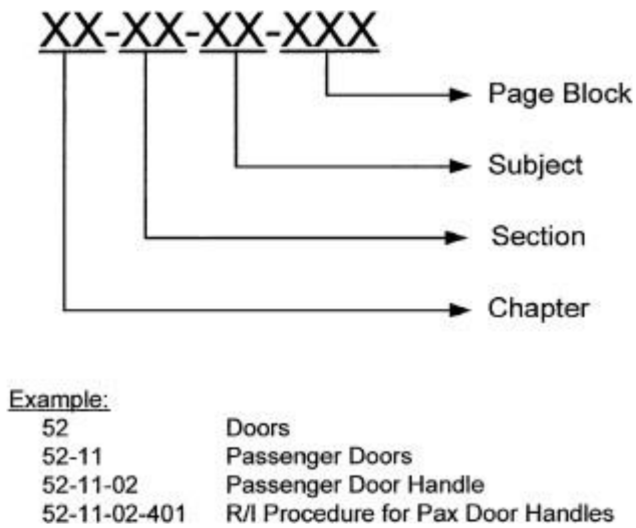


Fig - ATA format for maintenance manuals.

- The advantage of this system is quite apparent to a line maintenance mechanic who works on a Boeing 757, then a Douglas MD-80, an Airbus A320, and then a Lockheed L-1011 in the course of a single day.
- No matter what the aircraft, if a write-up concerns a hydraulic system component, the mechanic knows that any maintenance manual information he or she needs will be found in ATA.

➢ Objectives of a maintenance program

- The five objectives of a maintenance program were discussed
- . In this topic , we will begin to outline a maintenance program that will address these five maintenance objectives.
- There are certain regulatory requirements that each airline must adhere to and certain additional necessary maintenance activities that airlines need to have in place to carry out their approved maintenance pro-gram requirements.
- The aircraft and aircraft systems are sophisticated, with miles of wires to chase, electromechanical valves, airframe systems, engines, auxiliary power units, hydraulic systems, and navigation systems, all of which require a well-trained professional technician with aircraft systems knowledge, experience, and a keen mechanical ability to correct any kind of discrepancy according to the approved maintenance program.
- These mechanical tasks and maintenance programs require oversight and monitoring to make sure airlines and aircraft operators are carrying out them out effectively.

1. To e...
   the equipn...
2. To restore safety a...
   ration has occurred
3. To obtain the information necessar...
   the maintenance program when these in...
4. To obtain the information necessary for design im...
   items whose inherent reliability proves inadequate
5. To accomplish these objectives at a minimum total cost, includin...
   costs of maintenance and the cost of residual failures

➢ Aviation Maintenance Program Outlined (AC 120-16E)

- The AC 120-16E is the type of information provided by the FAA to the aviation community. The FAA requires each commercial airline to have an operations specifications (Ops Specs) document authorizing maintenance program, the maintenance manuals required by FAA regulations, and their operational equip-ment as a commercial airliner. The AC requirement is under Title 14 of the Code of Federal Regulations (14 CFR), part 119, air carrier commercial operation under 14 CFR parts 121 and 135. This AC also applies to each individual employed or engaged in air carrier maintenance, preventive maintenance, or alteration of its aircraft.
- The following is an example of a maintenance AC 120-16E. It describes the scope and content of an air carrier aircraft maintenance program. It explains the background of these programs as well as the FAA regulatory requirements.

FAA AC 120-16E describes the elements listed below:

- Airworthiness responsibility
- Air carrier maintenance manual
- Air carrier maintenance organization
- Maintenance record keeping system
- Accomplishment and approval of maintenance and alterations
- Maintenance schedule
- Required inspection items (RII)
- Contract maintenance
- Personnel training
- Continuous analysis and surveillance system (CASS)

➢ Summary of FAA Requirements

- The objectives of an airline maintenance program were stated in above as follows:

1. To ensure the realization of the inherent safety and reliability levels of the equipment
2. To restore safety and reliability to their inherent levels when deterioration has occurred
3. To obtain the information necessary for adjustment and optimization of the maintenance program when these inherent levels are not met
4. To obtain the information necessary for design improvement of those items whose inherent reliability proves inadequate
5. To accomplish these objectives at a minimum total cost, including the cost of maintenance and the cost of residual failures

- To meet these objectives, an organization must perform certain scheduled maintenance tasks (objective 1) to maintain the equipment capability.
- Unscheduled tasks are done whenever the equipment has deteriorated below acceptable standards or has completely failed (objective 2).
- Objective 3 requires that the opera-tor have some sort of data collection program in place to monitor reliability levels of the equipment and investigate problem areas to effect maintenance program improvement when applicable.
- Objective 3 can also address deficiencies in the management and administrative aspects of the maintenance program.
- Objective 4 requires that the operator initiate action to effect redesign if reliability standards cannot be met and this deficiency is not attributed to the operator's maintenance program.
- Objective 5 indicates that the maintenance program should be a direct asset to the organization in that the operator does not waste time, money, or manpower performing unnecessary or ineffective maintenance but performs only that maintenance which is necessary and performs it in a timely manner.
- To accomplish the above objectives, the programs and processes required by the FAA as described above must be put into place.
- An effective maintenance pro-gram is developed for the equipment and systems based on the best knowledge and ability of the manufacturers' and the industry's representatives. This maintenance program is then employed by the operator in an effort to maintain the equipment in top operating condition. Through the collection and analysis of performance data during actual operation, and through monitoring the effects of maintenance within the operator's own environment, the maintenance program can be tweaked and adjusted, as necessary, to optimize the entire set of processes.
- This results in an optimized maintenance program that not only satisfies objective 5 but also allows the operator to meet objectives 1, 2, 3, and 4.

➢ Additional Maintenance Program Requirements

- In addition to the maintenance program elements described in the previous sections, there are a number of other activities needed to carry out an effective maintenance and engineering program.
- The basic structure of the organization discussed here may not be adequate for all maintenance organizations.
- Some organizations may need to expand or combine activities, out of necessity, as dictated by the size of the specific operation.
- The important thing to remember is that, regardless of the organizational arrangement, these functions are necessary to carry out an effective and efficient maintenance and engineering program. These additional activities and their implementing organizations are generally called engineering, material, planning, maintenance control, training, computing, and publications.
- We will discuss each of these in subsequent sections.

Engineering

- The primary purpose of the engineering section of the maintenance organization is to establish the initial maintenance program from the manufacturer's maintenance manual and other documents and to continually upgrade the program over time.
- Engineering will also provide technical assistance in troubleshooting equipment problems; develop workable maintenance processes and procedures when required; review manufacturer's service bulletins and other maintenance tips, changes, or suggestions; and provide engineering expertise to the company or its hired consultants in designing and modifying the maintenance facilities (i.e., hangars, shop, ramps, etc.).

Material

- The function of the material section is to provide the maintenance organization with parts and supplies necessary to carry out the maintenance activities.
- This would include the purchase and warehousing of the necessary spare parts, supplies, and tools for the maintenance activities; issuance of parts to mechanics as needed; handling of warranty claims on parts, equipment, and tools; and passing repairable components to the appropriate workshop or vendor for repair.

Planning

- The planning section is responsible for planning all of the scheduled maintenance activities, including the manpower, facilities, and supplies needed for these activities.
- Planning also collects data on the time, manpower, and facilities actually used in the performance of the maintenance to accurately readjust these requirements for use with subsequent maintenance planning activities.

Maintenance control center

- The maintenance control center (MCC), sometimes called the maintenance operations control center (MOCC), is the nerve center of the line maintenance organization; it is responsible for keeping track of all vehicles in operation.
- Vehicle location, maintenance and servicing needs and other requirements are monitored by the MCC during the operational phase of activity via telephone, radio, facsimile, and any other available means of communication.
- The MCC keeps track of the vehicles and coordinates with key units throughout the operations, maintenance, and engineering activities so that maintenance, when needed, can be coordinated and expedited to minimize delays and down time.
- The MCC locates and dispatches the necessary personnel within the company who can provide whatever maintenance, troubleshooting, or parts assistance that is needed to support the operational phase of the activity.
- Maintenance crews at outstations can coordinate maintenance actions, the borrowing or buying of parts locally, and even the contracting of temporary third-party maintenance personnel through the MCC at the home base.

Training

- Maintenance training is an ongoing process.
- Although maintenance mechanics receive initial training through certain formal training schools to qualify for the job, continual training is required to keep them current, to refresh their skills when necessary, and to develop new skills and learn new processes and proce-dures as these are developed.
- The training section can be part of the maintenance and engineering organization or it can be part of the airline's overall training pro-gram that also covers the non maintenance training requirements.

Computing

- The computing section provides the equipment, the software, the training, and the support for all computing activities within the maintenance and engineering organization. In some airlines this section may be included within the company's computer organization.
- It is recommended, however, that computer support for maintenance have dedicated personnel and that they work closely with, if not directly for, the maintenance and engineering organization.
- Various computer programs are available for maintenance activities, which include modules for data collection on malfunctions; for parts tracking and control; for collecting and manipulating reliability data, such as failure rates, removal rates, and time limitations for parts, etc.; for tracking of serial numbered parts; and for numerous other traceable information needs for monitoring maintenance activities.

- All maintenance activities need to be coordinated and tracked and the maintenance computer systems should be under the control of people who know maintenance as well as computers.

Publications

- The publication section (or technical library) of the maintenance and engineering organization is responsible for keeping all technical publications up to date, whether they are on paper, microfilm, or electronic media.
- The publications section receives all publications and is responsible for distributing the documents or revisions (partial or complete) to the appropriate work centers. The work center personnel are responsible for inserting changes and disposing of obsolete pages, but technical publications personnel should spot check the work centers to see that this is being done.
- During the yearly audit of each unit, QA will check to see that all documents are up to date

Organization of Maintenance and Engineering

- The structure for an effective maintenance and engineering organization will vary with the size and type of organization. It may also vary with the management philosophy of the company. But one thing must be kept in mind: the organizational structure must allow the company to meet its goals and objectives and each unit within the company must be endowed with sufficient personnel and authority to carry out those objectives and meet those goals.

- The following structure was determined, from experience and observation, to be the most efficient and effective one for a midsized commercial airline.
- For application to large or small airlines, this structure will have to be modified; but all of the functions identified here will have to exist separately or in combination to accomplish all of the functions and activities identified in Chap. 6 as essential for effective operation.

Organizational Structure

- The basic organizational structure for our midsized airline is shown in Fig. below.
- There are three basic concepts underlying the structure we have defined. Two of these come from traditional management thinking.
- These are the concepts of span of control and the grouping of similar functions.
- The third concept is some-what unique to aviation: the separation of production activities (maintenance and engineering) from the oversight functions of inspection, control, and monitoring (quality assurance, quality control, reliability, and safety).

Span of control

- The span of control concept may be considered passé to some, but it is still a useful concept. This concept states that a supervisor or manager can effectively

- supervise or control three to seven people. Any less than three would be ineffective use of time and manpower, and any more than seven would spread the boss too thin. In the organizational structure shown in Fig., we have adhered to this concept.

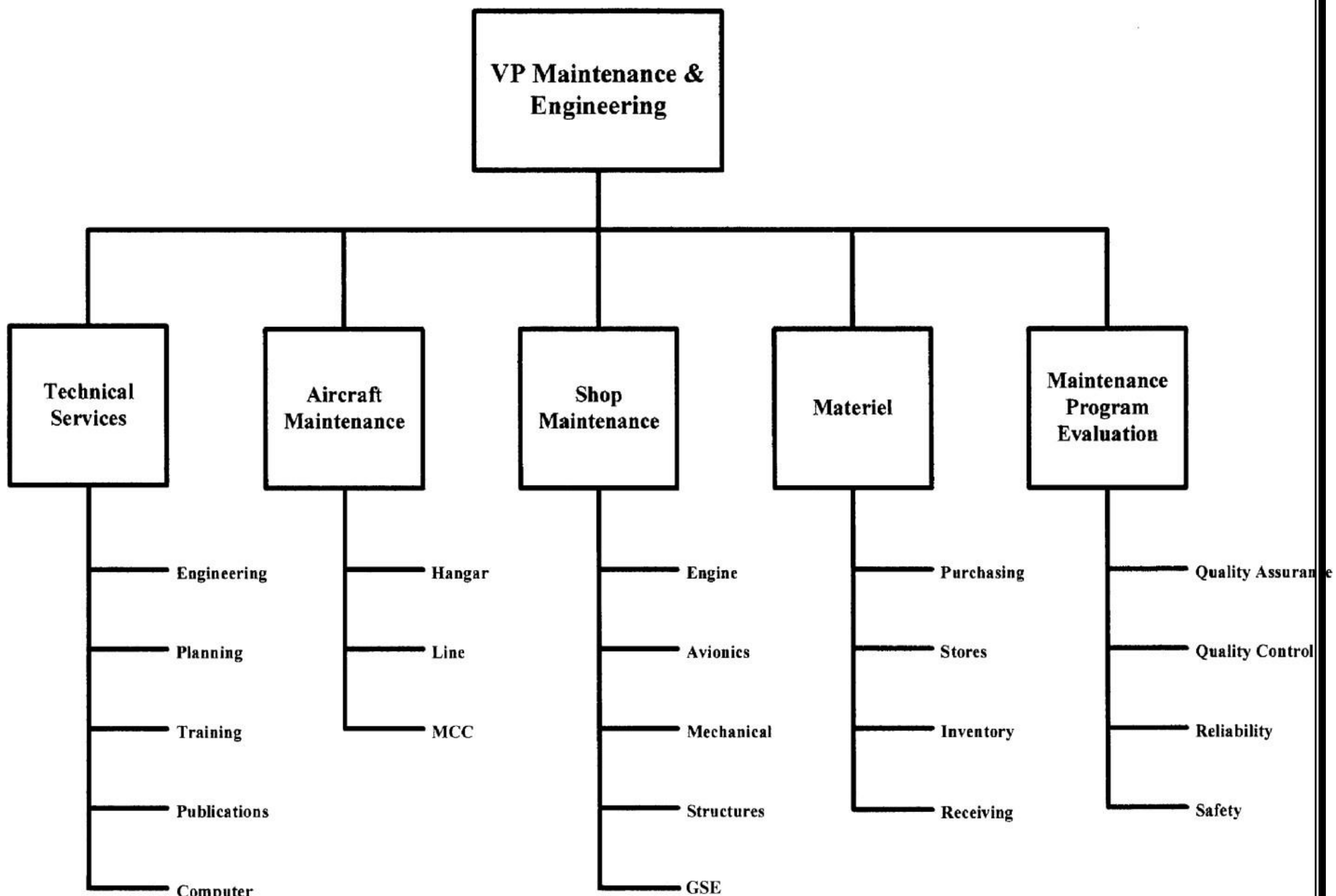
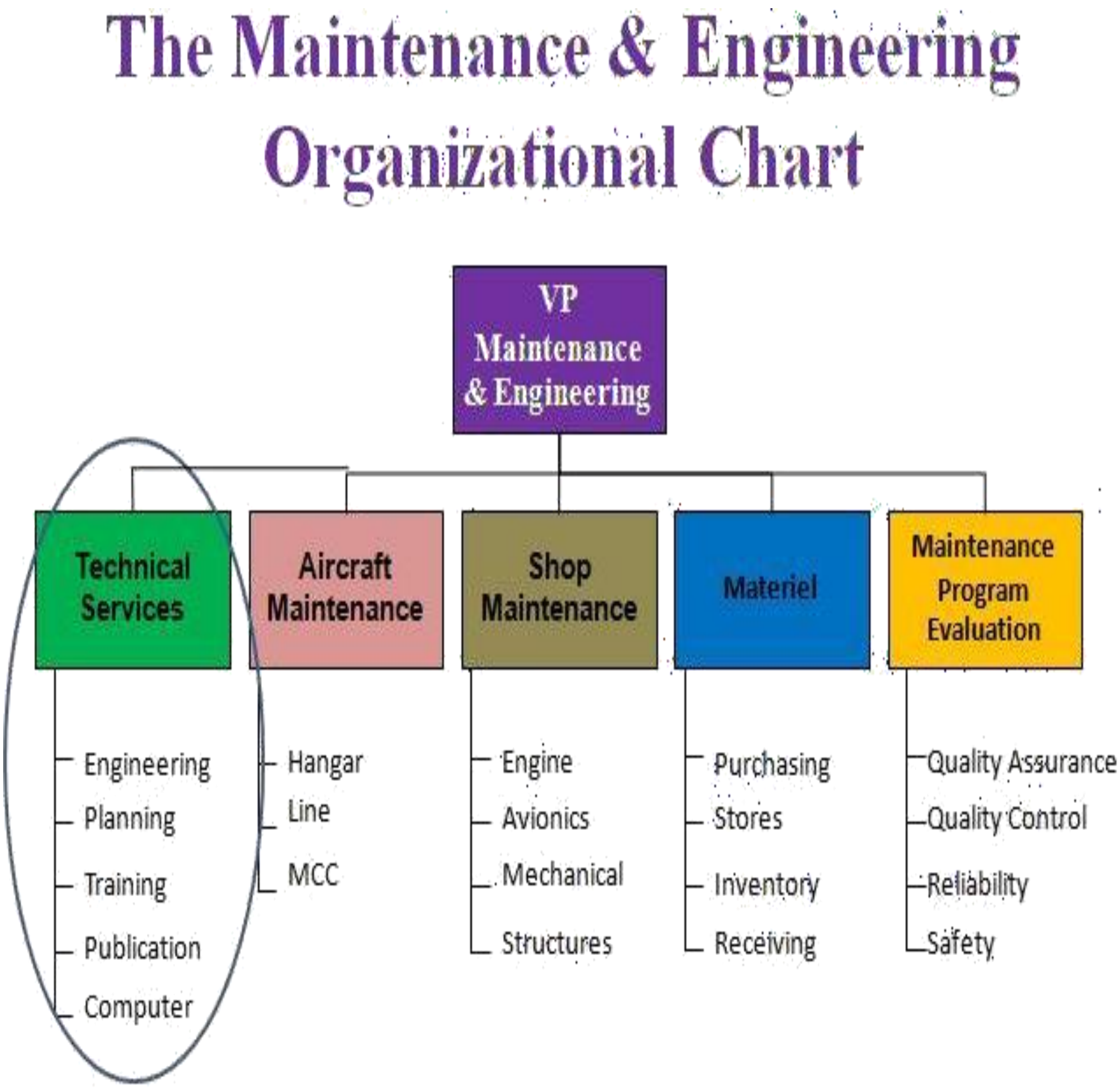


Fig - Typical maintenance and engineering organization.

- The VP of maintenance and engineering supervises five directors. Each director has the necessary number of managers under him or her to carry out the prescribed functions of the directorate. We find that by limiting the number of people that a manager has to supervise, the organization's work is divided into pieces that are more easily managed without losing the people-to-people contact that is so necessary for a happy and efficient work force.

➢ The M&E Organizational Chart



- Figure above is the basic organizational chart for the maintenance and engineering organization of our "typical" midsized airline.
- We will briefly discuss each layer and each function. T
- The structure starts with the VP level and continues downward with designations Director, Manager, and Supervisor as appropriate. Your organization may have other titles that their operatives prefer to use but the structure should be similar to Fig above.

General Groupings

Vice president of maintenance and engineering

- The head of the entire maintenance and engineering function within the airline should be at a relatively high level of the airline's structure. He or she should be directly under the head of the airline or under the head of the company's operational activity (President, Chief Operating Officer, or whatever title is used). The VP of M&E position should also be at the same level as the head of flight operations (VP Flight Ops or whatever he or she is called). Flight operations and maintenance are considered to be two sides of the same coin; they complement each other and carry equal weight.
- The flight operations department is responsible for conducting the air transportation operations; i.e., the flying. Maintenance and engineering, on the other hand, is responsible for delivering airworthy vehicles to the operations department to meet the flight schedule.
- The M&E department is responsible for con-ducting all scheduled maintenance, modification, etc. on the vehicles within the specified limits of the maintenance schedule and still meet the operations department's flight schedule. Without maintenance, flight operations would be quite limited in their activities; without flight operations, maintenance wouldn't have much purpose in maintaining the equipment. They need each other and the airline needs both.

Directors of major functions

- The five major functions shown in Fig. above are, in the order addressed in this topic , technical services (which includes engineering, planning, training, technical publications, and computing); aircraft maintenance (flight line, hangar, out-stations, and the maintenance control center); overhaul shops (for off-aircraft maintenance, repair, and overhaul); material services (responsible for ordering and maintaining supplies, handling warranties, and moving repairable and consumable parts through the system); and maintenance program evaluation (the monitoring activity for the organization, its workers and its suppliers).
- As you can see, there is more here than just maintenance and engineering. We will discuss each of these in more detail later.

Managers and supervisors

- Within each directorate, there are several managers. Each of these managers has a specialized area of responsibility within the overall scope of the directorate's function. Specific activities within each manager's area of responsibility require staffs of specialists with supervision by knowledgeable people.
- In some large organizations, the supervisor may need additional separation of activities or duties and appoint "leads" or "straw bosses" to decrease his span of control to a workable size. However, for most operators, the span of control can be much wider at this level.

Manager Level Functions—Technical

Services Directorate

- The technical services directorate contains numerous activities and services that support the maintenance and inspection functions. In the typical setup of Fig. above, we have identified various activities for each directorate.
- Each activity is under the direction of a manager. There may be further echelons of management, such as supervisors and leads as necessary.
- The manager of engineering is responsible for all engineering functions within the M&E organization.
- This includes
- (*a*) The development of the initial maintenance program (tasks, intervals, schedules, blocking, etc.);
- (*b*) the evaluation of service bulletins (SBs) and service letters (SLs) for possible inclusion into the airline's equipment;
- (*c*) oversight of the incorporation of those SBs and SLs that they deem beneficial;
- (*d*) overseeing the incorporation of airworthiness directives (ADs), the modifications that are required by the regulatory authority;
- (*e*) the evaluation of maintenance problems determined by the reliability program and for problems (if any) resulting from the maintenance checks performed by maintenance; and
- (*f*) for establishing the policies and procedures for the M&E organization.
- The engineering department is also involved in the planning of facilities (new hangars, maintenance shops, storage facilities, buildings, etc.) for the airline, which are to be used by the M&E organization.
- Although engineering usually will not actually do the design and engineering work, they will work with the engineering consulting firm or contractor that has responsibility for the project to ensure that the final result meets the airline's requirements.

Production planning and control

- The manager of production planning and control (PP&C) is responsible for maintenance scheduling and planning.
- This function must plan and schedule the manpower, parts, facilities, tools, and any special assistance required for all maintenance or modification activities. Included in the functions of PP&C are the following: (*a*) all planning activities related to maintenance and engineering (short, medium, and long term); (*b*) the establishment of standards for man-hours, material, facilities, tools, and equipment; (*c*) work scheduling; (*d*) control of hangars; (*e*) on-airplane maintenance; and (*f*) monitoring of work progress in the support shops.

Training

- The manager of technical training is responsible for curriculum, course development, administration, and training records for all formal training attended by the M&E unit's employees.

- The organization coordinates any training required outside the unit (vendor training) and coordinates with line and hangar maintenance personnel for the development of on-the-job training and remedial or one-time training activities.
- The training section must be able to establish new and special training courses to meet the needs of the airline. These course requirements are often the result of problem investigation by reliability, incorporation of new equipment or modifications, or the addition of aircraft types to the fleet.

Technical publications

- The manager of technical publications is responsible for all technical publications used by the M&E organization.
- The technical publications (Tech Pubs) keeps a current list of all documents received from manufacturers and vendors, as well as those produced in-house by the airline. Also on record are the number of copies, in paper, microfilm, or compact disc (CD) format, that each work center should receive.
- The Tech Pubs organization is also responsible for ensuring that appropriate documents and revisions are distributed to these various work centers.
- Work centers are responsible for keeping their own documents current, but Tech Pubs usually conducts periodic checks to see that this is being done.
- Tech Pubs is also responsible for maintaining the main technical library and any satellite libraries within the airline's system, including those at out-stations.

Computing services

- The manager of computing services is responsible for the definition of the M&E organization's computing requirements:
- (*a*) selection of software and hardware to be used, with usage information and requirements inputs from the individual units;
- (*b*) training of maintenance, inspection, and management personnel on computer usage; and
- (*c*) Provide continuing support to the using organizations.

➢ Manager Level Functions—Aircraft

Maintenance Directorate

- The aircraft maintenance directorate has responsibility for the major aircraft maintenance activities: maintenance on the flight line and maintenance per-formed in the hangar.
- Three managers report to the director of airplane maintenance: one for each of these activities and one for MCC.
- For airlines with different model aircraft or with two or more maintenance bases, the number of aircraft maintenance managers may be increased as necessary for the scope of the operation.

Hangar maintenance

- The manager of hangar maintenance is responsible for compliance with the airline's policies and procedures relative to all work done on the aircraft in the hangar, such as modifications, engine changes, "C" checks (and higher), corrosion control, painting, etc.
- The hangar maintenance function also includes various support shops (welding, seat and interior fabric, composites, etc.), as well as ground support equipment.

Line maintenance

- The manager of line maintenance is 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.
- Such activities include turnaround maintenance and servicing, daily checks, short interval checks (less than "A" check interval), and "A" checks.
- Sometimes, simple modifications can be done by line maintenance in order to avoid unnecessary use of the hangar.
- Line maintenance may also be utilized to perform line maintenance activities for other airlines under contract.

Maintenance control center

- The function known as the maintenance control center (MCC) keeps track of all aircraft in flight and at outstations.
- All maintenance needs of these vehicles are coordinated through the MCC. The MCC also coordinates downtime and schedule changes with the flight department.
- Some airlines might have a supervisor of line stations to coordinate outstation activities, but he or she is often part of the home base MCC operation.

- ### Manager Level Functions—Overhaul

Shops Directorate

- The overhaul shops directorate consists of those maintenance shops that perform maintenance on items removed from the aircraft.
- These shops include engine shop(s), electrical shop, electronics (or avionics) shop, and various mechanical shops.
- These may be separate shops or some may be combined for convenience, depending on the operation. Some of these shops may also perform contract work for other airlines.

Engine shops

- The manager of the engine overhaul shops is responsible for all maintenance and repair done on the organization's engines and auxiliary power units (APUs).

- If more than one type engine is used, there may be a separate engine shop for each type performing the work, but these would usually be under one senior manager with a supervisor for each engine type.
- The engine build up activities would generally come under the engine shop manager.

Electrical and electronics (avionics) shops

- The manager of electrical/electronic shops is responsible for all off-aircraft maintenance of electrical and electronics components and systems.
- There are a variety of components and systems in this field with wide variations in the equipment and in the skills needed to address them.
- There may be several shops (radio, navigation, communications, computers, electric motor–driven components, etc.) with separate supervisors. Shops are combined at times, however, to optimize manpower and space and to reduce test equipment inventories.

Mechanical component shops

- The manager of mechanical component shops has responsibilities similar to those of the manager of avionics shops. The only difference, of course, is that these shops would address mechanical components: actuators, hydraulic systems and components, aircraft surfaces (flaps, slats, and spoilers), fuel systems, oxygen, pneumatics, etc.

Structures

- The structures shop is responsible for maintenance and repair of all aircraft structural components. This includes composite material as well as sheet metal and other structural elements.

➢ Manager Level Functions—Material Directorate

- The material directorate is responsible for the handling of all parts and supplies for the M&E organization: (*a*) purchasing; (*b*) stocking and distribution (stores); (*c*) inventory control; and (*d*) shipping and receiving of parts and supplies used by the M&E organization.
- This includes not only the parts and supplies used in the maintenance, servicing, and engineering of the aircraft but also the sup-plies used for the administration and management of M&E (i.e., office supplies, uniforms, etc.).

Purchasing

- The manager of purchasing is responsible for buying parts and supplies and tracking these orders through the system. This begins with the initial issue of parts when a new aircraft is added to the fleet and a continual replenishment of those parts based on usage.
- The purchasing unit is also responsible for handling warranty claims and contract repairs.

Stores

- The manager of stores takes responsibility for the storage, handling, and distribution of parts and supplies used by the maintenance personnel in line, hangar, and shop maintenance activities. Stores areas, or parts issue points, are placed near the various work centers to allow mechanics quick access to parts and supplies and to minimize the time spent obtaining those parts and supplies.

Inventory control

- The manager of inventory control is responsible for ensuring that the parts and supplies on hand are sufficient for the normal, expected usage rate without tying up excessive funds in nonmoving items and without running out of stock too soon or too often for commonly used items.

Shipping and receiving

- The manager of shipping and receiving is responsible for packing, waybill preparation, insurance, customs, etc. for outgoing materials, as well as customs clearance, unpacking, receiving inspection, tagging, etc. for incoming materials. This includes all parts being shipped into and out of the airline.

Manager Level Functions—Maintenance

Program Evaluation Directorate

- The maintenance program evaluation (MPE) directorate is an organization tasked with monitoring the maintenance and engineering organization. The MPE unit is responsible for the CASS activities. The unit's functions include quality assurance, quality control, reliability, and safety.
-

Quality assurance

- The manager of quality assurance is responsible for assuring that all units of M&E adhere to the company policies and procedures as well as FAA requirements.
- The manager of QA sets the standards for the M&E operation, and the QAauditors ensure compliance to those standards through yearly audits. Quality assurance is also responsible for auditing outside suppliers and contractors for compliance with the company's, as well as the regulatory authorities, rules and regulations.

Quality control

- The manager of quality control is responsible for conducting routine inspections of maintenance and repair work, certifying maintenance and inspection personnel, and management of the required inspection items (RIIs) program.
- This latter function involves the identification of RIIs and the certification of specific personnel authorized to inspect and accept the work.
- The QC organization is also responsible for the calibration of maintenance tools and test equipment and performs or oversees the nondestructive testing and inspection (NDT/NDI) procedures.

➢ Reliability

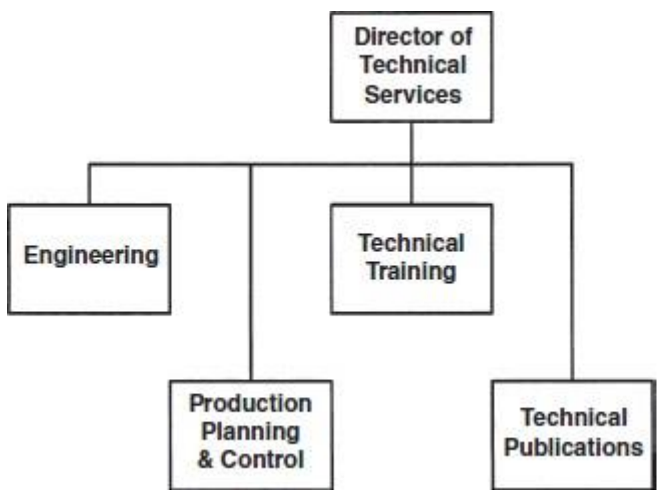
- The manager of reliability is responsible for conducting the organization's reliability program and ensuring that any problem areas are promptly addressed.
- This responsibility includes data collection and analysis, identification of possible problem areas (which are then addressed in detail by engineering), and publication of the monthly reliability report.

Safety

- The safety organization is responsible for developing, implementing, and administering the safety- and health-related activities within the M&E organization.
- The safety manager is also responsible for handling all reports and claims regarding M&E safety issues.

UNIT – III
TECHNICAL SERVICES

- The technical services directorate is responsible for providing technical support and assistance; continuous monitoring, updating, and development of maintenance programs for the airline's fleet type; maintenance program change; articulating aircraft manuals and their distribution; and all other M&E activities.
- The main job of engineering is to establish the maintenance program and subsequent schedules and to provide engineering expertise in new notice of proposed rulemaking (NPRM), new airworthiness directives (ADs) review, aircraft manufacturer documents, service letters, notice to aircraft operators, service bulletins, and to provide technical assistance to all other units within the M&E.
- Production planning and control (PP&C), discussed, is the primary force driving the day-to-day work activities of aircraft maintenance.
- This department is responsible for planning and scheduling all aircraft maintenance activities in the airline.
- The other functions of technical services are Technical Publications, , which is responsible for document receiving, distribution, and updates.
- Technical Training , is responsible for all training activities in M&E, including maintenance management, inspection, auditing personnel, and administrative support.
- Figure shows the organizational chart of the technical services units.



Organizational chart for technical services

➢ Engineering

- Engineering is defined by the Engineers' Council for Professional Development as the "profession in which knowledge of the mathematical and natural sciences gained by study, experience, and practice is applied with judgment to develop ways to utilize economically the materials and forces of nature for the benefit of mankind." The Encyclopedia Americana says "Engineers, unlike scientists, work toward the solution of specific practical problems."

- The Encyclopedia Britannica adds: “All engineers must have a positive interest in the translation of the theoretical into the practical.” In other words, an engineer is one who applies mathematics and scientific principles to the effort of resolving practical problems.
- Engineers are usually identified by some specialty: civil, mechanical, electrical, aeronautical, transportation, nuclear, to name a few. None of these specialties apply directly to aviation except aeronautical, and these aero engineers would normally be involved with design and development of air and space systems and equipment which, as we have said, the airline no longer does.
- The engineering department of an airline can vary widely; they perform many functions for the airline as a whole and specifically for the M&E organization. In some airlines, engineering is a corporate unit separate from the M&E operations, and in others it is part of M&E.
- The size of the airline often determines which is most desirable. In those airlines where engineering is outside the M&E organization, their function is usually oriented toward major engineering type activities, such as the development and support of buildings and other facilities; major aircraft modification design; and detailed engineering studies of maintenance problems as well as other airline technical problems.

Makeup of Engineering

- The airline engineering department is made up of the more experienced people of the maintenance organization.
- They must be knowledgeable of the total maintenance operation as well as the airline and regulatory requirements. Ideally, an airline would have both degreed engineers and senior licensed mechanics in the engineering department.
- There would be engineering staff for each type of equipment: avionics, electrical, hydraulic, pneumatic, power plant (engines and APU), structures, and mechanical systems. Avionics may even be divided into communications and navigation systems; and mechanical systems into flight controls, hydraulics, etc. Some airlines may have different groups of engineers for each model of airplane and/or engine.

Mechanics and Engineers

- Some airlines have engineering departments made up entirely of mechanics, while others have departments made up entirely of degreed engineers. Neither of these schemes is entirely satisfactory for our purposes.
- Although the mechanics are fully versed in the details of the systems and components in service, are experienced in the governing rules and regulations, and understand the idiosyncrasies of their fleet, they often do not have the same analytical discipline and other training of engineers.
- On the other hand, graduates of engineering colleges, more often than not, lack a suitable understanding of airplanes, air-craft engines, and the multitude of systems and components needed to provide airworthy vehicles for air transportation. The engineering curricula provide no training in maintenance and very little about other engineering disciplines.

- Engineers and mechanics are trained differently, and each approaches problems in different ways. While the mechanic’s approach is somewhat reactive, the engineer’s approach is more proactive. But, it takes both disciplines to run an effective engineering operation at an airline.

- ## Engineering Department Functions
- The engineering department provides preparation, study, and analysis of various aspects of the maintenance operation.
- They evaluate maintenance requirements and establish the maintenance program for the airline.
- They also evaluate suggested modifications of aircraft systems for possible incorporation into the fleet and provide technical assistance to maintenance.
- Engineering prepares the units for handling new equipment and facilities and provides assistance, where needed, in all other aspects of maintenance.
- These functions are discussed below.

- ## Development of the maintenance program
- Each airplane model has an initial maintenance program developed by the industry working groups and defined in the manufacturer supplied documentation.
- This is a suggested maintenance program for new operators and new equipment. Once in the field, operators can adjust the program to suit their own needs and operational environment
- This initial maintenance program is a generalized program and must be tailored to the individual operator from the very beginning. The manufacturer produces the FAA approved MRB report and a maintenance planning document
- It is the responsibility of the engineering department at the airline to package these tasks into workable units based on such factors as time, space, personnel, fleet schedules, and overall airline capabilities. For some airlines, the designated letter checks (A, B, C, and D) are sufficient.
- .The fleet is large enough for the airline to schedule people and facilities for continuing checks (e.g., one airplane per week or per month).
- In small airlines, there are not enough airplanes to allow this continued scheduling of “C” checks. Due to the higher manpower requirements for the “C” check, it is necessary for the small airline to adjust the schedule to smooth out the work.
- For most operators, the “A” check is done monthly. The “C” check comes about yearly (every 12 to 18 months for newer models) and requires a concentration of personnel for the 3 to 7 days required to perform it.
- For the small airline, staffing this annual effort is not feasible.
- To remedy the matter, the “C” check is divided into parts, called phases, and each part is conducted separately.
- For example, a “C” check could be divided into four phases (C1, C2, C3, and C4), each one carried out every 3 months until the entire “C” check is performed. An air-line may divide the “C” check into 12 packages and perform one package a month along with each scheduled “A” check. In either case, the personnel utilization is more constant throughout the year, the checks are done within the prescribed time limit, and the airline workload is stabilized.

- The tasks performed by maintenance at any of these checks can be quite detailed. To ensure that they are carried out correctly, task cards are issued to the mechanics. Many airlines use task cards produced by the airplane manufacturers and some write their own cards. Still others develop a combination of the two. Whichever method is used, it is the responsibility of engineering to develop these task cards, assemble them into appropriate packages, and ensure that they are current and effective.
- **Develop technical policies and procedures**
  Manual for M&E
- This document contains all the necessary information to describe the M&E organization, and its responsibilities.
- It identifies the organizational structure, provides information on duties and responsibilities of key personnel and key organizations, and provides a series of maps and layouts of the airline's facilities.
- It also gives detailed descriptions of how work is to be carried out, who is to perform the work, and how it will be managed, inspected, and released (if applicable). Engineering is responsible for developing this document with inputs from the other M&E units.
- The FAA defines the minimum requirements for the manual in FAR 121.369, but consideration should be given to additional policies and procedures that provide complete instructions to maintenance and engineering personnel for the conduct of their work.
- The manual can be a single document in loose-leaf form, it can be a series of separate documents, or it can be a multiple-volume set

Evaluate changes in the maintenance program

- From time to time there will be problems with the effectiveness of the maintenance program.
- Individual tasks may be ineffective or less than adequate.
- Some MRB tasks eliminated from the original program may, in retrospect, need to be reinstated.

Evaluate changes in aircraft or system configuration

- From time to time, the airplane, engine, and component manufacturers develop modifications and improvements for their respective systems, which are intended to improve operations, reliability, and/or maintenance processes. These are issued as service bulletins (SBs) or service letters (SLs). If a safety or air-worthiness issue is involved, the modification may be issued by the FAA as an airworthiness directive (AD).
- Airworthiness directives are mandatory, so there is no need for engineering to evaluate the change. Engineering will, however, be required to provide the information needed by maintenance to accomplish the modification regardless of whether it is an AD, SB, or SL. This will be accomplished by issuing a detailed instruction produced in the form of an engineering order (EO) which is discussed below.

Evaluation of new aircraft added to the fleet

- One of the primary functions of engineering is to evaluate new equipment for the airline.

- When the business people of the airline decide to expand the operation, one of the first questions to resolve is "What airplane/engine combination should we buy?" Part of this decision is based on the routes to be flown, the destination cities, the expected market share and, of course, the cost of the equipment versus the revenue expected. These are operations and business decisions based on market conditions and airline goals and objectives.
- Another important part of the decision, however, is "What is the best equipment to buy from the maintenance and engineering standpoint?" The two decisions—business and technical—must be reconciled to the satisfaction of the overall airline goals. At this point, for the sake of the present course of study, we will skip the business decision and concentrate on the technical decision.

• Evaluation of used aircraft to be added to the fleet

- If the airline is contemplating the purchase or lease of used airplanes from another airline or leasing organization, other items must be considered in addition to the above items relating to equipment differences from the existing fleet. These items would include such information as the current configuration of the airplane, including engine type; the maintenance program and check schedule that the current operator is using; status of modifications (ADs and SBs).

• Evaluation of new ground support equipment

- On a smaller scale, the engineering department will also be called upon to evaluate the need for new equipment in support of aircraft added to the fleet.
- This would include tools, test equipment, stands, electric and pneumatic carts, heaters; tow bars, tractors, etc. Some existing equipment may or may not be usable with the new airplane models (purchased or leased). In some cases, the GSE, though usable, may not be available in sufficient quantity to serve the increased fleet size. Additional purchase would be necessary in such cases.

• Development of new facilities for M&E

- At times, it is necessary for the airline to build new facilities or expand existing ones to support new equipment, airline expansion, or modernization efforts.
- This would include such projects as hangars, engine test facilities, component shops, storage facilities for various types of equipment, and storage for special parts.
- The engineering department will not (usually) be involved in the design and construction of these new facilities. That will be contracted out to more appropriate companies.
- Engineering will, however, have a considerable input into the design in terms of requirements. A hangar, a workshop, or any other facility must be designed for the express use of the airline and the M&E organizations that will occupy it. Therefore, the engineering department will act as liaison between the users and the designers and builders to ensure that the finished product is acceptable.

• Issuance of engineering orders

- Any work performed by maintenance in the form of standard checks—daily, 48-hour, transit, "A" check, "C" check—is done on standing orders from the VP of maintenance and engineering as identified in the maintenance section of the Ops Specs.

- Any work not included in these standard checks must be assigned by engineering order.
- Some airlines may call this document by another name, such as work order, technical order, or engineering authorization (EA). This EO is developed by engineering, with inputs from appropriate work centers, to define the scope of the job and schedule the work. Work performed as a result of SBs, SLs, ADs, and all work resulting from evaluation of problems defined by reliability investigations or QC reports, will be issued on an engineering order.
- All work centers involved in the particular project will be defined on the EO: maintenance (line, hangar, or shop as appropriate); material (for parts, supplies, tools); quality control (inspection of work if required); training (remedial, upgrade, or new course).
- Engineering releases the EO after all involved organizations (maintenance, material, planning, etc.) have agreed to its contents.

- **Provide assistance in troubleshooting**
- **difficult problems**
- The day-to-day problems that mechanics run into on the line, in the hangar, and in the shops, are often routine and call for well-defined responses.
- At times, the problems are more elusive and the mechanic must apply his or her troubleshooting skills to resolve the problem. When the problem eludes the mechanic's expertise, assistance is available from engineering to get to the bottom of the problem. This assistance can be given to line, hangar, and shop people, as well as vendor's handling warranty claims or working on contract. Parts suppliers who perform repairs on rot able units and contractors doing third-party maintenance may also require engineering's assistance.
- It should be noted that this is not the primary responsibility of engineering and should be used only in difficult circumstances. Engineering is not a substitute or replacement for maintenance.

- **Other engineering functions**
- Engineering can also provide expertise to training, material, the technical library, or any other M&E organization needing technical help. They are considered the technical experts of the organization and are available to lend technical assistance to anyone in the airline needing such assistance.

➢ Engineering Order Preparation

Engineering initiates an engineering order for any work not included in the standard maintenance program plans as established by the Ops Specs. However, the need for an EO can be generated from various sources. Its implementation can also take various paths depending on the type and complexity of the work involved.

- For example, EOs related to maintenance modifications and other directives (ADs, SBs, SLs, etc.) will be scheduled by the planning organization (PP&C).

- Other problems may necessitate changes in the maintenance program (intervals, tasks, etc.); change in processes; parts procurement activities; or may require training (refresher or upgrade; classroom or on the job).
- In these cases, the EO might be issued directly to the M&E unit or units involved. The following eight steps generalize the process:

1. A decision is made to do work based on one of the following: reliability program alert; work force requirement (QA, QC, maintenance manager, or mechanic); an AD, SB, SL, or fleet campaign.
2. Engineering analyzes the work requirements (problem and solution): troubleshoot or investigate the problem to determine scope and needs; analyze AD, SB, SL, etc. if applicable for time, personnel, etc. requirements.
3. Determine the approach to follow: incorporate work into PP&C check or other scheduled or unscheduled maintenance activity; schedule other corrective action as necessary; issue EO as required.
4. Identify the needs for schedule and performance of the work: engineering studies, plans, etc.; the need for special skills if any (in-house or contract); the need for parts and supplies (on hand or order, consider lead time for delivery); determine need and availability for special tools and/or test equipment needed.
5. Identify work required: personnel (maintenance, engineering, contract, etc.); facilities (hangar space, GSE, etc.); time requirements for work to be done.
6. Call a coordinating meeting to finalize EO (if necessary): all organizations involved in the work; coordinate and resolve difficulties.
7. Issue engineering order: PP&C will plan work and monitor execution; or EO may go directly to material, training, etc. as necessary.
8. Engineering closes EO when all work is completed: notification comes from each work center involved in the particular EO; for fleet campaigns, ADs, etc. involving entire fleets, EO remains open, PP&C schedules each aircraft for incorporation; engineering closes EO when fleet is complete.

Production Planning and Control

Introduction

- Production is planning and control (PP&C), because of its key role in planning and scheduling, is the heart of the maintenance and engineering (M&E) organiza-tion. Although the title PP&C is common throughout the airline industry, the activities actually performed sometimes fall short of the ideal notion of what PP&C should be. The PP&C organization is primarily responsible for planning and scheduling all aircraft maintenance activity within the airline.

PP&C Organization

- The planning work can be done by a centralized or decentralized PP&C group.

- In the centralized group, all functions—forecasting, planning, and control—are done within the organization, with liaisons to the work centers during actual performance of work.
- In a partially decentralized organization, the forecasting and planning would be done by PP&C, and the control would be done by personnel in the hangar or other work centers. In some airlines, the PP&C function is entirely decentralized. That is, all the planning and control is done by each work center.
- If the airline structure and size is such that the planning has to be done by the individual work centers instead of a centralized group, there must still be some coordination and control at the M&E organizational level.
- The M&E organization is normally led by the vice president of maintenance and engineering. The production planning and control department typically reports to the VP of M&E. The PP&C department is normally overseen by a man-ager, followed by the maintenance planner, and long-range planner.

- **Manager, PP&C**
- The PP&C manager is normally responsible for the planning department and its functions.
- This includes making sure that all assigned maintenance and inspection planning activities are accomplished according to the airline's policy and FAR's and the company's required maintenance programs.
- The PP&C manager must have the cross-functional ability to work with other departments within the airline's organization; plan, coordinate, and route aircraft to maintenance bases in a timely manner; and take appropriate and necessary action which may affect the airline's daily operation

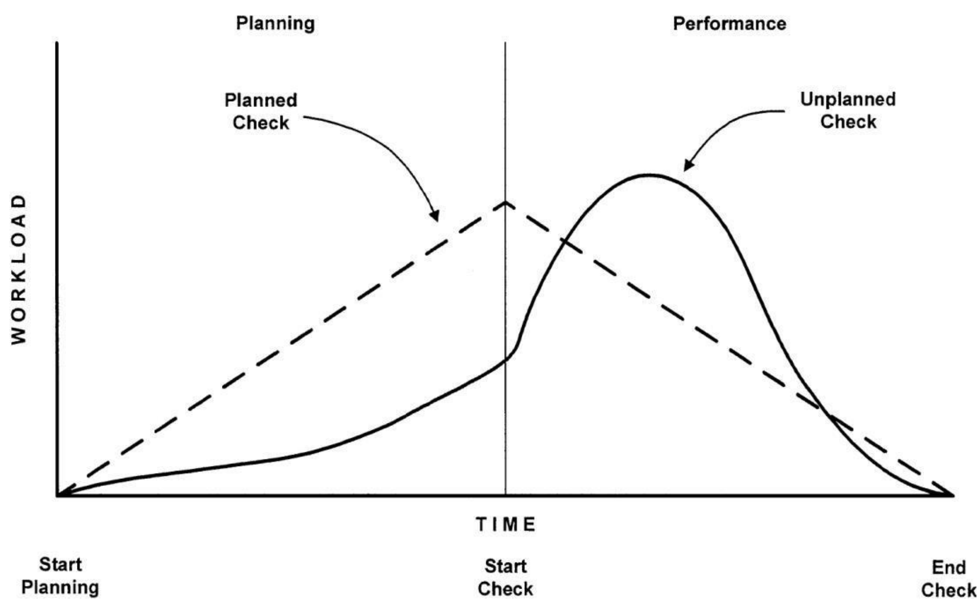
- **Maintenance planner, PP&C**
- Maintenance planners are assigned to different maintenance bases. One maintenance planner can track two to three different maintenance bases and is normally the contact for maintenance bases for planning schedules.
- The maintenance planner's primary function is to develop all scheduled work and/or work scope needed for all line maintenance and hangar maintenance aircraft.
- It is the maintenance planner's duty to track and monitor the completion of all planned work assigned to a maintenance base and the aircraft.
- The maintenance planner coordinates the aircraft routing to the maintenance base and also coordinates with the stores department about any logistics required for maintenance planning.

The Production Planning & Control Department's Function

- The PP&C title is a bit misleading.
- It implies two functions: planning and control.
- PP&C actually has three functions: forecasting, planning, and control.
- Forecasting activities include estimating maintenance workload for the existing fleet, creating business plans, and being aware of any changes in the forecast period.

Planning involves scheduling upcoming maintenance, and includes planning and scheduling details (manpower, parts, and facility) and timeframe requirements for such maintenance: less than "A" check items, daily items, 48-hour checks, and letter checks. These plans would include incorporation of SBs, fleet campaign directives (FCDs), SLs, and ADs, as well as other maintenance tasks, such as engine changes, fuel nozzle changes, gear changes, and generator changes deemed necessary by the airlines.

- The plan is somewhat idealized, however. During the actual performance of maintenance, many things occur that require altering the plan.
- The control function allows for adjustments to the plan and keeps (or attempts to keep) a check on schedule.
- There are several methods of adjusting the plan, including deferral of maintenance to a later check, addition of personnel to complete the work, or outsourcing the work to a contractor. Feedback from a check allows PP&C to adjust the planning effort for future checks.



The importance of planning

Forecasting

- Forecasting is concerned with the future workload of the M&E organization.
- The PP&C department is responsible for reviewing and providing upcoming maintenance on the aircraft fleet.
- This requires workload planning, goal setting, implementing, and monitoring.
- It must also take into account the routine and non routine maintenance requirements, as well as planned changes in future operations relative to maintenance.
- Any changes in fleet size, routine structure, facilities, manpower, or skill requirements are tracked.

- Future plans may also accommodate the aging and replacement of equipment, corrosion prevention control program, addition of new equipment, modification of equipment, and the upcoming ADs and SBs. Activities throughout M&E will change as these assets and requirements change.
- The forecast function ensures that M&E and PP&C are up to date on these changes and ready to adjust their processes and procedures accordingly.
- Forecasts are usually made for the long and short term but often an intermediate term forecast is also made.

Production Planning

- While forecasting is long range and general, planning deals with the day-to-day activities of M&E.
- The goal of M&E is to deliver airworthy vehicles to the flight department in time to meet the flight schedule, with all maintenance activities completed or properly deferred. In business terms, this is what we "produce"— airworthy vehicles with all maintenance properly addressed. Thus, the activities of line, hangar, and shop maintenance constitute the production aspect of M&E. Production planning, then, is the planning of that work with the stated goals in mind.
- Production planning involves the planning of all maintenance activities: daily, 48-hour, and transit checks; letter checks; and modifications due to airworthiness directives, service bulletins, service letters, and engineering orders. It also involves the planning and scheduling of all aspects of these checks, including manpower, parts, supplies, and facilities. Coordination with flight operations and with ground handling and support activities is also included in the planning effort.

"A" check planning

- "A" checks are usually routine.
- The tasks required are defined by engineering using the MRB or Ops Specs document. The time, manpower, and parts and supplies needed are generally fixed.
- There are variations, however, that must be addressed. When there is a write-up in the aircraft maintenance log that cannot be addressed at turnaround or on daily or overnight checks, it may be deferred until a later time. The deferral may be a result of a lack of parts, a temporary lack of skilled labor, or lack of sufficient time required (at the time of occurrence) to effect resolution. In these cases, the deferred maintenance is scheduled by PP&C for the next "A" check.
- The necessary parts, supplies, and personnel should be available at that time.
- Performance of an "A" check may also include, because of time and parts constraints, some "less than "A" check" items (100 hours, 250 cycles, etc.). These may be near the time or cycle interval and so are placed with the "A" check for convenience. If there are SBs or SLs that do not require extensive time or parts to complete, these may also be scheduled for the "A" check.
- [illegible]
- The "B" checks, if they are used, are often similar to "A" checks but involve different tasks, usually at intervals which fall between consecutive "A" checks.
- The planning for these is essentially the same as for "A" checks.

"C" check planning

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- The “C” check is usually done about once a year (12 to 18 months on the newer model aircraft), depending on the airline flight schedule.
- The planning effort is more detailed and more elaborate than for the “A” check.
- Normally, a “C” check will take 4 to 7 days to complete, depending upon the model and the circumstances. The number of shifts worked, the availability of manpower and parts, and the skill requirements for the work will affect the length of time involved.
- The check will consist of three categories of tasks: routine, variable routine, and nonroutine.
- **Routine tasks** are those tasks identified in the MRB document. These are items that must be performed at the specified interval. Since some of these items are performed every “C” check and others are performed every second, third, or fourth check (2C, 3C, or 4C), the amount of time required to perform each scheduled check will vary from check to check. This scheduling and variation in time requirements are PP&C’s concern.
- Variable routine tasks are those tasks which vary from one check to another and from one aircraft to another. These tasks include incorporation of service bulletins and airworthiness directives, as well as fleet campaigns, items deferred from previous maintenance checks, and any other one-time maintenance actions required for a particular aircraft. The time required to accomplish these tasks is generally fixed, so these items are similar to the routine tasks for planning purposes.
- Non routine tasks are those work items that are generated by the accomplishment of other, routine tasks.
- For example, if a routine task says to inspect the wheel-well area for hydraulic leaks, the task will take a certain amount of time (scheduled). If a leak is discovered, however, it must be addressed. This constitutes the production of a non routine maintenance task and subsequently a non routine task card. Since the number of non routines can only be estimated and the amount of time required to complete the non routine item varies with many factors, it becomes an interesting task for PP&C to properly estimate the time needed to complete these non routine items and the entire check.

- Below is a list of items that might be included in a “C” check. Not all of these would be included each time, however.
    1. “C” check items from the approved maintenance program (routine)
    2. Deferred maintenance from line or other check packages (variable routine)
    3. Incorporation of SBs, SLs, ADs (variable routine)
    4. Incorporation of airline mods and fleet campaigns (variable routine)
    5. Cleaning, painting of aircraft (variable routine)
    6. Work generated by inspections and routine items (non routine).
- Once the package is set and the time estimated, PP&C must arrange for and schedule all the necessary elements for proper execution of the package. That would include the following:

1. Locate and secure hangar space for the duration of the check
2. Obtain a release of the airplane from operations for maintenance purposes (this may be accomplished by MCC)

3. Arrange for and schedule the washing of the aircraft
4. Secure tow vehicles and manpower needed to move the airplane to the wash rack and then into the hangar
5. Ensure all parts and supplies needed to carry out the check will be on hand
6. Ensure delivery of those parts and supplies to the hangar at the time needed
7. Identify manpower and skills needed for the check

Production Control

- The plan produced by PP&C allows a certain amount of time for the performance work based on past knowledge of the work to be done and also based on the assumption that parts, supplies, manpower, and facilities will be available when needed.
- The plan also assumes that there is no variation in the flow of work activity. The PP&C planners can only estimate the amount of time required for non routine items, and this can be less than accurate. Take, for instance, a routine task that says "check the hydraulic line for leaks."
- If there are no leaks, the inspection task should take a specific amount of time, but since there is no way for the planner to determine if there will be leaks or to know the extent of any leak(s) found, there is no way for him or her to accurately estimate the time required to perform the nonroutine task of repairing the leaks. The time needed to fix a leak still must be estimated and scheduled.

Technical Publications

- The technical publication department is vital to aircraft maintenance operations, since this entity is solely responsible for receiving and distributing publications throughout the airline maintenance bases, hubs, and smaller stations.

Functions of Technical Publications

The technical publication organization essentially has three functions:

1. To receive and distribute, within the airline, all those publications issued by outside sources
2. To print and distribute the publications generated by the various organizations within the airlines
3. To establish and maintain a complete, up-to-date library system for all such documents needed for M&E operations.

- Outside sources of documents would include airframe and engine manufacturers, vendors and manufacturers of equipment installed on the aircraft, and manufacturers of special tools and test equipment used in the maintenance effort.

Airline Libraries

- The primary reason for having a technical publications organization is to ensure that all applicable publications related to the airline operation are available to the users and are up to date with the latest changes.
- The most common way to accomplish this is to establish a main library for the M&E organization. If the M&E organization is of any appreciable size, the location of a single library would be inconvenient for many users and the number of copies of each document might be limited. For that reason, the technical publications organization at most air-lines maintains, in addition to the main library, one or more satellite libraries strategically located to minimize travel times to access the information needed.
- Each library—main and satellite—should contain the necessary tables, chairs, shelves, microfilm readers and printers, computer terminals, and copy machines as needed to serve the users and the document for-mats (paper, microfilm, electronic) which will be available there.

Maintenance control center (flight line)
Line stations (1 or more)
Hangar dock
Overhaul shops in hangar
Engineering
Maintenance training
Production planning
Quality assurance
Reliability (may be colocated with engineering or QA)
Material

Satellite Libraries

➢ Control of Publications

- Maintenance-related documents are classified as either "uncontrolled" or "controlled" documents.
- Uncontrolled documents are issued for general information only and are not used to certify airworthiness. They do not require any of the tracking system requirements discussed below for controlled documents.
- Controlled documents are used to certify airworthiness of the aircraft, engines, and components. Each controlled document will contain a list of effective pages (LEP) and a record of revisions to the document identifying the revision number or letter and the date of that revision. The LEP will also reflect the active page numbers of the latest revision. Table below is a typical list of controlled documents.

Operations specifications
Technical policies and procedures manual*
Manufacturer and vendor manuals (see Table 5-1)
Regulatory authority documents (see Table 5-2)
Applicable airworthiness directives
Applicable aircraft type data sheets
Applicable aircraft supplemental type certificate

Controlled Documents Listing

➢ Training Organization

- Since all airline personnel require training of one sort or another, it is necessary to have a training organization to address these needs.
- This organization can take various forms.
- This can be an airline's training organization, training department, or school at the corporate level that is responsible for training of all airline personnel; or there can be a separate organization responsible for maintenance training, flight crews, cabin crews, ground handlers, and management and administrative personnel.
- Flight crew training is normally contracted out to various flight academies or the aircraft manufacturer, since they have the classroom facilities, aircraft simulators, and experienced pilots who train the flight crew.
- This depends on the airline's size and operations. Some airlines do have in-house simulators with a check airman pilot who acts as a flight instructor. Cabin crew is similar to aircraft flight crew in that their training may be performed by the manufacturer or in-house. The cabin crew's training emphasizes safety and evacuation of the aircraft with mock-ups and what to do in the event of an air-craft emergency on land or on water. They learn how to deploy slides and/or rafts.
- The ground handling crews have a separate training department and normally are trained in-house due to aircraft availability.

➢ Airline Maintenance Training

- An airline maintenance training program is required by the FAA under FAR 121.375, which requires airlines to provide training to their maintenance personnel. The airline's maintenance training department is responsible for having a comprehensive training program that is effective in teaching its employees and contract maintenance workers how to service and maintain aircraft
- and their systems.
- In a commercial airline, the training department is led by the training manager, who is responsible for accuracy, functionality, training strategies, and the quality of the maintenance training program.
- The director of training normally works with the director of maintenance (DOM) and director of quality control (DQC) for their personnel training. This ensures that employees schedule the required training, refresher training for aircraft and related systems, and company-required training in a timely manner.
- The DQC normally works with the training department to comply with any airworthiness training,
- required inspection authorization (RII), and various other QA and QC training.

- For aircraft maintenance personnel, there are several kinds of required training activities.
- The training listed here is given by an airline after hiring an AMT with a valid A&P:
- (*a*) organizational training;
- (*b*) manufacturer or vendor training;
- (*c*) quality training;
- (*d*) on-the-job training (OJT);
- (*e*) equipment operation and safety training; and
- (*f*) refresher training.

Airframe Manufacturer's Training Courses

- Whenever an airline buys one or more aircraft from the airframe manufacturer (Boeing, Lockheed, Airbus, etc.) they usually get, as part of the purchase price, a certain number of training slots for the manufacturer's training classes on that model.
- This would include courses on the airframe, power plant, and avionics equipment installed. Who attends these classes for the airline differs from operator to operator and is often dependent on airline size and management.
- For small airlines, the mechanics who will be working on the aircraft systems while in service or their supervisors will attend these classes.
- Very often, both will attend. In larger airlines, some or all of these training slots may be given to the maintenance instructors of the airline's training organization.
- The choice, of course, is at the airline's discretion. If airline training instructors attend, they will return with the responsibility of creating the airline's version of the course and presenting the material to the airline's mechanics.
- In cases where the new equipment is only partially different from equipment currently in use—a 767-300, for instance, going to an airline that already flies 767-200s—only the differences between the two models need be taught to the air-line personnel.
- Airframe, engine, and equipment manufacturers may provide a variety of one-time programs at the airline venue. This might include training on such topics as extended range operations with two-engine airplanes (ETOPS); corrosion protection and control program (CPCP); maintenance error detection aids (MEDA); nondestructive test and inspection techniques (NDT/NDI); aviation safety; reliability programs; and the like.
- Although these courses are presented by outside sources, the airline training office is involved, since they must provide classroom space and other assistance as necessary and they must update the training records of those in attendance.

UNIT – IV
MAINTENANCE AND MATERIAL SUPPORT

Line maintenance (on – aircraft)

Introduction

- The makeup of the line maintenance depends on the size of the airline.
- The **line maintenance organization** may take a different structure, but a commercial midsize airline is normally organized according to the aircraft it operates, the number of daily flights, and the maintenance personnel required to run a good operation.
- The **maintenance control center (MCC)** coordinates all maintenance activity on the flight line at the home base, and all outstations. Due to aircraft turnaround times, flight line maintenance is a fast-paced maintenance environment, consisting of scheduled and unscheduled maintenance.
- The work done by line maintenance is any maintenance that can be done on the aircraft in service without disturbing the flight schedule. These maintenance tasks may include everything from daily oil checks, to 48-hour check, and the "A" check items.
- If an airline has "B" checks, these are usually done by the line maintenance personnel as well. In many airlines the "A" check interval tasks are added or other tasks scheduled such as the daily line maintenance checks. All of this work is defined by the airline's maintenance program, and scheduled by production planning and control and administered by the maintenance control center.
- The crew used for line maintenance, again determined by the size of the organization, may consist of a single crew to perform all of the items mentioned or separate crews for certain tasks.
- **For example**, one crew might be assigned exclusively to different checks while another crew handles all servicing and the logbook discrepancies of the scheduled aircraft. The daily servicing and checks are usually performed first thing in the morning or overnight.
- The **line maintenance** crew is normally an experienced crew, with a very good knowledge and understanding of the aircraft that the airline operates and their systems. When a technician receives a maintenance call from an inbound aircraft concerning the discrepancy it is arriving with, the **line maintenance** technician usually has a good idea how to resolve the discrepancy quickly and return the aircraft to service in a safe and airworthy condition.
- The technicians at the flight line often work in adverse conditions: hot weather, rain, and snow. These technicians often must stand, kneel, or bend in awkward positions to remove and install aircraft parts. They have the tremendous burden of maintaining safety standards, and sometimes the tasks they perform to meet those standards can be stressful.
- The flight line is normally equipped with an office for the aircraft maintenance supervisor, a technician ready room (break room), a parts and tooling room, and an aircraft maintenance library, where all the aircraft maintenance manuals are readily available for troubleshooting. The line avionics room contains all radio equipment and charging stations for aircraft test equipment, which includes very sensitive equipment.

Functions that Control Maintenance

- There are two organizations in M&E responsible for controlling maintenance activities, and these are shown in Fig.
- We have already discussed the primary control function, production planning and control.
- This group requires input from various sources identified on the left of Fig.

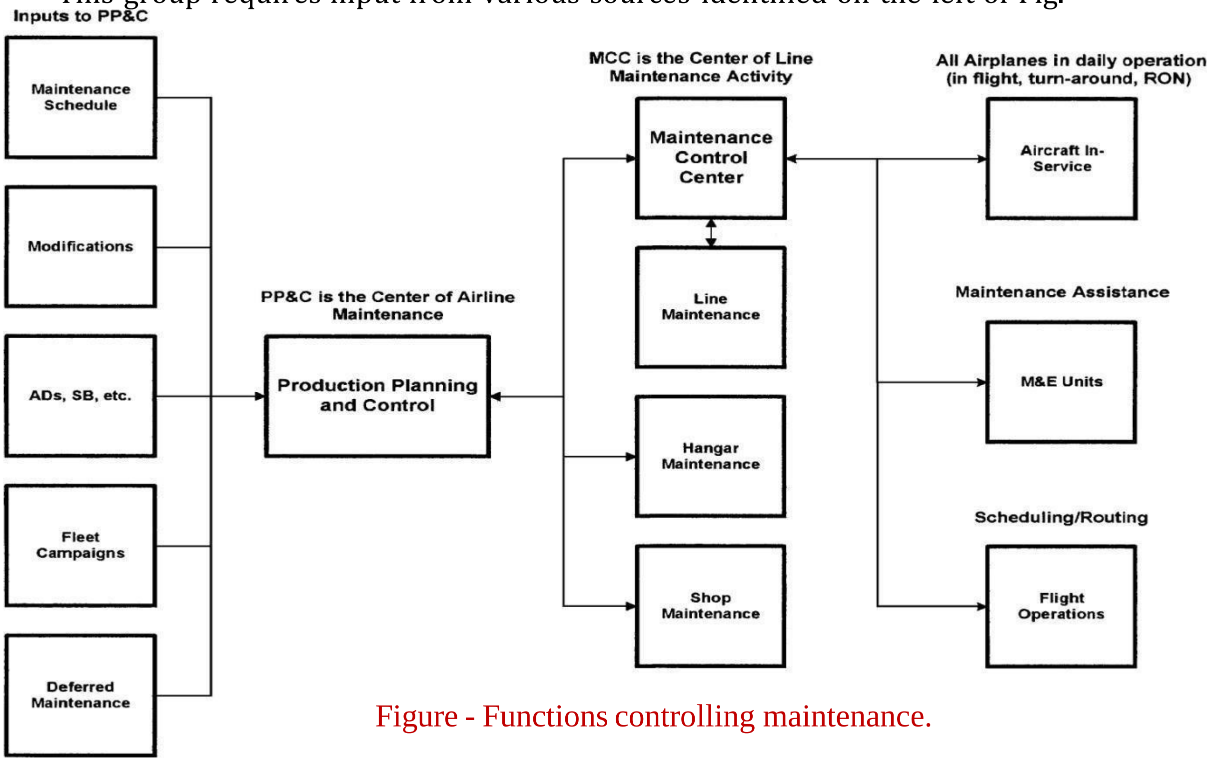


Figure - Functions controlling maintenance.

- Any maintenance that is identified in the airline's maintenance program, plus any additional requirements for modification, upgrade, or maintenance deferred from earlier checks, are controlled (scheduled) by PP&C.
- This maintenance is directed toward the hangar, the shops, and the flight line as necessary. The PP&C organization interfaces with line maintenance through the second controlling activity, the maintenance control center.
- The MCC coordinates all maintenance activity—scheduled or unscheduled—for the aircraft in service with the applicable M&E organization and with the flight operations. Note the double-headed arrows in Fig. These indicate a two-way communication. The MCC must deal with all aircraft in the flight schedule, regardless of where they are in the route structure, and must coordinate all maintenance activity whether it is done by the airline or a third party. The MCC also coordinates the contracting of maintenance at units where no previous maintenance agreement exists.
- The MCC also coordinates with any of the airline's M&E units for support of in-service aircraft discrepancies and the rescheduling of maintenance actions; and with the flight operations organization regarding down times, flight delays, and cancellations.

- If maintenance is required by an aircraft in service and such support is not available at the aircraft's current location, maintenance may be deferred—all other requirements being met. This deferral will be handled by the MCC, and they will schedule the work for another outstation or the home base wherever the appropriate time, facilities, and staff exist. If the maintenance must be deferred to a major check ("A" check or higher), then the MCC would coordinate that action with the PP&C, who will then schedule the work for an appropriate down time and ensure that parts, supplies, etc. will be available for that check. These deferrals, of course, must be in accordance with the MEL and CDL requirements.

Maintenance Control Center Responsibilities

- The maintenance control center is the heart of line maintenance. Regardless of how large or small an airline is, the MCC functions must be established and must be in control. The purpose of the maintenance control center is to:
    1. Complete all daily checks on designated aircraft.
    2. Perform transit or turnaround maintenance on aircraft as needed.
    3. Coordinate servicing of these aircraft (food, water, fuel, etc.).
    4. Troubleshoot maintenance problems and schedule repairs (if possible) in the allotted turnaround time or defer maintenance (MEL, CDL, NEF) until a more appropriate time.
    5. Coordinate with various departments—stores/material, engineering, inspection, planning, and other M&E organizations—for assistance in resolving maintenance problems at the home base or outstation.
    6. Coordinate with flight operations for the maintenance, deferral of maintenance, functional check flight (FCF), aircraft ferry permits, whenever the schedule may be impacted.
    7. Track all aircraft during flight to determine their location, maintenance requirements, and status.
    8. Coordinate maintenance at outstations with other airlines or approved third-party contractors as necessary.
    9. Collect log pages of any in-flight engine shutdown (IFSD), bird strikes, lighting strikes, or any emergencies that require an aircraft to return from flight and or any ground interruptions

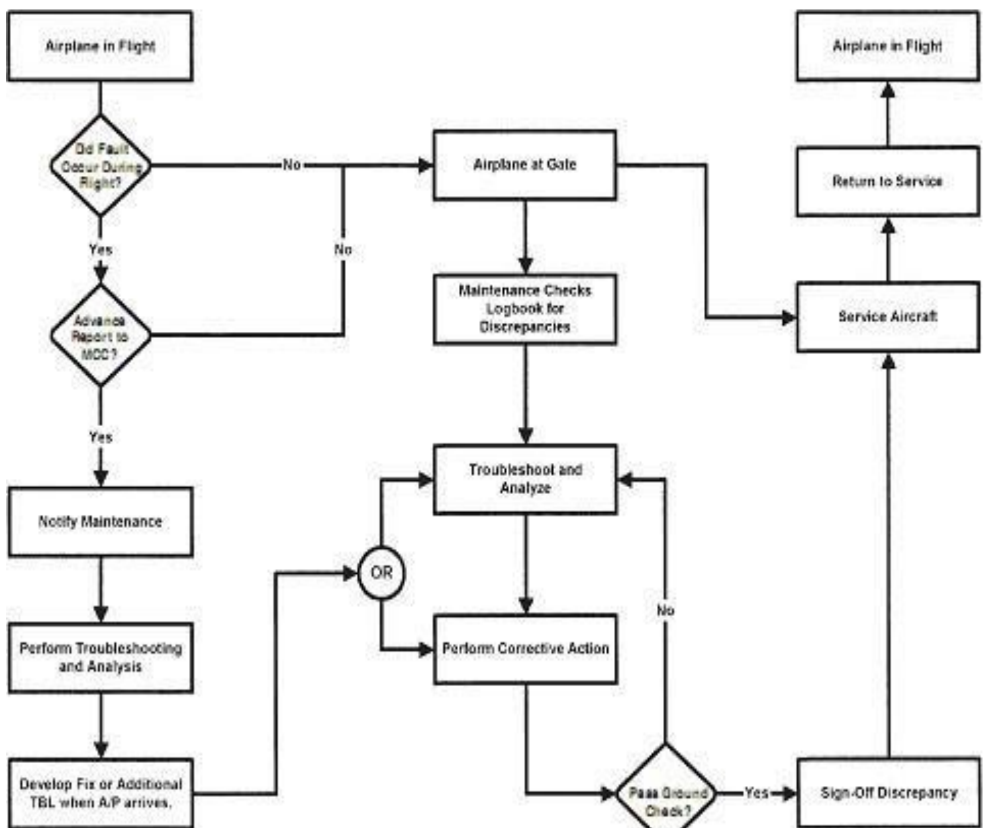
- Needless to say, the personnel in the MCC have quite a large job to perform.
- To do this, they need the right facilities to aid them in the performance of the job. First, they need a centrally located room near the main flight line operations where they can have close contact with all of the activity.
- Second, the MCC should have sufficient tally boards or computer displays of all aircraft (by aircraft type and tail number) to identify flight schedules, flight durations, current location of aircraft, and maintenance needs, if any.
- These boards should also display the status of that maintenance and the due date of the next scheduled maintenance checks (A, B, C, etc.). If these checks are performed only at certain bases, it is the MCC's responsibility to coordinate with flight operations and scheduling to see to it that the aircraft is in the proper place for that check when it comes due.
- The MCC should be "on top" of everything that is happening to all aircraft in service
- Third, the MCC must have sufficient communications devices to carry out all the requirements stated above. That means telephones for internal and external conversations with anyone related to a given problem; radios for communications with aircraft; hand-held radios (or cell phones) for communication with maintenance crews on the line and in

the field not accessible by other communications devices; and teletype, facsimile machines, and/or computer terminals for the transfer of data and forms between the various units.

- To carry out many of the tasks assigned to it, the MCC must have access to maintenance manuals and other technical documents.
- The fourth requirement for the MCC, then, is to have within the facility an extensive technical library. Since the MCC is first to be notified of any maintenance problems, they are the first line of defense and are the ones responsible for effecting a speedy solution.
- They must coordinate with other M&E units to reach that successful completion. The MCC is in charge and is responsible for returning the aircraft to service.
- Finally, the MCC must have sufficient, qualified staff to carry out these activities and the ability to manage quick and accurate responses to any and all problems relating to maintenance of in-service aircraft.
- All MCC staff should be licensed mechanics.
- The MCC plays a very significant role in the effort to meet the goals and objectives of the maintenance and engineering organization, as well as those of the airline.
- The MCC department's primary function, as mentioned previously is to ensure that all aircraft are available for daily flying.
- The MCC also supports the airline's reliability program. The MCC is responsible for identifying and reporting all delays and cancellations of aircraft and must provide the details of all incidents. Since the line maintenance department and its procedures are integral to these delays and cancellations, the MCC is a key player in the investigation and solving of these problems. (Reliability and repeat items,
- The MCC also coordinates, issues, controls, and reviews all maintenance deferred items under the MEL, CDL, and NEF systems. The MCC has the authority to deny or defer any item due to its condition, penalty restriction, or the number of time discrepancy has been repeated.
- For some airlines, repeat discrepancies are categorized in their Ops Spec. Some may specify that the discrepancy or write-up has occurred more than three times in 5 days; other airlines may specify 7 days. If the repeat rates are not specified as part of the Ops Spec, they should be clearly stated in the airline's reliability program document.
- If the problem persists, there must be an error.
- The error could be procedural, mechanical, operational, or pertaining to the maintenance manuals, environmental conditions, or faulty parts from stock.
- Whatever the reason, the MCC does an immediate investigation to determine the problem and solve it. This is an effort to identify and contain the problem without waiting until reliability data confirms it. In all likelihood, a repeat discrepancy will not even show up in the reliability data because if addressed quickly, it will not recur in sufficient numbers to cause a reliability alert.

- **Line Maintenance Operation—General**
- Figure shows the typical flight line activities for a given flight.
- An aircraft may or may not experience any faults or discrepancies during the flight.
- When the aircraft arrives at the gate, normal services (fuel, food, etc.) will be provided, as well as the exchange of passengers, their baggage, and any cargo.

- If a failure or discrepancy did occur in flight, there are two possible scenarios.
- Normally the problem is written up in the aircraft maintenance logbook and addressed by the ground crew upon flight arrival.
- Maintenance actions would be as indicated by the center column blocks of Fig. To minimize delay on the ground, however, it is recommended that advance warning be given to the maintenance personnel by the flight crew through flight operations and the MCC. This allows maintenance to spend time before the aircraft arrives to review past records and troubleshoot the problem. Thus, the actions shown in the left hand column of Fig.are employed. In many cases, the maintenance crew can meet the aircraft with a solution in hand thus minimizing maintenance downtime and delays.
- This may be accomplished by a separate team or the same team that handles any other logbook items. Note that both sign-off of all discrepancies (or deferrals) and servicing of the aircraft must be completed prior to returning the aircraft to flight service.



Line maintenance operations—turnaround.

Aircraft Logbook

- The aircraft logbook is a type of document that is required by the FAA and the airline to document any maintenance discrepancies.
- An aircraft cannot fly to any destination without its logbook neither can an aircraft be taxied to any other location without having the logbook on board.
- The logbook shows if there are any open maintenance discrepancies, and if by moving or starting an aircraft, someone may damage the aircraft or its systems.

- The aircraft maintenance department is responsible for keeping the logbook up to date, which includes recording of such information as total flight hours and cycles when fixing an aircraft's maintenance discrepancy.
- The pilot in command must write such basic information as the names of the flight crew and the flight number, and must sign the logbook accepting the aircraft.
- The logbook contains a section that allows the flight crew to write any maintenance discrepancies found during the preflight check, encounter any maintenance problems while in the air, or discovered during the postflight check.
- The flight crew must write the maintenance discrepancy in the logbook and notify the MCC, so maintenance personnel can address the problem. Depending on the maintenance discrepancy, it may be fixed quickly or it may be deferred under the MEL program.
- Once the MCC and AMT have agreed of the deferral item, the AMT enters the appropriate information in the corrective action box adjacent to the mechanical discrepancy box and signs off with the information and authorization number of the MEL, which was obtained from the MCC.
- When maintenance is completed on the aircraft and the discrepancy is signed off, the AMT will remove the log page copy and forward it to the MCC.
- Some airlines collect log copies at the end of each flight day. The logbook pages are normally duplicate copies but may be in triplicate. Only copies of a logbook page are removed. The original log page always stays with the aircraft until the logbook is full and a new book is installed. The completed logbook is forwarded to the aircraft records department.
- The log pages sent to the MCC are entered into the M&E maintenance database, and the information is used by M&E, QA, QC, and the reliability department for various other actions, ATA verifications, and future references.
- The ACARS (ARINC communication and reporting system) is used to transmit data to the airline home base.
- The ACARS system is a digital datalink used by the flight crew to transmit messages between the aircraft and the maintenance base while in flight. This helps the MCC to evaluate discrepancies and the time needed for repairs.
- The ACARS system is also used to sign off maintenance discrepancy (used as an electronic logbook) depending on the aircraft used and its capabilities.
- The ACARS system is also used in preflight communication and other inte-gral systems, to calculate the weight and balance of aircraft, and to monitor engine trends.

Ramp and Terminal Operations- Transiting aircraft are the subject of a lot of attention at any airport, and that attention is usually concentrated in a short (often 30-minute) time span called the turnaround. During this turnaround, flight handling, servicing, and maintenance chores must be accomplished.

- Although not all these actions would be required at every turnaround, the following sections provide an overview of what might be done.

Flight handling

- The main purpose of flight handling is to move passengers, their baggage, and/or any carried cargo off and on the aircraft as necessary.
- This begins with parking the aircraft at the gate and positioning the air stairs or the gateway ramp and opening the aircraft doors.
- This is a joint effort involving maintenance; ground handling crews, the flight and cabin crews, airline terminal personnel, and the FAA tower personnel responsible for ground control.
- Watching this activity from the passenger lounge, one sees a well-coordinated ballet of workers and machines
- The baggage and cargo loading equipment and crews form a second wave of activity followed by servicing and maintenance activities.
- Servicing consists of refueling, adding potable water, and all the food and beverages for the next flight, as well as removing the trash and other waste materials of the previous one.
- These deferrals must be handled in accordance with MEL requirements and with the pilot in command (PIC), who has final say on whether or not to dispatch the aircraft in such condition.
- If the deferral is not allowed, maintenance must effect repairs at once and, in some cases, take responsibility for a flight delay or cancellation.
- If a delay or cancellation does occur, the MCC must coordinate with flight operations and with the airline's terminal personnel to handle the passengers and, if required, their baggage.

Flight line (preflight and postflight)

The preflight inspection must be accomplished on the aircraft's first flight of the day. Preflight normally contains the recommended sequence and expanded procedures.

- The preflight inspection is normally accomplished by the first officer (copilot) and does
- not require the presence of both crew members.
- Preflight for winter operating conditions are different, and require basic pre-cautions, compliance with special procedures, and attention to detail. Airline pilots are provided specific aircraft winter operating policies and procedures in their flight manuals, which include ground deicing and anti-icing programs.
- The following is an example of the recommended preflight sequence:
- Exterior safety
- Exterior preflight inspection
- Cabin safety inspection
- Flight deck equipment location

Flight deck safety scan

- The exterior, cabin, and flight deck scans are performed in detail with an overall visual observation.
- While performing walk around, the first office pays particular attention to all aircraft surfaces, such as windows, antennas, engine, cowlings, access panels, and emergency exits.

- The equipment hatches not in use are properly closed and secured. If any abnormalities or maintenance discrepancies are noted during the preflight check, the flight crew will send a message via ACARS or the aircraft radio using a preset maintenance frequency and request maintenance via the MCC.
- The postflight inspection must be accomplished after each flight.
- This is intended to detect obvious discrepancies and consists of less tedious check than a preflight inspection.
- In the event the outbound crew meets the incoming crew at the aircraft, the postflight check is not required, since a preflight check will be accomplished by the next outbound crew.
- If there are any maintenance discrepancies found during the postflight check, the crew will report discrepancies to the MCC. Also, it is the departing crew's responsibility to shut off all power, batteries, external power, and oxygen supply after all passengers have been deplaned.

Maintenance Crew Skill Requirements

- It is often thought that, because of the simple nature of the work—turnaround maintenance and servicing—the line maintenance unit can be manned by the newer, less experienced personnel.
- Nothing could be further from the truth.
- The work done by line maintenance covers a broad scope of activity.
- While the shops and hangar can employ specialists who work essentially on one or a few items repeatedly, line personnel need to know the entire aircraft: all of its systems and their interactions.
- Line mechanics have to deal with a different problem, often on a different type of aircraft, each time they are called upon to meet an incoming flight.
- The crews assigned to line maintenance must be well qualified in their profession.
- They should be certified mechanics approved by the regulatory authority and the airline to work on airframe, power plant, and aircraft systems, and they must be certified to sign off maintenance tasks and authorize an aircraft to "return to service."
- The line maintenance crew may also include unlicensed helpers and trainee personnel, but they must work under the supervision of qualified personnel.
- Dedicated QC inspectors may be assigned to the line crews (larger airlines), or line maintenance personnel can be appointed as designated inspectors to address the quality issues as they arise
- The skills required by the line maintenance crews are just as broad-based as the work effort.
- Crews must be familiar with all aircraft types within the airline's fleet.
- They must be familiar with applicable FAA rules and regulations, as well as the airline's policies and procedures that relate to the line maintenance activities.
- General maintenance skills and techniques are a must, but the line maintenance crews must also know what specialists, if any, will be needed to complete a particular job if they cannot handle it themselves.
- Much of this effort, of course, would be handled by the line maintenance supervisor or by the MCC.

- The paperwork includes logbook handling (pilot reports, or PIREPS); task card handling ("A" check and below); engineering orders; repeat items (with MCC); incoming and outgoing deferred maintenance items (DMIs); and any other reports or MCC actions that may occur.
- The makeup of the line crews, the number of shifts, shift length, and scheduling of personnel is dependent on several factors: the size of the airline, the flight schedule, types of aircraft flown (different types often require different skills), and type and amount of work performed. Each airline must decide the most appropriate approach to meet their own needs.

Hangar Maintenance (on-Aircraft)

- Hangar maintenance, whether or not the airline actually has a hangar for such activity, refers to that maintenance which is done on an out-of-service (OTS) air-craft.
- This includes any major maintenance or modification on aircraft that have been temporarily removed from the flight schedule, usually for that express purpose.
- The following types of activities are addressed in hangar maintenance:
    1. Schedule checks ("C" check, "D" check, heavy maintenance visit)
    2. Modification of aircraft airframe or aircraft systems according to service bulletins, airworthiness directives, or engineering orders
    3. Fleet campaign directives
    4. Aircraft engine removal and installation
    5. Aircraft painting
    6. Aircraft interior modifications
    7. Special inspection required by the FAA (i.e., corrosion program)
- Any hangar visit can include various combinations of the preceding activities in order to achieve maintenance objectives and to minimize maintenance down-time. Scheduling of these activities is done by the production planning and control organization with coordination of all involved units.
- The hangar building itself also provides space for numerous support shops, the overhaul shop and ground support equipment, as well as office space for the hangar maintenance management, PP&C, stores and logistics, and administration staff.
- A dock area should be provided to serve as the control center of the hangar maintenance check-in progress. This includes the space where work cards and nonroutine work cards are kept for the purpose of assigning work and signing off various maintenance job tasks.
- This area is also the central point of hangar supervisory and inspection personnel.
- This dock area is to hangar maintenance what the MCC is to line maintenance: the center of activity and control.
- The parts and supplies needed for maintenance being per-formed in the hangar should be stored in a dedicated area as near the aircraft as possible. Separate space should be provided for the items removed from the air-craft and for new items to be installed. All items should be properly tagged.
- Hangar floor layouts and dock spacing are planned according to the fleet type, which may include aircraft with four engines, aircraft with two engines, wide-body aircraft, narrow-body aircraft, and aircraft with differing engine locations.

- The hangar is to accommodate maintenance simultaneously on different types of aircraft. The hangar floor maps and layouts are normally identified in the airline's TPPM. Depending on the airline's operation and the work per-formed, it may require a separate dock and a separate crew to perform different tasks.
- The hangar capabilities and needs from those mentioned are essentially the same:
- (*a*) hangar space must be adequate for the work performed, and
- (*b*) Hangar maintenance must be planned, scheduled, and controlled to ensure that the required work is completed on time.

Organization of Hangar Maintenance

- Hangar maintenance is a manager-level position under the director of aircraft maintenance (DOM).
- Under the DOM is a typical organizational structure with managerial and supervisory positions: aircraft maintenance, GSE, facilities, and support shops.
- The supervisor of aircraft maintenance is responsible for all the hangar maintenance activities.
- He or she controls the flow of aircraft into and out of the check, as well as the maintenance crews working the checks.
- The supervisor of aircraft maintenance coordinates with the overhaul and support shops, materials, production planning and control, flight line maintenance, and flight operations regarding the aircraft in the hangar.
- The supervisor of GSE and facilities are responsible for all ground support equipment used to support the hangar maintenance personnel, as well as the flight line maintenance activity and the building and facilities used by maintenance.
- The supervisor of support shops is responsible for all support activities for aircraft service and maintenance that is not designated as overhaul shops.
- The support shops include those in support of welding, composite material, sheet metal, upholstery, seats, and interior.

Problem Areas in Hangar Maintenance

- There are several areas within the hangar maintenance activity that, at times, may cause some problems. These are discussed below to prepare the reader for the real world of maintenance.

Non routine items

- The basic maintenance checks have task requirements for various inspections, functional checks, and operational checks of the aircraft equipment.
- These are known as routine maintenance items, and they require a fixed amount of time to be accomplished.
- The time requirements are identified in the MPD/OAMP and the estimated items required for completing the job, assuming that all parts, supplies, tooling, equipment, and personnel are available at the aircraft.
- The requirements assume that all work will go smoothly and without any delays or interruptions and that the mechanics will know exactly what to do and how to do it. The airlines usually multiply the estimated time by two or three (more for older aircraft) in order to be more realistic.

- This is usually done by engineering when the maintenance program is developed or by PP&C when the planning is done.
- If things always went according to plan, all the work needed for most checks would be straightforward and maintenance activities would require a fixed amount of time. Nevertheless, many of these routine tasks will reveal problems that must be addressed. The requirements in skills, parts, supplies, and time can vary considerably depending on the nature of the discrepancy found. These are called nonroutine items and, by their nature, they can extend the aircraft downtime needed to accomplish the hangar check.
- It is the responsibility of the hangar maintenance or dock supervisor to adequately estimate the time required for these nonroutine items. It is an ongoing effort for the maintenance crew and management to ensure that these nonroutine items do not cause undue delays.

Parts availability

- One activity that affects maintenance downtime is the time mechanics spend "chasing parts." Again, it is a function of PP&C to determine what parts and supplies will be needed for routine and non routine work as well as for items deferred from other maintenance checks and those parts required by service bulletins, airworthiness directives, and any other work to be incorporated in the scheduled check. Material is responsible for the delivery of parts and supplies to the hangar just-in-time (JIT) for maintenance to use them.
- The hangar management, in turn, must provide a parts staging area in the hangar near the aircraft dock for these parts and supplies to be delivered and stored. This area must be accessible to the work force and at the same time protected from parts robbing or pilferage.
- This area should also provide space for mechanics to drop off any parts removed from the aircraft that are to be repaired or discarded, so that material may properly process them. It is the responsibility of maintenance to ensure that these items are properly tagged. The establishment of this parts staging area and the delivery of parts when needed allow maintenance people to exert their time and effort on the job they were hired to do—maintenance—rather than spend it traipsing around the airport gathering the parts and supplies they need.

The saga of parts robbing

- Parts robbing or cannibalization, as it called in aircraft maintenance, is a necessary evil. We are primarily against the practice but understand its necessity at times.
- This is particularly true if you want to meet the deadlines and goals established for the airline maintenance programs: To deliver an airworthy vehicle to the flight department in time to maintain the flight schedule and to deliver the aircraft with all required maintenance accomplished.
- The quick return of an airplane to service by line maintenance is an admirable achievement, but robbing a part from another aircraft in order to do so often results in the delay of that second aircraft being returned to service. Atypical scenario goes something
- like this:
- Aircraft tail number (TN) 317 is in transit (30-minute turnaround) and will require a part that is not available in stores due to a maintenance discrepancy. To avoid the delay or cancellation of TN 317's scheduled flight, the needed part is taken from TN 324, which is in the hangar undergoing a "C" check. Thus, TN 317 is returned to service without

incurring a delay and flight operations, line maintenance, the airline business office, and the passengers are all happy, but what about hangar maintenance?

- The rules regarding parts robbing are established in the aircraft TPPM or an airline's aircraft operations manual.
- The policies do specify
- (*a*) cannibalization of parts should only be practiced in absolute necessity,
- (*b*) parts must be ordered through stores and material, and
- (*c*) robbing parts should only be done with the consent of management.

Hangar Maintenance Activity—A Typical "C" Check

- The content of a "C" check will vary from one airline to another, from one air-craft to another, and even from one check to another for the same aircraft or type.
- The discussion that follows is typical and, for convenience, is divided into several stages, which, in reality, may overlap or even fuse together.
- For this illustration, we will break the typical check into five sections:
- (1) preparation;
- (2) preliminary activities;
- (3) conduct of the check;
- (4) completion and sign-off; and
- (5) Return to service.

Preparation for "C" check

- We have already discussed the preliminary activities of engineering ,production planning and control , and the M&E planning meeting ,so these will not be repeated here.
- To begin the actual check, the hangar maintenance organization must prepare for receipt of the aircraft and for the logistics and management of the check.
- The hangar is cleaned; space is cleared for the aircraft; stands, scaffolding, and other equipment needed are brought into the hangar for immediate use or made available for later use.
- The parts storage area is stocked with parts and supplies needed for the work to be performed. This, of course, is an ongoing process throughout the check. The parts and
- supplies will be delivered "as needed" or just-in-time.
- In the dock area, where administration and management of the check takes place, a large wall rack with pockets is populated with all routine task cards as required by the maintenance program and the particular check to be per-formed.
- There is a row for the cards of each work center (avionics, hydraulics, etc.) and two marked-off areas to separate the completed cards from those still to be worked. Work crews are available or on standby waiting for the arrival of the aircraft.

Preliminary "C" check activities

- The first order of business, usually, is to wash the aircraft. The vehicle is towed by ground crews, with appropriate "wing walkers" and communications gear for safety, to the wash rack area for a thorough cleaning.
- After washing is done, the aircraft is towed to the hangar where it is parked and chocked; now the work begins. Panels and cowlings are opened and visual inspections are conducted. Any discrepancies found at this time will require nonroutine work cards. These cards are generated by QC and are placed in the card rack for later accomplishment with other work cards. Next, or in conjunction with the inspections, the stands and scaffolding (as needed) will be placed around the aircraft to allow access to work areas

during the check. Any ground power, pneumatic, or hydraulic carts, as well as any special tools and test equipment needed for the scheduled tasks, will also be put into place.

Conduction of the "C" check

- Mechanics are assigned to tasks according to the check schedule produced by PP&C in an efficient manner.
- The work to be done in any given area by more than one work center is scheduled in sequence to avoid congestion in the work area and to minimize the opening and closing of panels, cowlings, etc.
- Any non-routine items generated during normal work will be written on nonroutine cards and worked or scheduled for work at a later time. Most units produce a PERT chart or some other form of visual aid showing the planned work schedule. This chart is updated, or annotated, as necessary during the check to accommodate the nonroutine work or any
- other delays or schedule adjustments that may be encountered.
- Requests for additional parts and/or supplies not in the original plan, or for parts and supplies not yet delivered to the work site, will be relayed to material by the dock staff. Material will deliver these items to the parts staging area to eliminate parts chasing by
- mechanics.
- Quality control inspectors will reinspect any items previously rejected and approve the work. Any delays in the check schedule, especially those affecting return to service, will be coordinated with the MCC and flight operations by the dock manager.
- If all goes well, the "C" check will be completed on time and the aircraft will come out of check "clean," i.e., all required tasks completed with no deferred maintenance items.

Completion and sign-off of the "C" check

- Although the maintenance work is the key part of the effort, the check is not really complete until it has been assured that all task cards—routine and non-routine—have been completed, signed off, and where required, inspected, stamped, and approved by quality control.
- That includes all rejected work and the subsequent rework and buyback actions. The person responsible for this activity is the senior QC inspector assigned to the check.
- He or she must review every work card for mechanics' signatures or initials as required, indicating accomplishment and completion of the task and for QC stamps (and initials) for any work where QC inspection is required.
- Any discrepancies noted at this time must be corrected even if it requires further work and inspection. When all work cards have been completed, signed off, and accepted QC signs off the check as complete and releases the aircraft out of check, ready for service.

Return to service

- Once QC has signed off the check, the dock manager notifies MCC and flight operations of the availability of the aircraft.
- The aircraft is then towed from the hangar to the ramp by maintenance, and Flight Ops returns the aircraft to the active flight schedule. Ground crews service the vehicle (fuel, food, etc.), and cabin crews ready the aircraft for passengers.

Morning Meetings

- One of the most important activities of the M&E operation is the morning meeting. This is held first thing each morning and is conducted by maintenance control center (MCC) to address current maintenance status:
- Aircraft out of service with maintenance status throughout airline's system (hangar and line maintenance)
- Aircraft AOG situation and resolutions
- The day's flight schedule
- Any significant issues or changes in maintenance that may affect the day's flight and maintenance work schedule
- During this morning meeting, maintenance personnel may also discuss (or there may be a separate meeting on) upcoming hangar and shop maintenance activities and problems.
- There is another meeting following the morning MCC aircraft maintenance situation meeting, where daily maintenance planning is discussed, including the aircraft routing due to required maintenance and requirements for logistics and tooling which may be needed.
- The purpose of these meetings is to enable M&E managers and supervisors to keep abreast of everything that is going on in the maintenance area and quickly address any problems that may arise.

- **Hangar maintenance support and overhaul shops (off-aircraft)**
- Hangar maintenance and overhaul shops are a vital part of the hangar operation. These shops are designed to help and support heavy aircraft maintenance checks ("C" and "D" checks) and consist of various specialties.
- The employees in these support shops require special skills for the work they perform. They do not require an FAA license as do those who work in the overhaul shops, who are required to have either an A&P license or a FAA repairman certificate.
- The support shop work can be performed on the aircraft or off the aircraft, depending on the work discrepancy. Due to the nature of some repairs, these heavy tasks are done while the aircraft is out of service for a length of time. Thus, support and overhaul shops are part of the hangar maintenance function.
- Hangar support and overhaul shops consist of various specialties. They perform work to refurbish or repair aircraft panels, surfaces, and aircraft engine cowlings (sheet metal or composite) material.
- They also have an interior shop for repair, modification, and refurbishment of aircraft interiors; repair and modification of passenger and crew seats; and aircraft painting. The shops associated with hangar activity would be those working in welding (gas, electric,
- and heliarc).
- The work performed by these shops is not directly a part of the scheduled maintenance program, and it is not specified in the MRB document or the air-line Ops Spec as routine or nonroutine maintenance, but work will be required on the various components mentioned above from time to time, either by non-routine work card or by SB, AD, or an EO. Some airlines may also perform work in these support shops for other airlines or fixed-base operators to generate revenue.

Support and Overhaul Shops Organization

- The manager of the overhaul shop is responsible for overall management and administration of maintenance support and overhaul shops.
- With the aid of shop supervisors, managers oversee and manage overhaul, repair, and maintenance of components and equipment removed from the aircraft for maintenance.
- This maintenance can be anything from simple cleaning and adjustment to complete overhaul.
- Shop maintenance is normally done on an out-of-service basis: equipment is removed from the aircraft and replaced with a serviceable unit by the line or hangar maintenance personnel.
- The removed unit, properly tagged as to maintenance status, is then sent to stores and material, where it is either discarded according to standard maintenance procedures or routed to the appropriate shop for repair.
- This would include the airline's shop or an approved component repair contractor.
- Units under warranty would be sent to the manufacturer or to the designated warranty repair facility by material. Upon completion of such repair, the unit is returned to material with a serviceable tag then returned to stores for future use as required.
- On certain occasions, determined by the airline and the circumstances, a unit may be removed from an aircraft by the line or hangar maintenance personnel, sent to the appropriate shop for repair, and returned to the aircraft for reinstallation.

Types of Shops

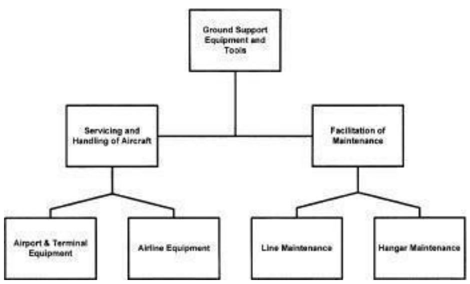
- There are two types of shop maintenance activities in an airline maintenance organization. One type is the shop function that is related to hangar maintenance on aircraft in heavy check. These support shops include such special skills and activities as working with sheet metal, composite material, and air-craft interiors. The work they do is primarily in support of out of service aircraft, although some support is given to line
- maintenance as needed.
- The other types of maintenance support and overhaul shops involve support for the specialized equipment on the aircraft, such as engines, avionics, and hydraulic and pneumatic systems. The work performed in these shops is on equipment that has been removed from the aircraft during line or hangar maintenance operations.

- **Sheet metal shop, Aircraft interior shop, Engine shop, Avionics shop (explain) text book page numbers 171 -173, Ground Support Equipment Shop (GSE)**

Ground Support Equipment

- Modern commercial aircraft require a considerable amount of tools and equipment to support the maintenance and operations activities.
- In addition to the tools and test sets used by mechanics and technicians for normal maintenance, there is a vast array of equipment that comes under the special heading of ground support equipment.

- There are also special tools and jigs for maintenance activities that are designed for one type of aircraft only; other special tools and jigs are usable on several types of aircraft.
- Ground support equipment is defined as “that equipment required to support the operation and maintenance of the aircraft and all its airborne equipment.
- This GSE includes an extensive variety of equipment ranging from simple jacks and stands to million dollar towbarless towing vehicles. For the sake of discussion, we can divide GSE into two broad categories:
- (*a*) equipment to support the servicing and handling of operational aircraft while engaged in flight turnaround and ground movement activities; and
- (*b*) equipment used to facilitate maintenance whether at turnaround or during scheduled or unscheduled downtime



Ground support equipment categories.

- The first category, servicing and handling equipment, can be further divided into GSE that is owned and operated by the airport authority or terminal operator and that owned by the airline itself.
- The second category, maintenance equipment, includes equipment that may be used on the flight line, in the hangar, or shared by both activities.
- This breakdown is shown in Fig-above.
- Table below is a list of typical ground support equipment used for handling, servicing, and maintaining aircraft.
- The table identifies typical ownership and usage of the GSE.

Name of GSE item	Airport owned	Airline owned	Usage (L, H, B)*	Handling & servicing	Maintenance
Air start units	X	L	X		
APU cradles	X	B		X	
Axle jacks	X	B		X	
Baggage carts	X	L	X		
Baggage loaders (at A/C)		X	L	X	
Battery charging equipment		X	B		X
Boarding wheelchairs		X	L	X	
Cargo container/pallet handling		X	L	X	
Cargo trailers	X	L	X		
Communications equipment		X	B	X	X
Deicing equipment (motorized & stationary)	X		L	X	
Diesel powered ground power units		X	B	X	X
Fixed jacks	X	B		X	
Hydraulic oil fill carts & couplings		X	B		X
Hydraulic test carts		X	B		X
Lavatory service components		X	B	X	
Lifting equipment: cranes & platforms		X	B		X
Nitrogen servicing equipment		X	B		X
Oxygen servicing equipment		X	B		X
Passenger loading bridges	X		L	X	
Passenger loading stairs (powered & unpowered)	X	X	L	X	
Pneumatic air start units, couplings & accessories		X	B	X	X
Potable water service components		X	B	X	
Power supplies: 28 vdc & 400 Hertz		X	B	X	X
Recovery jacks	X	L		X	
Refueling trucks X	X	L	X		
Snow removal equipment (ramp & runway)	X		L	X	
Specialized maintenance tools		X	B		X
Stands and scaffolding (many variations)		X	B	X	X
Thrust reverser dollies		X	B		X
Towbarless A/C handling tractors	X	X	L	X	X
Towbars	X	L	X	X	
Towing tractors (gas, diesel, electric)	X	X	B	X	X
Variable jacks	X	B		X	
Weigh systems	X	L		X	
Wheel and tire build-up fixtures		X	B		X
Wheel and tire dollies		X	B		X
Wheel chocks	X	B	X	X	

List of Ground Support Equipment (GSE) Items **Page number – 176 from text book (refer the table given above)**

- To maximize in-service reliability and profitability, operators must procure GSE and tooling appropriate for their aircraft when a new model is being incorporated into the fleet. Tugs, tows, towbars, and other special tools and fixtures are sometimes mated to specific aircraft models.
- Other GSE and tooling can be used on more than one type of aircraft.
- The GSE and facilities organization must work with engineering at the outset, whenever the purchase or lease of new aircraft is considered, to determine what existing equipment and tools (if any) can be used with the new model and to determine what additional equipment and tools must be ordered specifically for the new model.
- This activity should be done at least 9 to 12 months prior to delivery of the first aircraft so that these tools and equipment will be available when the aircraft arrives.
- Selection of GSE and tooling is related to a number of variables:
- (*a*) the type and level of maintenance to be performed by the airline;
- (*b*) the number of line stations to be supported (multiple units may be required);
- (*c*) the number of ramp operations to be accommodated (individual or simultaneous use requirements);
- (*d*) the extent of overhaul work to be done by the operator; and
- (*e*) Coordination with other units for borrowed equipment or contract work to be done (by or for your airline).
- Because of the complexity and variety of this equipment, it is usually handled by a separate maintenance activity within the airline.
- For small to midsized airlines, the GSE is handled by a group attached to the hangar maintenance organization and is often housed in the same hangar as other overhaul and sup-port shops.
- In larger airlines, GSE may have a separate manager or director under M&E and may be housed in its own hangar.
- Because of the size and quantity of ground support equipment, it is often stored outside the hangar in a designated area on the ramp near the operator's facilities.
- Some smaller equipment would be stored in the hangar. Special tools and fixtures may be
- stored in the hangar tool shed.
- The GSE and facilities group in our typical midsized airline is also responsible for general maintenance and upkeep of all GSE, as well as the general maintenance and upkeep of all buildings and facilities used by the M&E organization.

Mechanical shops

- The mechanical component shop can also be separated or combined depending upon airline size and requirements.
- These shops would include hydraulic systems and components, pneumatic systems and components (heat, air), oxygen systems, and flight control surfaces. The battery shop is also part of the mechanical shop, where maintenance personnel repair, store, and charge aircraft batteries.

- The wheel, tire, and brake shop has responsibility for various actions relating to the aircraft:
- (*a*) the repair, assembly, and disassembly of aircraft wheels;
- (*b*) the repair, servicing, and retreading of aircraft tires; and
- (*c*) Adjustment and placement of aircraft brakes.
- Again, these activities may be performed in one or several shops depending on the amount of work and the complexity of the fleet.

Outsourcing of Shop Maintenance Work

- As with line and hangar maintenance, some or all of the shop maintenance at a given airline can be outsourced to other airlines or to third-party maintenance organizations.
- In the case of partial outsourcing, the director of overhaul shops is responsible for coordinating these activities into the overall airline maintenance plan.
- If all shop maintenance is done by outside con-tractors, the overhaul shops directorate would not exist at the airline.
- However, to ensure that work is done within the airline's schedule and maintenance plan, someone in the aircraft maintenance directorate of the M&E organization must be designated as the overhaul shop maintenance coordinator.

Operation of Overhaul Shops

- Work on a flight line is hectic at times and subject to flight schedules, maintenance emergencies, foul weather, and the ever-irritating "time limitations."
- Hangar work may be less hectic with more time to accomplish each job, but there is still a time limitation and other pressures. In shop maintenance, however, the pressures of time and schedule are somewhat lessened by the nature of the shop operation.
- Items come in for servicing, repair, or overhaul and are addressed, usually by specialists in the type of equipment or system involved. Some of the basic troubleshooting has already been done to indicate such-and-such a unit is bad and has to be replaced. This done, the mechanic turns the errant item into material and draws a good one for installation.
- Material, then, sends the properly tagged incoming unit to the appropriate shop. The shop mechanic or technician then uses his or her standard bench check procedures to determine the problem, make the necessary repairs, and perform some check to ensure that the job has been completed successfully.
- Once maintenance is completed and the proper paperwork filled out and attached, the
- serviceable unit is sent back to material for placement in stores for reissue when needed.
- Each maintenance shop will have a work area and a storage area with adequate separation of serviceable, unserviceable, and discarded units. Usually there will be a spare parts area, maintained by material, for the small parts needed for work. Again, proximity of these areas to the work area minimizes the time a mechanic spends in "parts chasing." Of course, each shop will be equipped with the necessary tools, work benches, test stands, and test equipment for the type of equipment to be worked on.
- The overhaul shops generally work a standard shift, with or without overtime; night shift and weekend work depends on the airline and its workload.
- The pace may be slower than on line or in hangar, but short turnaround for maintenance or mean time to repair (MTTR), is still important.

- The number of items held in stock is based not only on the failure rate for the fleet, but also on the amount of time it takes to pass the repairable item through maintenance.
- The sequence goes like this: (*a*) remove unit from the aircraft; (*b*) send the unit to material for replacement; (*c*) route unit to the repair facility (in-house or third party); (*d*) return serviceable unit to stores for reissue.

Shop Data Collection

- The airline's maintenance reliability program, discussed in detail in Chap. 18, involves many data collection tasks throughout the M&E activity.
- One very important source of such data is the overhaul shops.
- While flight line and hangar reports provide information on systems and components, the shop data provide useful information on internal components of equipment and subsystems that contribute to the on-aircraft failures and write-ups.
- These shop data collection efforts are submitted through shop tear-down reports that identify servicing, repair, and overhaul actions taken, as well as the parts and supplies used in that maintenance work. These components are then tracked by reliability to determine if there is an unnecessarily high failure rate that should be of concern to the airline or the equipment manufacturer.

Material Support

Organization and Function of Material

- Material is one of the key units within an airline's maintenance and engineering organization.
- It is the one that spends the most money and is, therefore, under scrutiny by the airline's higher management as well as the M&E management.
- The high-level concern for operating costs is at the root of one rather prominent controversy in the M&E area.
- Mechanics, engineers, and technical management in M&E are aware of the changing requirements of aging equipment and the increasing need for spare parts with age. These working experts are also aware, from experience, of what constitutes a reasonable substitute for a given part and what does not, even though the specifications for both units are within limits. The past expe-riences of these people are more conducive to addressing the goals of M&E than the experience of the finance and administration people.
- Our recommendation, then, is that the material support effort be an integral part of the maintenance and engineering organization with oversight by account-ing and finance for expenditures.
- The functions of material. Briefly, these are (*a*) to provide parts and supplies for all aspects of the M&E operation; (*b*) to maintain adequate supplies of these items on hand and in convenient locations for quick access by maintenance; and (*c*) to provide adequate support to the maintenance organization within reasonable budget constraints.

Material Management

- Material, inventory, stores, and logistics management's primary function is to understand the logistics and scope of aviation inventory management.
- These responsibilities include concerns about replenishment of stored parts, cost of inventory, forecasting of new and in-house available inventory, realistic and physical space of the inventory, replenishment of minimum and maximum, repair parts, returns and defective parts, bogus parts, knowing the supply network and its demands, and the ongoing process of utilizing aircraft parts.
- Material and other items needed on a daily basis require a sophisticated maintenance support operation.
- Stores management has continuous contact with the aircraft manufacturer; parts overhaul vendors, aircraft part suppliers, and vendors of hardware and software.
- They determine the inventory needed based on fleet size, parts utilization, parts reliability, and a vendor's repair capability and turnaround time.
- The managers set targets and goals that are normally achievable to balance the need for product availability. Material management positions may vary depending on the airline's operations.
- We will briefly describe the areas of inventory control, stores, purchasing, and shipping and receiving

Inventory control

- Inventory control refers to a continual effort to supervise the supply, storage, and accessibility of aircraft parts.
- It is the inventory control's responsibility to ensure that all necessary parts and supplies are on hand and available at selected locations throughout M&E.
- Their purpose is to support all maintenance activities by having an adequate supply of parts and parts storage, not being over- or undersupplied, and avoiding any aircraft on the ground (AOG).
- Inventory control also monitors raw stock material, monitors components repair orders in progress, keeps an accurate count of stock onsite, and assures the availability of airworthy parts.

  The monitoring of the inventory system helps to keep costs low, which means that when the supply of a part goes to its minimum target the part is ordered before it drops to a critical level if AOG will cost more than the normal price of the part.
- The airline's logistic management and inventory control strives very hard to maintain a good balance since aircraft parts are expensive.

Stores

- Stores is responsible for issuing parts to and exchanging parts with the mechanics.
- Stores is also responsible for delivering parts to the work centers as necessary and ensuring that parts and supplies that require special storage and handling are properly managed.
- Stores also routes repairable units to the appropriate maintenance shop.

Purchasing

- Purchasing is responsible for the procurement of all parts and supplies used by M&E.
- They deal mainly with suppliers and manufacturers, attending to such things as specifications, costs, delivery, etc.

- Essentially, purchasing has primary budget control in material and works closely with
- finance on expenditures and budget matters.
- Purchasing and inventory control work together to avoid AOG situations because the part(s) purchased in the AOG situation will be expensive.
- The purchasing and stores departments work together on aircraft parts purchases, warranty, and modifications (discussed later in this chapter) due to cost and budgets.

Shipping and receiving

- The shipping and receiving area is one of the busiest places in aviation stores and logistics; not only do stores receive parts for themselves and for maintenance; they also receive courier deliveries for the entire airline operation located at a main hub.
- Shipping and receiving normally handle all packing and unpacking of parts and supplies coming into and out of the airline.
- They also maintain the ability to handle any inspections that might be needed relative to the shipment or receipt of goods.
- Shipping and receiving require qualified personnel and management since they also send and receive dangerous goods.
- It is their responsibility to make sure that the container in which dangerous goods will be shipped is sufficient and the paperwork is filled out correctly according to the company's dangerous goods policy.
- They must know the segregation process for items such as flammable, corrosive, and temperature-sensitive items as required by the manufacturer's material safety data sheet
- (MSDS).
- The material organization varies depending on the airline's structure, size, and the availability of qualified personnel.
- Some activities may be combined for departmental convenience.
- In the following sections, we will discuss various functions of the material organization.

Support Functions of Material

- These support functions can be stated briefly as (*a*) ordering; (*b*) storing; (*c*) issuing; (*d*) controlling; and (*e*) handling of parts and supplies.
- The first four involve mainly parts and supplies, while the last (handling) involves the movement of parts between the various facilities concerned.
- We will address these items separately.

Parts ordering

- Ordering of parts includes the initial provisioning when new equipment and systems become part of the fleet.
- It also includes reordering whenever supplies on hand drop below a certain level (more on this later). The initial provisioning is established at the outset by a recommended spare parts list prepared by the air-frame manufacturer.
- This list is based on the manufacturer's recommendations and on fleet-wide experience of those airlines already using the equipment in similar operations.
- Based on initial provisioning and on the airline's ongoing experience after entering service with the model, changes in the stock levels and quantities held will be inevitable.

- The components on hand and the quantity needed for day-to-day operation is determined by a number of variables, and these will differ from one operation to the next.
- The flight schedule—number of hours and cycles flown, stage length, flight environment—as well as the number of aircraft in the fleet, affect the usage rate of components and thus the number of parts needed in stock to support the maintenance and operations.
- The location of where maintenance is done may also affect stock levels in that extra parts and supplies may be needed at several line stations to facilitate maintenance.

Parts storage

- Storing of parts is the next material function to consider.
- There are two concepts here:
- (*a*) putting every part where it can readily be located and issued when needed; and
- (*b*) storing certain parts under specified conditions.
- The latter category includes proper storage of fuels, lubricants, paints, oils, and other flammable or perishable items. Oxygen bottles and the tools used on oxygen systems require special handling and storage.
- All of this proper storage is a material function.
- The basic or standard storage arrangement is the traditional array of storage shelves or bins, marked by a coordinate system so that every part has a location and each location is easily found.
- This, most often, is a "row-shelf-bin" locator grid of the operator's choosing. For example, part number 1234-5678-C could be located in D-2-14; i.e., row D, shelf 2, bin number 14. Here the rows of shelves are lettered: "A, B, C ...." The shelves, numbered
- from top to bottom, are
- "1, 2, 3.... " And finally, each bin (on each shelf) is numbered consecutively from
- left to right: "1, 2, 3.... " Any similar system can be used.
- This location system might be further stratified by aircraft model.
- While many components, subassemblies, and units may be used on several model air-craft, many are unique to one model.
- Most airlines with mixed fleets have separate parts bins for each model to allow separate cost information to be kept by model.
- Any need to issue a part from one model's stores for use on another model will be handled through the paperwork process by material personnel.
- This would include computer records to show availability and location of parts.
- Additional storage facilities would be necessary for specific operations.
- To facilitate maintenance and minimize the time required by maintenance for parts chasing, for example, spare parts could be available at line stations to support limited maintenance in addition to the normal turnaround maintenance.
- Stores facility areas are subdivided into sections for the convenience of stores personnel:
- Quarantine area
- Flammable, hazmat, and refrigeration area

- Serviceable, nonserviceable, and red-tag parts area Parts issue and
- return area
- Parts receiving inspection area

Parts issue

- Issuing parts to mechanics is another major function of material.
- Items such as bolts, nuts, and other common hardware are better stored in open, accessible bins near the work location so that the mechanics have easy access.
- For other items, such as black boxes, assemblies, and other major items, it is better for all concerned to have "parts windows" or other facilities where material personnel can issue parts to mechanics, as needed, and attend to the proper handling of the parts tags and other important paper and computer work.
- Some of these parts, of course, are repairable and the mechanic is required to "give one to get one."
- This exchange is handled by the material control clerk who also ensures that the maintenance tags on both units are properly filled out (by the mechanic) and that the unit turned in is routed to the appropriate repair facility for rework.
- For those items that are not repairable, material is responsible for discarding the unit.
- This parts issue window should be as close to the work center as possible to minimize parts chasing time for mechanics.
- In some airlines, the necessary parts can be ordered through a computer terminal at the work site and delivered to the mechanic by material.
- No matter what method of issue is used, it is the responsibility of material to update the computer "quantity on hand" information each time a part is drawn or exchanged.
- In the case of repairable parts, material (through the computer) must also keep track of where the part is at all times (shop, stores, in transit, on aircraft).
- Another useful service offered by material is the buildup of kits for certain maintenance actions. To remove and replace some items, certain hardware is needed in addition to the primary unit and its accessories.
- Very often removed hardware, "O" rings, gaskets, and the like, are not reusable.
- Some airlines aid their line station maintenance activities by maintaining fly-away kits (FAKs) on board the aircraft.
- These kits contain items that might likely be needed for turnaround maintenance and servicing at stations where maintenance crews are available but such supplies are not.
- Items such as tires, engine oil, and other common components may be included.
- The purpose of the FAK is to provide these items when needed, but the extra weight on board the aircraft may be a limiting factor on how much is carried.
- The units carried in the FAK should be based on past experience of the aircraft's out-of-service history and some of minimum equipment list (MEL) parts requirements due to maintenance.
- The FAK content list documents the parts inside the FAK and is monitored by the aircraft maintenance department.
- In addition to monitoring the content of the FAK, material must be replaced to ensure that a complete kit is always on board the aircraft. Monitoring the FAK should be part of the

task card bundle when the aircraft is sent for an "A" check and for every subsequent "A" check afterward.

- There should be a log associated with the FAK to identify missing content or pending orders and usage of the part.

Parts control

- Controlling parts cover a variety of activities.
- We have already mentioned identification of storage locations for all parts and the need for tracking certain components such as repairables through their processing.
- We have also mentioned the need for material to deliver parts and supplies to maintenance work centers to minimize or eliminate the time spent by maintenance personnel in parts chasing.
- Additional personnel in material for this purpose are a great help to the maintenance effort.
- It is also necessary to track flight hours, flight cycles, calendar time, and location of parts that are designated as "time-limited" parts.
- These are serial-numbered parts that require removal from service before a specified interval has elapsed. These parts accrue time or cycles only while in service.
- Therefore, the aircraft on which they are mounted must be known, and its time and/or cycles must be tallied against the part. If the component is removed before its time limit is reached, it can be repaired, restored, or completely overhauled as necessary with or without zeroing out the time
- One of the parts control processes employed by many airlines is the "parts quarantine" area.
- This area is used to separate parts removed from aircraft until it can be determined if repair is necessary or if a unit can be returned to stores for reissue.
- If the replacement part fixes the problem, it is assumed that the part in quarantine is in need of repair and material routes it to the appropriate repair facility.
- If the replacement unit does not resolve the problem, then the one in quarantine is assumed to be okay and is returned to stores.
- This is not always the best approach, however. Some airlines will return the quarantined
- part to the shop for checkout before returning it to stores to ensure serviceability.
- This quarantine activity is an integral part of troubleshooting and should be monitored by QA and reliability to determine if the troubleshooting skills of maintenance personnel are in question.

Parts handling

- Handling of parts and supplies is sometimes referred to as "shipping and receiving."
- However, this latter term does not tell the whole story.
- Handling begins with receipt of parts and supplies and involves, in some cases, an incoming inspection by quality control to ensure that the part is the correct one: part number, serial number if applicable, modification status, serviceability, expiration date (if applicable), and so forth. Physical condition is also examined.
- This can be done by QC or by someone in material designated by QC to perform such inspections.

- After receipt and incoming inspection, the parts are distributed to the proper place—stores, hangar, line, shops, etc.—and computer records are updated accordingly.
- During day-to-day operations, material is issuing parts to mechanics and, in some cases, accepting an exchange part.
- This exchange requires that material, upon checking for proper tagging by the mechanic, route the part to the appropriate shop, vendor, or contractor for repairs.
- Upon return of the repaired part, material will check the tag for correctness, update the computer record, and route the part to stores.
- One function that comes under this topic of handling of parts, a rather important financial consideration that airlines sometimes overlook, is the handling of warranty repairs.
- It is a fact that many aircraft components are expensive and that maintenance costs are also high.
- If parts are shipped out for warranty repair, they sometimes incur longer lead times before being returned to stores. In this case, the airline has two options.
- The usual one is to increase the stock level or reorder point in order to accommodate this extension.
- In some cases, however, airlines that have the capability to do the repair work enter into a contract with the warranty holder to perform the repair work themselves.
- This not only reduces the processing time, but it also provides the airline with additional revenue for the contract work.

Other Material Functions (also _refer from the text book from page 189-193

UNIT – V

OVERSIGHT FUNCTIONS, ART & SCIENCE OF TROUBLE SHOOTING

Quality Assurance

Requirement for Quality Assurance (QA)

- For each type of aircraft flown, the airline must generate the operations specifications (Ops Specs) that establish, among other things, the maintenance and inspection programs to be used to keep the aircraft in an airworthy condition.
- This is referred to as the continuous airworthiness maintenance program or CAMP and is defined in the operator's Ops Specs.
- The Ops Specs is approved by the FAA, but it is not enough to ensure that such programs are effective. Federal Aviation Regulation (FAR) 121.373 (Continuing Analysis and Surveillance) pro-vides an additional requirement. Paragraph (a) of 121.373 reads as follows:
- Each certificate holder shall establish and maintain a system for the continuing analysis and surveillance of the performance and effectiveness of its inspection pro-gram and the program covering other maintenance, preventive maintenance, and alterations and for the correction of any deficiency in those programs, regardless of whether those programs are carried out by the certificate holder or another person.

- The functions of QA are (*a*) the administration and management of QA and CASS activities; (*b*) the conduction of QA audits of all M&E organizations; (*c*) the maintenance of technical records; and (*d*) liaison with the regulatory authority for all M&E functions.

Quality Audits

- In support of the FAR 121.373 requirements (i.e., CASS), a quality audit should be performed on each and every unit within the M&E organization.
- Generally, this would be done on a yearly basis, but other schedules (more or less often) may be appropriate for certain areas.
- This audit should be a detailed, fact-finding effort designed to look at all aspects of the operation, determine any discrepancies, and establish a corrective action with a finite time for correction of each such discrepancy.
- This means the auditor, or audit team if one is required, will look at administrative and supervisory aspects of the operation being audited as well as the performance of work.
- In relation to work performance, they will look at (*a*) the adequacy of tools, test equipment, and facilities; (*b*) the competency of assigned personnel (licenses, training, skills, and skill levels, etc.); (*c*) shop and office orderliness; and (*d*) the use and handling of tools, parts, supplies, and paperwork.
- The following is a sample, but not exhaustive, list of airline activities that should be audited.
  - Processes and procedures related to line, hangar, and shop maintenance: logbooks; completed checks; conduct of transit, daily, and 48-hour maintenance checks; handling of deferred maintenance; fueling activities; quality control inspections; procedures related to work transfer at shift change; and procurement of parts and supplies.
  - Processes and procedures related to material: receiving, storing, labeling, and handling of parts and supplies, including high-value, time-limited, and flammable items; tracking of time-limited parts; processing of warranty claims; establishment and replenishing of fly-away kits; hangar, line, and outstation parts allocations.
  - Processes and procedures related to engineering: development of maintenance program; investigation of problem areas; establishment of policies and procedures; procedures for the evaluation of service bulletins, service letters, and airworthiness directives.
  - Processes and procedures related to training of maintenance and inspection personnel in the use of computing systems, manuals, documentation, tech-nical libraries, and safety equipment.
- These quality audits should be performed on each M&E organization by the supervisor of quality audits and his or her staff once per year.
- A schedule should be prepared in advance of each calendar year showing approximate dates and subject of each audit.
- This is not an attempt to “catch” someone doing wrong. The purpose is to review current operations and ensure that deficiencies are corrected.
- However, spot checks or surprise audits could be implemented if the situation calls for it.
- Audits should be standardized.

- Although specific areas of investigation would vary from one audit to another, as can be seen in Table 16-1(refer the table from text book --- page number 199) , there are certain items that are common to many organizations. Standard forms should be developed with specific areas of interest noted for each unit audited.
- The supervisor of quality audits is also responsible for auditing all outside organizations that have dealings with M&E.
- This includes parts suppliers, parts pools, third-party maintenance organizations, and other contractors.
- This is not just a cursory approval of an organization that has already received approval by its own regulatory authority or that airline's QA department.
- The quality audits performed by your airline must ensure that the work performed by these con-tractors is in compliance with your airline and your regulatory requirements, no matter how similar or different they may be from the contractor's.
- Certain other types of audits can be performed either on a yearly or on an as necessary basis. These are audits of certain processes, procedures, or functions, which may span two or more organizations or activities within M&E. Each organization involved would be audited for their part in the larger process, procedure, or function without a full audit of their organization (unless that is deemed necessary due to these or other findings). These audits include the following:

- Ramp operations. All line maintenance and support functions related to activities in the airport ramp and gate areas. This would include parking, taxiing, refueling, aircraft servicing, loading and unloading (passengers, cargo, etc.), and turnaround maintenance. Such an audit might be performed in conjunction with a problem concerning delays and cancellations or with terminal operations in general.
- Airplane tire pressures. The process for checking and adjusting tire pressures (inspection techniques, use of nitrogen, etc.) throughout the fleet might be audited. This would include all model aircraft, all stations where such work is likely to be done, and the crews involved.
- Shop records. Although this subject would normally be part of a standard audit for any unit where records are kept, situations may arise that require an audit of the record keeping process airline-wide. New procedures, new computer processes, or reliability program findings, for example, could necessitate such an audit.
- Required inspection items (RIIs). Again, this would be included in the standard audit each time any unit involved with RIIs is audited. But it may be necessary to check the RII process itself, as well as to review the authorization of those mechanics performing RIIs.
- AD and SB compliance. All ADs are required to be implemented within some specified time limit and often apply to specific aircraft (by tail number, model, or dash number, etc.). Service bulletins, although optional, must be reviewed for proper compliance if incorporated. Sometimes an AD is generated for an already released SB. Even if the airline rejected the SB (for whatever reason) as an AD it must be incorporated. This audit would look at engineering for the handling of ADs and SBs and the subsequent generation of EOs and other work orders; it will also look at appropriate units involved in the incorporation of these modifications (maintenance, material, training, etc.).

- Major repairs and alterations. These audits are usually performed to ensure compliance with requirements whenever major aircraft repairs or alterations are done. These modifications would be performed on a fleet of aircraft, but the audit would normally be done only once.
- Safety equipment. Availability and accessibility of safety equipment in the various work centers may be part of the center's normal audit, but a spe-cial audit of all safety equipment may be desirable at times. This may include an audit of the safety organization itself.
- Safety training. Training in the location and use of safety items and the proper employment of safety measures is also done in conjunction with work center audits, but again, a special audit of the entire safety program may be in order.
- Accident/incident reporting. These processes and procedures would be addressed in an audit of the safety organization, but an audit may be necessary of the total program, including other work centers.
- Fire protection/prevention. All systems, equipment, and procedures related to fire protection and fire prevention may be the subject of a one-time audit.
- Hazardous materials handling. The proper handling of these materials requires training of personnel who have contact with such materials. The overall program, spanning several work centers, may be audited.

ISO 9000 Quality Standard

- There has been much interest lately in quality: quality of workmanship, quality of service, quality of life.
- Most of industry throughout the world is adopting the international standard of quality, known as ISO 9000 (ISO, International Standards Organization).
- This standard establishes the requirement for a quality system in organizations performing design and/or manufacturing or providing technical service to others. It identifies three types of organizations, with the ISO 9000 specification tailored to each one. The following information comes from The Handbook of Maintenance Management by Joel Levitt.
- ISO 9001 is for facilities that design/develop, produce, install, and service prod-ucts or
- provide services to customers who specify how the product or service is to perform.
- ISO 9002 is for facilities that provide goods or services to the customer's design specifications.
- ISO 9003 is for those doing final inspection and testing.
- Each facility must be certified to the applicable ISO 900X program based on the type of work performed. Maintenance (aircraft or other) is not specifically addressed in any of these ISO standards, but many aviation regulatory authorities outside the United States require commercial airline operators to develop a quality standard using ISO 9000. Table 16-2 outlines the require-ments for each type of ISO 9000 organization. The far right column (added by this author) identifies those items that would relate to aviation maintenance.

Technical Records- We identified the FAA requirement for an operator to maintain certain records on the status of the operating aircraft.

- This requirement is to ensure that aircraft are maintained in airworthy condition and in accordance with certification requirements.
- These records allow FAA or other regulatory authorities to see that this is being done. It shows the current status of the air-craft and that the status is up to date.
- It also allows a new operator, if the air-craft is sold, leased, or returned to a lessor, to know the exact status of the aircraft with respect to ADs, SBs, and other modifications and major repairs.
- It also lets the new operator know what the maintenance schedule is for that aircraft and where it stands in the progression of letter checks at the time of transfer; i.e., how long until the next "A" check or "C" check and what multiple checks (3A, 4C, etc.) might be due.
- There are four classifications of records an operator must keep: continuous, routine,
- repetitive, and permanent.
- Continuous records, listed in Table 16-3, are continuously updated to reflect the status of the airline's operation at any point in time.
- Routine records, in Table 16-4, are usually maintained for a period of 15 months. Some
- routine records may be transferred to permanent status as noted in the table.
- Repetitive records, shown in Table 16-5, identify all work that is repeated at regular intervals, such as daily, transit, and letter checks.
- Normally, the letter check records are kept only until completion of the next check.

TABLE 16-3 Continuous Records

General records (aircraft, engines, components, appliances)
Time in service records
Time limits
Time since last overhaul
Time since last inspection
Life-limited parts
Operating limits
Accumulated hours and cycles
Modifications per SB and/or AD
Product improvement by manufacturer or operator
AD status
List of applicable ADs
Date and time in service
Methods of compliance (AD, SB, EO, etc.)
Time to next action for recurring ADs
Aircraft records
Current inspection status
Time in service since last inspection
Routine tasks performed during last inspection
Nonroutine tasks performed during last inspection
Component records
Overhaul list (FAR 121.380)
Time since last overhaul
Time remaining to next overhaul
Component history cards

TABLE 16-4 Routine Records

General records (aircraft, engines, components, appliances)
Fleet campaigns (may be transferred to permanent)
Completed checklists
Maintenance ferry checklist
Engine-out ferry checklist
Test flight checklist
Aircraft records
Logbooks
Flight logbook
Maintenance logbook
Cabin logbook
Engine and APU records
Logbooks
Maintenance training records

TABLE 16-5 Repetitive Records

Aircraft records
Maintenance/inspection checks (daily, 48-hour, transit, letter checks)
Signed-off routine task cards
Signed-off nonroutine task cards
Package closeout records
Maintenance/inspection checks (4C, D, structural—all aircraft)
Signed-off routine task cards (may be transferred to permanent)
Signed-off nonroutine task cards (may be transferred to permanent)
Package closeout records
Weight and balance
Engine and APU records
Overhaul, check, and hot section inspections

TABLE 16-6 Permanent Records

General records (aircraft, engines, components, appliances)
AD compliance records
Signed paperwork (task cards, EOs, etc.)
SB/SL compliance records
Signed paperwork (task cards, EOs, etc.)
Major repairs/alterations records
Accident reports
Repair authorizations, sketches, drawings
SBs, STCs, modifications, EOs
Weight/CG change reports
Test flight reports
FAA form 337 (major repairs and alterations)

- However, information from these checks would be needed for justification of interval adjustment .
- In such cases, the check package data remains on file or the significant items from each check, each aircraft, are summarized and filed for future use and the original check package paper is destroyed.
- Permanent records, listed in Table 16-6, identify permanent changes to the configuration of the aircraft, engines, components, and appliances and are retained permanently.
- If the aircraft is sold, leased, or returned to a lessor, the permanent records must be transferred to the next operator with the aircraft.

Other Functions of QA- The portion of QA that handles records may also be responsible for monitoring the currency of mechanics' licenses and inspectors' qualifications and authorizations (RIIs and conditional inspections). This group would also have administrative control over the development and modification of the TPPM and

- other documents requiring approval from the director of MPE.
- The QA also performs in-house audit and spot checks that are frequently accomplished on various shifts to get an idea of how well the company's maintenance policies and procedures are being followed. These spot checks may be of aircraft being maintained at hangar, line maintenance, safety, maintenance shops, paperwork, tooling, or equipment being used.

Quality Control

Introduction

- The inspection function of an airline M&E organization is part of the basic maintenance program established by the Ops Specs.
- It consists, in part, of inspections performed by the mechanics during routine maintenance work: general visual inspections, detailed inspections, as well as the obvious checking and rechecking of one's own work.
- Some maintenance actions require a "second pair of eyes" to perform an inspection to ensure that the work was performed correctly or to double-check the work.
- This includes the required inspection items (RIIs) and also includes oversight checking of newly hired or newly trained personnel to ensure they are performing up to standards. Still another type of inspection, the conditional inspection, is required for special events, such as bird strikes, hard landings, lightning strikes, flights through heavy turbulence, or the accidental dragging of wing tips or engine pods upon landing or taxiing. For these special events, the inspection must be detailed enough to detect possible structural damage and may require special nondestructive techniques for test and inspection (NDT/NDI).
- For a mechanic to carry out RIIs or con-duct conditional inspections, he or she must be properly trained, qualified, and approved to do said inspections by quality assurance as per FAR 121.371.

Quality Control Organization

- To carry out all of these inspection requirements, it is necessary to establish a quality control function within the M&E organization.
- This function can take various forms. In the typical midsized airline, we have included the quality control function within the MPE directorate.
- This is assuming that the organization is large enough to employ full-time QC inspectors. In smaller organizations, however, the QC inspectors may, by necessity, be located in the work centers.
- Very often, however, an airline will have both types of inspectors.

- Full-time inspectors are called “dedicated inspectors” while the part-time inspectors are called “delegated inspectors” (sometimes called “designated inspectors”).
- In either case, someone in the MPE organization should have oversight of all QC
- inspectors. This over-sight function is usually given to QA if there is no QC department.
- A dedicated inspector may be an experienced mechanic, technician, or engineer, must hold a valid A&P license, and must be trained on general inspection techniques, as well as on the special techniques required for the specific areas to which he or she is assigned to inspect. A QC inspector must be approved by the QA organization to conduct such
- inspections.
- A delegated (or designated) inspector may be a mechanic or supervisor in a specific work center who is qualified to perform certain inspections. He or she is often limited to perform inspections only in specific areas simply because there is no other expert in the airline qualified to do such inspection or there is not enough of such work to assign anyone to the inspection work full time.
- In other instances, where workload is insufficient for full-time inspectors, the delegated inspector may be required to perform all QC inspection within a given work center.
- To maintain the separation of inspectors from the inspected, however, it is considered that during the inspection activities, the delegated inspector is working for QC (or QA)
- not for the work center.
- Internally, QC is divided into four functions, each under its own supervisor.
- Size of the airline and management preference may suggest other arrangements, but in our typical midsized airline,
- We have supervisors for aircraft inspections, shop inspections, material inspections, and
- testing and calibration.
- The supervisor of aircraft inspections would oversee all QC inspectors, dedicated or delegated, who are responsible for the inspections performed on the aircraft whether in the hangar or on the line.
- The supervisor of shop inspections has the same responsibilities for those inspections performed in all support and overhaul shops for off-aircraft maintenance.
- The material inspections supervisor is responsible for all inspections required on incoming and outgoing components handled by material.
- The fourth position on the QC organizational chart is responsible for supervision of all nondestructive test and inspections (NDT/NDI) and for the calibration of tools and test equipment used throughout M&E.
- This includes electronics test equipment used on the line, in the hangar, and in the shops, as well as special tools, such as torque wrenches, which require regular checks for calibration accuracy.
- The QC unit is responsible for seeing that all such tools and equipment have valid calibration stickers showing the last calibration date or the date the next calibration is due; i.e., expiration of the current calibration.
- Quality control is also responsible for sending such equipment to the appropriate calibration laboratory, which may be run by the airline or by a third party.

FAA and JAA Differences- The above discussion covers the approach to QC relative to the U.S. standards. In Europe, airlines under the Joint Aviation Authorities (JAA) have a different setup. Under JAA rules, there is no quality control organization, only quality assurance.

- However, all aspects of the QC function discussed above still exist under the JAA but are controlled differently.
- The JAA is not a regulatory authority.
- It is an advisory group with the purpose of standardizing aviation regulations throughout Europe. In all cases, the regulatory authority of the airline's own country has the final say in what the airline should do.
- The certified and trained mechanic is considered qualified enough to inspect his own work to assure that it has been done properly.
- If the mechanic is properly trained and is a conscientious worker, this is to be expected. These mechanics, however, must be properly trained in the inspection techniques and must be approved by the QA department to do the inspection.
- For those inspections (safety or airworthiness related, for example) that require a second pair of eyes, the second person, under JAA rules, must also be properly trained and approved by QA.
- For the conditional inspection items mentioned above where structural damage might be involved, the inspector or mechanic performing such inspections must also be trained in the proper techniques (i.e., NDT/NDI) for the given inspection and be approved by QA to
- perform these conditional inspections.
- Under JAA rules, where there is no QC, the mechanic does not have "free run" of the situation. The key words used above are "properly trained and approved by QA."
- This is true for the FAA or the JAA. In other words, the requirements are the same under both FAA and JAA jurisdictions, only the terminology and the titles used are different.

QC Inspector Qualifications

- Anyone working as a quality control inspector, whether dedicated or delegated, must possess certain qualifications.
- The basic qualification for all inspectors is to have a valid mechanic's license and 2 years of work experience under that license without any violations.
- They must have completed all company required training and aircraft fleet training and have knowledge of airlines regulations, policies, and procedures; they must know the company's RII program; and they should have completed the QC inspector's course and
- successfully passed the QC exam conducted by the airline's QC organization.
- The inspector's course should cover the duties and responsibilities of QC inspectors and instructions in inspection procedures and techniques.
- The course should include instruction on corrosion, its detection, and its control. Nondestructive test and inspection techniques should be addressed to the extent that the individual inspector requires for his or her duties.
- The course should also include a review of regulatory and airline procedures related to
- the inspector's specialty.

- Once trained and approved for QC inspection, the mechanic is required to maintain proficiency in the inspection methods used, the specifications of the equipment involved, the methods and procedures for determining quality, and the proper use of inspection aids, tools, and applicable NDT/NDI techniques.
- The airline must keep a record of those personnel who are authorized as QC inspectors.
- Their status, dedicated or delegated, as well as the items they are qualified and authorized to inspect must be recorded and made available to regulatory personnel.

Basic Inspection Policies

- The airline should establish the basic inspection policies for all dedicated and delegated inspectors to abide by.
- The policies most generally accepted by the industry address the following areas: (*a*) use of an inspector's stamp for official acceptance of work; (*b*) the continuity of inspection across shift boundaries; (*c*) the countermand of inspector's decisions; (*d*) reinspection of rejected work (buyback); and (*e*) the inspection of one's own work.

Inspection stamp

- All authorized QC inspectors are issued an inspector's stamp.
- These stamps are numbered and controlled, and each inspector is responsible for the security of his or her own stamp.
- When work is done by a mechanic, it is signed off by the mechanic on the appropriate work card or other official paperwork.
- If a specific task requires QC inspection, the inspector, after reviewing and accepting the work, will approve it by stamping and initialing the work card or task card.
- The stamp must be surrendered to QA whenever the inspector leaves the company or is no longer in the inspection unit.

Continuity of inspection

- Whenever work spans more than one shift, the airline is required to have procedures in place (in the TPPM) to ensure that complete information and status of the work progress is passed on to the next shift.
- This policy must also include the transfer of inspection authority to the next shift of inspectors. In some air-lines, the original work crew remains on the job until the work is completed, even if overtime is involved.
- In other airlines, crews work 10- to 12-hour shifts, which covers most jobs. But inspectors, often considered as management level, may work only 8-hour shifts. Whatever the shift schedule, the airline procedures must specifically identify how continuity will be maintained to ensure correctness of the work and of the inspection efforts.

Countermand of inspector's decisions

- A QC inspector's decision to accept or reject a job, or ask for a rework, cannot be countermanded or overridden by the mechanic or by the mechanic's management.
- When a delegated QC inspector in any shop or work center is performing an inspection, his or her decisions cannot be overridden by his or her own work center supervisor since the inspection is done under QC management.

- The only ones who can override an inspector's decision are the manager of QC, the director of MPE, or the VP of M&E.
- Where the QC inspectors are directly under QA authority, the director or manager of QA has override authority.
- In any case where an inspector's decision has been overridden, the responsibility for the action falls upon the airline and not on the inspector or the mechanic.

Buyback policy

- Any discrepancy written up by QC during a check (A, C, etc.) or in any spot check and any work rejected by QC during their acceptance inspection, must be reinspected by QC after the rework has been accomplished to gain final approval.
- This final inspection and approval is called "buyback."
- For "B" checks and lower, if no QC inspector is available, the supervisor of the mechanic performing the work has buyback authority.

Inspection of one's own work

- Neither a mechanic nor an inspector can inspect and approve his or her own work where two signatures are required. It is an accepted fact that a mechanic who is qualified and conscientious will be able to "self-inspect" his or her own work to ensure that it has been done correctly.
- However, if the work requires a second pair of eyes or a second signature, the second person cannot be the same as the first.

Completion of work

- Each work package has a list of tasks that must be completed for the check to be complete.
- Most tasks require only the mechanic's sign-off to indicate completion.
- Some tasks require a QC inspector to inspect, approve, and sign off the task also.
- In addition to this, the senior QC inspector assigned to the check has the responsibility of checking to see that all tasks have been completed successfully and signed off properly.
- This involves checking each task card for completion and sign-off, ensuring that all rejected work has been reworked and accepted, and verifying that any QC write-ups generated during the check have been addressed.
- Any tasks not completed for whatever reason, must be properly deferred.
- Normally, an airline wants an aircraft to come out of an "A" or "C" check "clean"; i.e., no deferrals, but this is not always possible.
- Once all the work has been completed and signed off (or deferred), the QC inspector accepts the work package as complete, signs it off, and releases the aircraft out of check.

Other QC Activities

- In addition to the inspection activities mentioned above, the QC organization also has responsibility for special nondestructive test and inspection techniques, the calibration of certain tools and test equipment used in maintenance, and a number of special reports to the regulatory authority concerning maintenance problems.

Nondestructive test and inspection

- There are a number of special test and inspection activities used in maintenance that require the partial or complete disassembly of components and some that require other means that render the tested unit unserviceable.
- Although the first type can be tolerated, the second cannot.
- To avoid the disassembly or destruction of components, several methods of test and inspection have been developed to provide a look at or into certain component and system conditions without permanently destroying the parts.
- These are called, for obvious reasons, non-destructive test or nondestructive inspection
- techniques.
- The NDT/NDI techniques used in aircraft maintenance include the use of x-rays, ultrasound, dyes, magnetic particle detectors, and boroscopes.
- Each is unique and each has its particular applications.
- The QC organization is responsible for conducting these tests and inspections or, in some cases, training the mechanics in the use of these techniques.
- Table 17-1 lists these NDT/NDI techniques and their applicability.

TABLE 17-1 NDT/NDI Techniques

X-ray	To view internal conditions of certain materials to indicate internal holes, cracks, or other problems.
Ultrasonic	Similar to x-rays but uses high-frequency sound waves. Internal aberrations will conduct the sound differently and thus generate different patterns on the monitor.
Eddy current	Eddy currents set up in various materials exhibit certain patterns. Internal cracks in materials would alter the pattern and thus show areas of weakness.
Dye penetrant	Special dyes are introduced into various flow systems. Leaks in the tubing, gaskets, connectors, etc. will be identified by leakage of the dye at the errant point.
Magnetic particle	Chip detectors strategically placed in engines to detect metal particles in the oil indicating engine wear.
Boroscope	To view the internal condition of the jet engine rotor blades, a special video probe is inserted into an access hole in the engine. The internal section of the engine then can be viewed on an external monitor while the engine fan is rotated to view all blades. *Caution*: The probe must be removed and the access hole secured before running the engine.

Calibration of tools and test equipment

- Certain measuring tools and test equipment used in maintenance require calibration on a periodic basis.
- The standards used in the United States are those of the National Institute of Standards and Technology (NIST).
- The airline must provide for the calibration of tools and test equipment with on-site standards, which can be traced back to the NIST.
- Maintenance requirements are to use only those tools and test units that have been calibrated and certified as serviceable.
- Responsibility for this lies with QC, although a dedicated laboratory facility is usually established, with specially qualified metrological technicians employed, to accomplish the work.
- Properly calibrated tools and test equipment will carry calibration stickers that will identify either the date of last calibration or the date calibration is due. The stickers should also include the initials and stamp of the approving laboratory. Mechanics should use only tools and test equipment that have valid calibration stickers. Compliance will be monitored by QC and QA.
- A valid calibration sticker, however, does not guarantee that the tool or test unit is still within calibrated limits. These units malfunction occasionally and a good mechanic should be able to detect such problems.
- The TPPM should spell out procedures for mechanics and technicians to use in reporting an out-of-calibration tool or instrument to QC.
- The processing to and from the calibration lab can be through QC or material.

Special reports to the regulatory authority

- A mechanical reliability report (MRR) is submitted whenever any malfunction or defect shown in Table 17-2 occurs.
- The MCC notifies QC whenever an incident occurs, and QC prepares a report to the FAA. Such reports are usually sub-mitted covering a 24-hour period (9:00 AM Monday to 9:00 AM Tuesday, for example) to the certificate-holding office of the airline. The report consists of type and identification number of the aircraft; the airline name; and the date, flight number, and flight stage when the incident occurred.
- The report would also include the nature of the incident, emergency procedures involved (if any), apparent cause, equipment affected, disposition, and a brief narration of any other pertinent information related to the incident.
- Information not available at the time of the original submission must be provided to the FAA in a follow-up report when the information becomes available.

TABLE 17-2 Mechanical Reliability Reports*

A fire or fires during flight
Whether or not the related fire warning system functioned properly
If not protected by a fire warning system

False fire warning

Engine exhaust system that causes damage during flight to
Engine
Adjacent structure
Equipment
Components

Aircraft component that causes accumulation or circulation in crew/passenger cabin of
Smoke
Vapor
Toxic fumes

Engine shutdown due to
Flameout
Foreign object ingestion
Icing

Engine shutdown when external damage to engine or airplane occurs

Shutdown of more than one engine

Fuel or fuel dumping system that
Causes leakage during flight
Affects fuel flow

Landing gear operation during flight
Extension or retraction
Opening or closing of landing gear doors

Braking system components resulting in loss of braking force when A/C is on the ground

Failure of all inertial navigation systems in flight
Any A/C components or systems that cause the crew to take emergency action

Cabin decompression in flight

Evacuation on the ground

Any failure, malfunction, or defect which occurs or is detected at any time if the airline determines that it has or may endanger the safe operation of the aircraft.

Required inspection items

- Mechanics throughout the M&E organization may be involved with RIIs, but it is a director or manager of QC's responsibility to see that the program is properly administered.
- The FAA defines an RII as "any item which, if performed improperly or improper parts are used, could endanger the safe operation of the aircraft." This would include such tasks as the following:
- Installation, rigging, or adjustment of flight controls
- Installation and repair of major structural components
- Installation of engines

- Overhaul, calibration, or rigging of components, such as engines, transmis-sions, gear boxes, and navigation equipment

Reliability

- Reliability equals consistency.
- It can be defined as the probability that an item will perform a required function, under specified conditions without failure, for a specified amount of time according to its intended design.
- The reliability program is a valuable means of achieving better operational performance in an aircraft maintenance environment, and it is designed to decrease maintenance-related issues and increase flight safety.
- The intent of this program is to deal systematically with problems as they arise instead of trying to cure immediate symptoms.
- This program is normally customized, depending on the operators, to accurately reflect the specific operation's requirements.
- Although the word reliability has many meanings, in this book we will define the terms that have specialized meanings to aviation maintenance and engineering.
- In the case of reliability, we first must discuss one important difference in the application of the term.
- There are two main approaches to the concept of reliability in the aviation industry.
- One looks essentially at the whole airline operation or the M&E operation within the whole, and the other looks at the maintenance program in particular.
- There is nothing wrong with either of these approaches, but they differ somewhat, and that difference must be understood.
- The first approach is to look at the overall airline reliability.
- This is measured essentially by dispatch reliability; that is, by how often the airline achieves an on-time departure[1] of its scheduled flights.
- Airlines using this approach track delays. Reasons for the delay are categorized as maintenance, flight operations, air traffic control (ATC), etc. and are logged accordingly. The M&E organization is concerned only with those delays caused by maintenance.
- Very often, airlines using this approach to reliability overlook any maintenance problems (personnel or equipment related) that do not cause delays, and they track and investigate only those problems that do cause delays. This is only partially effective in establishing a
- good maintenance program.
- The second approach (which we should actually call the primary approach) is to consider reliability as a program 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 improve the overall reliability of the equipment. This contributes to the dispatch reliability, as well as to the overall operation.

Types of Reliability

- The ~~term reliability~~ can be used in various respects.
- You can talk about the overall reliability of an airline's activity, the reliability of a component or system, or even the reliability of a process, function, or person.

- Here, however, we will discuss reliability in reference to the maintenance program specifically.
- There are four types of reliability one can talk about related to the maintenance activity. They are
- (a) statistical reliability,
- (b) historical reliability,
- (c) event-oriented reliability, and
- (d) dispatch reliability.
- Although dispatch reliability is a special case of event-oriented reliability, we will discuss it separately due to its significance.

Statistical reliability

- Statistical reliability is based upon collection and analysis of failure, removal, and repair rates of systems or components.
- From this point on, we will refer to these various types of maintenance actions as "events." Event rates are calculated on the basis of events per 1000 flight hours or events per 100 flight cycles.
- This normalizes the parameter for the purpose of analysis. Other rates may be used as
- appropriate.
- Many airlines use statistical analysis, but some often give the statistics more credence than they deserve.
- For one example, airlines with 10 or more aircraft tend to use the statistical approach, but most teachers and books on statistics tell us that for any data set with less than about 30 data points the statistical calculations are not very significant.
- Another case of improper use of statistics was given as an example presented in an aviation industry seminar on reliability
- The airline representative used this as an example of why his airline was going to stop using statistical reliability.
- Here is his example.
- We use weather radar only 2 months of the year. When we calculate the mean value of failure rates and the alert level in the conventional manner we find that we are always on alert. This, of course, is not true.

Historical reliability

- Historical reliability is simply a comparison of current event rates with those of past experience.
- In the example of Fig. 18-1, the data collected show fleet failures of 26 and 32 for the 2 months the equipment was in service. Is that good or bad? Statistics will not tell you but history will.
- Look at last year's data for the same equipment, same time period. Use the previous year's data also, if available. If current rates compare favorably with past experience, then every-thing is okay; if there is a significant difference in the data from one year to the next that would be an indication of a possible problem. That is what a reliability
- program is all about: detecting and subsequently resolving problems.

- Historical reliability can be used in other instances, also. The most common one is when new equipment is being introduced (components, systems, engines, aircraft) and there is no previous data available on event rates, no information on what sort of rates to expect. What is "normal" and what constitutes "a problem" for this equipment? In historical reliability we merely collect the appropriate data and literally "watch what happens." When sufficient data are collected to determine the "norms," the equipment can be added
- to the statistical reliability program.
- Historical reliability can also be used by airlines wishing to establish a statistically based program.
- Data on event rates kept for 2 or 3 years can be tallied or plotted graphically and analyzed to determine what the normal or acceptable rates would be (assuming no significant problems were incurred). Guidelines can then be established for use during the next year. This will be covered in more detail in the reliability program section below.

Data	12 Mos	2 Mos
Jan	0	
Feb	0	
Mar	0	
Apr	0	
May	0	
Jun	0	
Jul	0	
Aug	0	
Sep	26	26
Oct	32	32
Nov	0	
Dec	0	
Sum	58	58
n	12	2
Avg.	4.8	29.0
Std. Dev.	11.4	4.2
A.L.	27.6	37.5

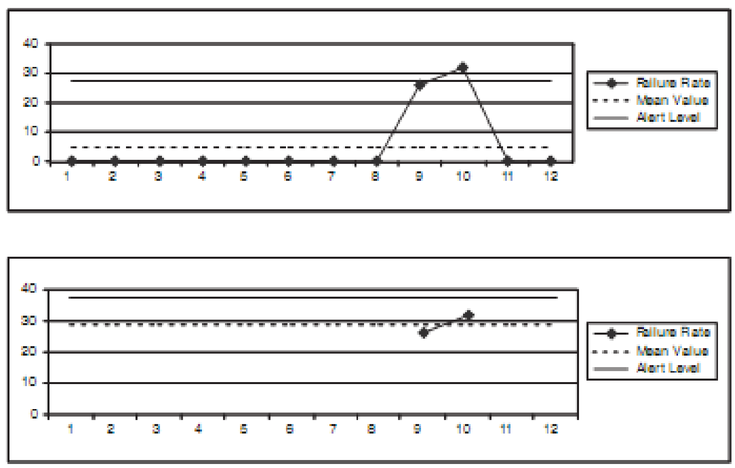


Figure 18-1 Comparison of alert level calculation methods.

Event-oriented reliability

- Event-oriented reliability is concerned with one-time events such as bird strikes, hard landings, overweight landings, in-flight engine shutdowns, lighting strikes, ground or flight interruption, and other accidents or incidents.
- These are events that do not occur on a daily basis in airline operations and, therefore, produce no usable statistical or historical data.
- Nevertheless, they do occur from time to time, and each occurrence must be investigated to determine the cause and to prevent or reduce the possibility of recurrence of the problem.
- In ETOPS operations, certain events associated with this program differ from conventional reliability programs, and they do rely on historical data and alert levels to determine if an investigation is necessary to establish whether a problem can be reduced or eliminated by changing the maintenance program.

- Events that are related to ETOPS flights are designated by the FAA as actions to be tracked by an "event-oriented reliability program" in addition to any statistical or historical reliability program.
- Not all the events are investigated, but everything is continually monitored in case a problem arises.

Dispatch reliability

- Dispatch reliability is a measure of the overall effectiveness of the airline operation with respect to on-time departure.
- It receives considerable attention from regulatory authorities, as well as from airlines and passengers, but it is really just a special form of the event-oriented reliability approach.
- It is a simple calculation based on 100 flights.
- This makes it convenient to relate dispatch rate in percent.
- An example of the dispatch rate calculation follows.
- If eight delays and cancellations are experienced in 200 flights that would mean that there were four delays per 100 flights, or a 4 percent delay rate. A 4 percent delay rate would translate to a 96 percent dispatch rate (100 percent − 4 percent delayed = 96 percent dispatched on time). In other words, the airline dispatched 96 percent of its flights on
- time.
- The use of dispatch reliability at the airlines is, at times, misinterpreted. The passengers are concerned with timely dispatch for obvious reasons. To respond to FAA pressures on dispatch rate, airlines often overreact. Some air-line maintenance reliability programs track only dispatch reliability; that is, they only track and investigate problems that resulted in a delay or a cancellation of a flight. But this is only part of an effective program and dispatch reliability involves more than just maintenance. An example will bear this out.
- Another fallacy in overemphasizing dispatch delay is that some airlines will investigate each delay (as they should), but if an equipment problem is involved, the investigation may or may not take into account other similar failures that did not cause delays. For example, if you had 12 write-ups of rudder problems during the month and only one of these caused a delay, you actually have two problems to investigate: (*a*) the delay, which could be caused by problems other than the rudder equipment and (*b*) the 12 rudder write-ups that may, in fact, be related to an underlying maintenance problem. One must understand that dispatch delay constitutes one problem and the rudder system malfunction constitutes another. They may indeed overlap but they are two different problems.
- The delay is an event-oriented reliability problem that must be investigated on its own; the 12 rudder problems (if this constitutes a high failure rate) should be addressed by the statistical (or historical) reliability program.
- The investigation of the dispatch delays should look at the whole operation.
- Equipment problems—whether or not they caused delays—should be investigated separately.

Elements of a Reliability Program

- A good reliability program consists of seven basic elements as well as a number of procedures and administrative functions. The basic elements (discussed in detail below) are (*a*) data collection; (*b*) problem area alerting, (*c*) data display; (*d*) data analysis; (*e*) corrective actions; (*f*) follow-up analysis; and (*g*) a monthly report. We will look at each of these seven program elements in more detail.
  Data collection: We will list 10 data types that can be collected, although they may not necessarily be collected by all airlines.
- The data collection process gives the reliability department the information needed to observe the effectiveness of the maintenance program.
- Those items that are doing well might be eliminated from the program simply because the data show that there are no problems.
- On the other hand, items not being tracked may need to be added to the program because there are serious problems related to those systems.
- Basically, you collect the data needed to stay on top of your operation.
- The data types normally collected are as follows:

1. Flight time and cycles 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-ups
8. Component failures (shop maintenance)
9. Maintenance check package findings
10. Critical failures

- ➢ Flight time and flight cycles. Most reliability calculations are “rates” and are based on flight hours or flight cycles; e.g., 0.76 failures per 1000 flight hours or 0.15 removals per 100 flight cycles.
- ➢ Cancellations and delays over 15 minutes. Some operators collect data on all such events, but maintenance is concerned primarily with those that are maintenance related.
- ➢ The 15-minute time frame is used because that amount of time can usually be made up in flight. Longer delays may cause schedule interruptions or missed connections, thus the need for rebookings.
- ➢ This parameter is usually converted to a “dispatch rate” for the airline as discussed above.
- ➢ Unscheduled component removals. This is the unscheduled maintenance mentioned earlier and is definitely a concern of the reliability program. The rate at which aircraft components are removed may vary widely depending on the equipment or system involved.
- ➢ If the rate is not acceptable, an investigation should be made and some sort of corrective action must be taken. Components that are removed and replaced on schedule—e.g., HT items and certain OC items—are not

included here, but these data may be collected to aid in justifying a change in the HT or OC interval schedule.

- Unscheduled removals of engines. This is the same as component removals, but obviously an engine removal constitutes a considerable amount of time and manpower; therefore, these data are tallied separately.

- In-flight shutdown (IFSD) of engines. This malfunction is probably one of the most serious in aviation, particularly if the airplane only has two engines (or one). The FAA requires a report of IFSD within 72 hours.[3] The report must include the cause and the corrective action. The ETOPS operators are required to track IFSDs and respond to excessive rates as part of their authorization to fly ETOPS. However, non-ETOPS operators also have to report shutdowns and should also be tracking and responding to high rates through the reliability program.
- Pilot reports or logbook write-ups. These are malfunctions or degradations in airplane systems noted by the flight crew during flight. Tracking is usually by ATA Chapter numbers using two, four, or six digits. This allows pinpointing of the problems to the system, subsystem, or component level as desired. Experience will dictate what levels to track for specific equipment.
- Cabin logbook write-ups. These discrepancies may not be as serious as those the flight crew deals with, but passenger comfort and the ability of the cabin crew to perform their duties may be affected. These items may include cabin safety inspection, operational check of cabin emergency lights, first aid kits, and fire extinguishers. If any abnormality is found, these items are written up by the flight crew in the maintenance logbook as a discrepancy item.
- Component failures. Any problems found during shop maintenance visits are tallied for the reliability program. This refers to major components within the black boxes (avionics) or parts and components within mechanical systems.
- Maintenance check package findings. Systems or components found to be in need of repair or adjustment during normal scheduled maintenance checks (non-routine items) are tracked by the reliability program.
- Critical failures. Failures involving a loss of function or secondary damage that could have a direct adverse effect on operating safety.

Other Functions of the Reliability Program read from text book 233 -236

Maintenance Safety

Industrial Safety

- The Code of Federal Regulations, Title 29, Part 1910, deals with industrial safety (29 CFR 1910). Its title is "Occupational Safety and Health Standards" and is part of the U.S. Government regulations for the Department of Labor (DOL).
- The agency within DOL responsible for enforcing these regulations is the Occupational Safety and Health Administration (OSHA).

- Aviation is not addressed specifically in these OSHA regulations, but all aspects of the aviation maintenance activity (as well as flight operations, office, and terminal activities) are covered.
- Table 19-1 lists the subparts of Part 1910 as of January 2003. It is up to the aviation industry itself to ferret out those parts and sub-parts of 29 CFR 1910 that apply to aviation matters and materials and to tailor the requirements directly to those airline activities.

TABLE 19-1 Occupational Safety and Health Standards

Subpart	Title
A	General
B	Adoption and extension of established federal standards
D	Walking–working surfaces
E	Means of egress
F	Powered platforms, man-lifts, and vehicle-mounted work platforms
G	Occupational health and environmental control (ventilation, noise, nonionizingradiation)
H	Hazardous materials
I	Personal protective equipment
J	General environmental controls (sanitation, lockout/tagout, marking of hazards)
K	Medical and first aid
L	Fire protection
M	Compressed gas and compressed air equipment
N	Materials handling and storage
O	Machinery and machine guarding
P	Hand and portable power tools and other hand-held equipment
Q	Welding, cutting, and brazing
R	Special industries (pulp, paper, textiles, etc.)
S	Electrical
T	Commercial diving operations

Safety Regulations

- The federal hazard communications (FHC) standard, 29 CFR 1910.1200, requires that management provide information about chemical hazards in the work force to all employees.
- This becomes part of the airline's safety program through the distribution of material safety data sheets (MSDS).
- These data sheets are generated by the chemical manufacturer and identify the hazards, precautions, and first aid instructions relative to the chemical's use.
- The airline safety managers must make the appropriate MSDSs available to anyone who may use or come in contact with the chemical.
- The airline may add any additional information to the MSDS as necessary to clarify the use of the chemical, as well as provide information on reporting incidents and hazards.
- The manufacturer's MSDS is general and deals with the chemical; the airline additions to the MSDS address specific airline concerns and procedures.
- Physical hazards, such as noise, ionizing radiation, nonionizing radiation, and temperature extremes, for example, are governed by other parts of 29 CFR 1910 and should also be addressed in the airline's safety program.
- This program would provide for the availability, training, and use of protective
- equipment, safety measures, and safety processes.
- Posture, force, vibration, and mechanical stress are common hazards work-ers are subject to in all work areas. The amount and type of exposure, of course, varies with the work
- being done. The airline safety program should address each work center's specific needs.

- Viruses, bacteria, fungi, and other substances that can cause disease are included in the regulations. These biological hazards come under the health classification and also vary
- depending upon the kind of work being done and other work environment conditions.
- Many of these safety and health requirements are already addressed in aviation industry documents and regulations.
- Airframe manufacturer's maintenance manuals, for example, usually cover safety features related to the performance of maintenance, such as the use of safety harnesses, use of protective clothing and equipment, the proper handling of hazardous materials, and the lockout and tagging of certain electrical and mechanical equipment to avoid inadvertent operation or subsequent accidents while people are working on or near such systems.
- The airline's operations specifications may identify other safety requirements.
- The TPPM, of course, should contain a summary of the entire maintenance safety program, and the safety manager should monitor all aspects of the program to ensure compliance with the OSHA requirements.
- This compliance, of course, is part of the QA audit responsibilities, but due to the special nature, safety is established as a separate function to monitor these activities.

Maintenance Safety Program

- FAR 119.65 identifies, but does not define, the basic positions required to oper-\ate an airline.
- Although certain positions are deemed necessary, the certificate holder will determine actual titles as well as the level of the office within the structure. Paragraph (d) of 119.65 says that the certificate holder will define the "duties, responsibilities, and authority" for all positions in the organization.
- The person in charge of safety is responsible for the overall safety program at the airline. There may be separate safety program managers for flight operations, maintenance, and the other administrative and managerial functions of the airline.
- One may be coordinator of the others, but the individuals will have responsibilities in their own work areas. In our typical, midsized airline (see Fig. 7-1) we have identified the maintenance safety program within the MPE directorate with the other maintenance oversight functions.
- The maintenance safety program manager has the following primary responsibilities:

- Identify and assess all health and safety hazards within the various M&E work areas
- Determine protective measures needed for hazardous conditions and ensure that protective clothing and equipment are available to the workers as necessary
- Make information available to workers handling hazardous chemicals, on the hazards and handling procedures involved with those chemicals, including any data supplied by the manufacturer, and any additional information deemed necessary for the airline activities
- Provide training on the identification of hazards, on the location and use of safety equipment, and on first aid and reporting procedures involved
- Establish and document the safety program in the technical policies and pro-cedures manual (TPPM).

General Safety Rules

- There are several special areas of concern for any airline maintenance safety program that require further discussion.
- These are smoking regulations, fire prevention, fire protection, storage and handling of hazardous materials, fall safety and protection, and hangar deluge systems.

Smoking regulations

- The term smoking materials refers to cigars, cigarettes, pipes, and other flammable materials such as matches and lighters.
- The safety coordinator should designate "No Smoking" areas, and the regulations must be enforced.
- Typical no smoking areas include the following: (a) inside aircraft at any time; (b) within 50 feet of an aircraft parked on the ramp; (c) within 50 feet of any refueling activity or refueling equipment; (d) within 50 feet of oil, solvent, or paint storage areas; (e) inside hangars, except in offices, washrooms, and other areas designated for smoking; and (f) any location of the airport designated as no smoking by the airport authority.

Fire prevention

- Smoking materials are not the only sources of ignition for fires.
- Electrostatic discharge can also provide the spark needed for ignition of flammable vapors and other substances.
- For that reason, all aircraft should be properly grounded while they are in the hangar or on the ramp, especially during refueling and defueling operations.
- Other materials susceptible to combustion include rags and paper. Combustible rags must be stored in National Fire Protection Association (NFPA)-approved, closed containers, and paper and other combustible trash must be stored in suitable trash cans. Other items, such as volatile cleaning fluids with a low flash point, oils, and paints, must also be properly stored and handled. When these items are present, the no smoking rules will
- apply and adequate ventilation will be required.
- The supervisor of any work center where these volatile materials are used must ensure that the products are stored properly and in quantities commensurate with reasonable needs.
- Use of these and other volatile materials will not be carried out in any room where there are open flames, operating electrical equipment, welding operations (arc or acetylene), or
- grinding activities.
- Flammable materials, such as paints, dopes, and varnishes, must be kept in NFPA-approved, closed containers away from excessive heat or other sources of ignition.
- Bulk supplies of these must be stored in a separate building at a location remote from the maintenance activity. If it becomes necessary to perform welding activities on aircraft, the management must determine proper procedures and arrange for standby fire fighters and equipment during the exercise.

Hangar deluge systems

- Airplane hangars are complex and expensive structures, and they often contain one or more aircraft, which are considerably more expensive than the building itself. The multitude of other equipment in the hangar, and the fact that air-craft may be jacked up, surrounded by scaffolding and maintenance stands, or in some other condition detrimental to moving them readily, make it imperative that these hangars be equipped with sufficient fire suppression equipment to protect the airline's investment.

- There will be fire extinguishers positioned around the aircraft and hangar work areas (both CO_2 and foam as required) and all fire and safety regulations will be enforced.
- But there is one more very important system required to protect the 50-to 150-million dollar *aircraft. This equipment, installed in numerous hangars around the world, is known as the hangar deluge system*
- These are elaborate systems with tanks of fire retardant chemicals buried in the ground or beneath the hangar floor, connected with a plumbing system that essentially mixes the retardant with water to create the foam and dispenses it throughout the hangar.
- The system usually has a control room in, or adjacent to, the hangar where operators can operate the system and direct the firefighting equipment (movable, adjustable nozzles) to specific areas; or the system can be automatic, covering the entire hangar.
- The order of activity is to evacuate personnel from the hangar and release the fire suppressant. The time it would take to move an aircraft out, if it were in a condition to allow such movement, would very often be more than one would have.

Fall prevention and protection

- The OSHA regulations concerning fall protection and prevention refer to work surfaces, scaffolding, and other high and precarious places, such as building construction sites, but not specifically the wings and fuselages of airplanes where maintenance people have to go occasionally. However, the same philosophy exists.
- Dangerous areas must be identified and should have specific equipment and procedures in place to protect anyone involved in working these areas.
- Aircraft do not have nice, flat surfaces as afforded by buildings and scaffolding. Although OSHA rules for such structures (rails, safety belts, and harnesses) do apply, the rounded surfaces of aircraft present additional problems. For one thing, aircraft surfaces are not always safe to walk on at all and are so noted with large, black letters: "NO STEP."
- The curved surfaces, and the fact that there is usually no structure to grab hold of to retard your fall, makes aircraft walking even more dangerous than other high places. The OSHA rules specify that a worker should not have a distance greater than 4 feet in which to fall. Anything greater requires safety gear in the form of rails, belts, or harnesses or some combination of these.

Accident and Injury Reporting

- Each incident involving airline personnel that results in damage to facilities and/or equipment or in injury to personnel must be reported to the safety man-ager, regardless of whether the personnel, equipment, or facilities is owned by the airline or some other unit.
- An initial report will be made immediately after the accident or incident occurs using telephone, telex, fax, radio, or any other means of communication available.
- This report should be made directly to the safety office if the event occurred on the home base or through the MCC if it occurred at an outstation. Within 24 hours of the event, the

work center supervisor where the accident or incident occurred will send a completed accident report or personnel injury report, as applicable, to the safety office.

- Forms for such reports should be developed by the safety office and made available to all airline work centers.
- Samples of these forms and the instructions for proper completion and submission of the forms should be included in the safety pro-gram section of the technical policies and procedures manual.
- The safety office will create a log of all accident and incident activities involving airline personnel whether at the home station, at outstations, or at contractor facilities.
- The PP&C organization will issue a work order number for the tracking of each accident or incident through the process of investigation, repair, insurance claims, or any other process required.
- The work order will also serve to collect time and cost data relative to the accident or incident.

Human Factors in Maintenance

- In the early 1980s, the aviation industry implemented crew resource management (CRM) in an effort to detect and correct human errors made by flight crews.
- The action was successful and is continuing.
- In the 1990s, it was deter-mined that the same approach should be used to identify and correct errors in maintenance activities that contributed to aircraft accidents and incidents.
- This activity—human factors in maintenance (HFM)—has developed into the maintenance resource management (MRM) program. The FAA addresses this activity in Advisory Circular AC 120-72.
- While many people assume that human factors in maintenance refers to the actions of mechanics, the MRM program admits to several major areas where maintenance errors can occur.
- These areas are (*a*) equipment design and manufacture; (*b*) manufacturers' documentation and procedure writing; (*c*) airline procedures and work areas; and (*d*) mechanic training and performance.
- The human interaction with systems makes it imperative that the users, operators, and maintenance people be considered during the design, development, and operational phases of the system's life.
- During design and development, the human requirements and interactions must be known or anticipated at all levels of the system.
- This includes not just the equipment but also the man-uals and the training program for that equipment. During the operational phase, feedback from the field will dictate changes necessary for system improvement relative to the operator, user, or mechanic in terms of local procedures, as well as the manufacturer's procedures, training, and design efforts.
- Lessons learned during this operational period relative to human interaction with the system can be used to advantage by the manufacturers in the development of new
- systems or modification of existing ones.

- Traditionally, the systems engineer needs to be familiar with a variety of engineering disciplines to perform his or her job successfully. Adding human factors to the toolbox means adding one more discipline: human factors engineering. This involves not just the understanding of human characteristics but also how these characteristics relate to the overall operation of the system. It requires the systems engineer to understand the effects these humans can have on the system operation whether the necessary interaction exists or not, whether the response is correct or incorrect, and even if the response or interaction is absent when it is required. It is necessary for the systems engineer to address these effects as part of the basic system design.
- The effects of human presence are as real as the presence of voltages and mechanical linkages.
- The human being is an element of the system. When all the elements are working properly, the system will work properly.

Human Factors in Maintenance

- In Appendix A, we extended the definition of systems to include more than just the electromechanical components we normally consider.
- A system can also be a checklist, a procedure, or a form to be filled out. Maintenance, of course, deals with all of these kinds of systems, and the human element is just as important in each of these.
- How maintenance people perform is only part of the problem; the facilities in which they work, the equipment they encounter, and the forms, processes and procedures they use are all subject to human actions and, there-fore, to human error. And the errors are not always due to the mechanic.
- There are several areas in maintenance that contribute to the errors made by the users, operators, or mechanics.

TABLE B-1 Human Factors Design Guidelines

1. Design the system to be compatible with human abilities, capabilities, needs, and strengths.
2. Design the system to compensate for human failings and deficiencies to avoid human errors.
3. Provide the human elements of the system with sufficient education and training to resolve any human factors–related problems that could not be alleviated by application of the first two rules above.

Human Factors Responsibilities

- Human factors efforts are usually divided into three basic categories of activity: (a) aircraft and component design,
- (*b*) maintenance product design, and
- (*c*) maintenance program applications. Each of these is discussed below.

Aircraft and component design

- The responsibility for this category rests with the manufacturers of airframes, engines, and installed equipment. It deals with the task of designing for maintainability.
- This concerns the design of equipment that can be worked on for service, inspection, adjustment, and removal/installation (R/I) efforts. These design efforts must ensure that there is sufficient workspace to do the work required and that there is also enough space to use the tools and test equipment that may be needed.
- The manufacturer's responsibility also includes consideration of the weight and handling characteristics of the unit undergoing maintenance.
- Equipment parameters must be within the physical limits of the workers required for the particular task. If this cannot be accommodated, special handling equipment must be developed to permit proper handling and to protect both the equipment and the workers from harm.
- Design effort should also take into account the number and skills of the workers
- required for a given task to be completed with reasonable staffing requirements.
- Whenever computer diagnosis is utilized, using built-in test equipment (BITE) or other external systems, the equipment, processes, menus, and other task or information selection methods must be designed for the mechanic's ease of use and understanding; that is, it should be user friendly.
- Results from such activities must be understandable and usable by the mechanic.

Maintenance product design

- Maintenance personnel require auxiliary equipment and written material to perform the required maintenance on aircraft systems.

  Ground support equipment (GSE), special tools and test equipment, and various forms of documentation must be designed with the mechanics' capabilities and limitations in mind, and these products must be made available to the mechanics. Mechanics must be able to use the GSE and tools effectively, so the design requirements discussed above for air-frames, engines, and installed equipment must apply to these elements also.
- Documentation, whether written by the manufacturer, the regulators, or the airline, must be clear, understandable, and accurate (i.e., technically correct) for the mechanic to effectively utilize the information. This written information must also be accessible to the mechanics on the line, in the hangar, and in the shops, as necessary. It must also be available to the training organization. The user-friendly approach is also required for all these maintenance products.

Maintenance program applications

- The basic maintenance program developed by the MSG process is based on the needs of the equipment (i.e., design goals, safety, and reliability) and on the regulatory requirements (safety, airworthiness, etc.).
- When the airline receives the aircraft and its initial maintenance program, that program is usually tailored to the specific airline operation.

- This adjustment of tasks and task intervals must also include human factors considerations.
- That is, the adjustment of the program must be in line with the human capabilities and requirements concerning work schedules, endurance, and skill makeup of the work crew to avoid over work, fatigue, etc.
- The appropriate GSE, tools, and test equipment must be provided to do the work, and the work force must be properly trained on all aspects of the job: the actual maintenance work to be performed; the use of GSE, tools, and test equipment; the use of built-in or external computer diagnostic equipment; and the basic human factors aspects of the job. These actions are the responsibility of the airline itself.

The Art and Scienceof Troubleshooting

Introduction

- One of the most common misconceptions about troubleshooting is that it is basically a series of wild-assed guesses (WAGs) or, at best, a series of scientific WAGs (SWAGs).
- This is not the case if you know what you are doing; it is of little help if you do not. And then there are those who claim that you cannot "teach" troubleshooting.
- This author disagrees with that notion.
- It is possible that some people cannot teach the subject due to a lack of knowledge or skill, and it may also be possible that some people cannot learn the technique for some reason or another.
- But experience has shown that the art and the science—and it is a combination of the two—can be taught. That is, it can be taught up to a point. Since there is some skill involved in troubleshooting (i.e., the art), what one learns about it must come from within. However, there are some basic concepts to be applied in troubleshooting (i.e., the science) that can be taught.
- As electronic and mechanical equipment gets more and more complex, the job of the technician or mechanic gets more and more frustrating.
- Today's new generation jet airplanes constitute the most intricate and complex systems ever engineered by human effort. In the past, each piece of equipment or each system required its own specialist to maintain and repair it to optimum condition.
- Troubleshooting consisted of checking out the system to determine if it was at fault and
- querying the user to determine if it was properly operated.
- Today, with electronic control of mechanical systems, redundant systems, computer fault recording, and cross-feeding of data between and among systems for logical decision making, the technician or mechanic requires not only a broader knowledge of his or her own equipment but also knowledge of those systems with which that equipment interfaces. Inputs from air/ground relays, gear-down sensors, air data computers, and from numerous other systems and sensors, blur or even erase the dividing lines between individual systems and components.
- Now, the repairman needs to know the entire airplane to effectively isolate the problems indicated by crew write-ups, fault balls, computer fault messages, flight deck lights, and other "things that go bump in the flight."

- The mechanic needs to understand the systems approach.
- The art of troubleshooting, which is just as important as the science, can only be learned by continued effort in studying and repairing the equipment.
- This art involves the ability to think a problem through and to apply all you know about the problem, the equipment, and the nature of failure so that you can fathom the most difficult and perplexing of problems.
- This appendix will, first, identify the basic steps in the troubleshooting process and will, then, discuss the process by which one learns the art of troubleshooting.

Three Levels of Troubleshooting

- You can divide maintenance problems into three general categories:
- (a) problems with components or systems (i.e., self-contained); (b) problems relating to systems and their environments; and
- (c) problems related to the interaction of two or more systems.
- Each of these categories or levels requires a different approach and each will be discussed in turn below.

Level 1: the component or system

- This type of problem exists within the component's or the system's own world.
- It is a simple, standard fault with a simple, standard solution.
- This is the normal, day-to-day activity for the problem solver.
- The troubleshooting charts or common sense is usually enough to resolve these problems.
- This system or component is malfunctioning or has failed completely. Check inputs, outputs, etc. Troubleshoot within the unit/system. Know how the system works and follow normal troubleshooting practices.

Level 2: the system and its environment

- A system fails or "acts up" during some portion of its operation. It may recover and exhibit no more symptoms or may falter intermittently. It may work fine on the ground or in the shop when tested, but the malfunction still reoccurs in the air during normal flight
- operation.
- Troubleshooting these problems requires knowledge of and investigation of the primary system or component, as well as its inputs and outputs, but the external environment and its effect on the system must also be considered. This includes investigation of how the system or equipment was operated (correctly or not?) and what else was happening during the time of the malfunction (extraneous inputs).

Level 3: the interaction of systems

- Something happens in one system when another system is exercised.
- The two systems may or may not be interrelated or interconnected. Here, assuming that other standards of troubleshooting have failed, you look for some mechanical interference, such as rubbing of parts or electromagnetic interference coming from a nearby unit, electrical cable, or other system.
- As a last resort, you look for interference from radiated fields (high or low intensity, any frequency). These are emanations from on-board or off-board systems that interfere with the problem system. This is occurring more and more with the composite (non-metallic) materials used in airplanes.

- The composite materials used in modern aircraft do not provide the electromagnetic
- shielding that the old, metal frames and fuselages used to provide.
- Again, the span of knowledge needed to pinpoint these problems is broader than the simple component or system failure discussed above. Knowledge of this type of interaction between (and among) systems may only come with time and experience, but it is necessary to gain that insight as you progress through the ranks from maintenance helper to master mechanic and troubleshooter. Once you have achieved this, you are an artist.

Knowledge of Malfunctions

- There are a few general concepts of problem solving and troubleshooting that one must understand before we get into the process itself. These are discussed briefly below.

What kinds of things can go wrong?

- Most systems will have a set of known things that can and will go wrong with them.
- The same failures will come up over and over again.
- Experience with these component or system characteristics will aid the troubleshooter more and more as his or her knowledge base is developed.
- Armed with this knowledge, the mechanic can sometimes skip certain steps and checks in a troubleshooting chart or procedure and go straight to those steps that are directly related to the problem at hand. Without this prior knowledge of failures, however, a good troubleshooter can still zero in on problem areas by knowing what kinds of things might go wrong with the system. Discussion with others who have worked the same system, and possibly had similar problems, is most useful.

Experience is the best teacher

- The expression "experience is the best teacher" is so common that it is almost a cliche´ and is often treated as just that.
- However, it is not an untruth. Until you get too old to remember things, remembering, in the maintenance field, can be one of your greatest and most useful assets.
- The same problems keep coming back. If the problem is the same then the solution is the same.
- Troubleshooting gets easier as you go. But there is always that stubborn problem that stymies even the best troubleshooter, and that is where all that experience, understanding, and luck have to be called upon. Without any of these, you're out of it.

No fault found

- No discussion about troubleshooting will be complete without mention of the concept of no fault found (NFF).
- It is a common action in maintenance to sign off a problem in the airplane logbook with the comment "No fault found" after ground checks have failed to reveal any problem. The NFF conclusion may also be used after an unsuccessful troubleshooting session.
- This NFF entry seems to be a catchall for ineffective or poor troubleshooting. If the flight crew wrote up an item in the logbook, then there must be some sort of problem.
- The fact that the mechanics cannot find the source of the problem does not mean that the write-up is in error. If you cannot find the problem through conventional processes, it will be necessary to use a different approach.

- The NFF result is not the end of troubleshooting; NFF is a signal to regroup, to start a different tack in the troubleshooting process. It may mean moving into a level 2 or level 3 approach.

Rogue units

- There is a special category of high–failure rate items generally referred to as rogue units.
- These are not unit types (i.e., black boxes, component parts, etc.) that have high failure rates but rather individual units of a type (serial numbered or not) which seem to fail regularly.
- As an example, suppose you have 25 black boxes (radios, for example) and you have failures in 10 of these boxes over a month. Each time the failure occurs it is a different box or a different aircraft.
- This may be considered a high failure rate for the system or unit, but it is not referred to as a rogue unit.
- On the other hand, if most or all of the failures involve a single unit (serial numbered or not), then that specific unit might be considered a rogue
- A rogue unit can sometimes be fixed if you know what components are causing the problem and these components can be exchanged or reworked. This task is usually left to the manufacturer, but it is often too expensive or even impossible to do. In most cases of rogue units, it is more sensible to remove the errant unit from the supply system. Although this may be difficult to do with units as expensive as those used on modern aircraft, that cost must be compared with the cost of continual maintenance, as well as with the cost of rebuilding the unit.

Bogus parts

- Rogue units should not be confused with bogus parts.
- Bogus parts are those parts built by vendors or contractors that are not up to the original manufacturer's specifications, and very often, those parts that are built without authorization by the original manufacturer or the regulatory authority.
- These parts are usually cheaper, which is the primary attraction, but they are also inferior. Generally, they have high failure rates, poor wear-out properties, or other detrimental performance characteristics.
- Although there is a considerable difference between rogue units and the bogus units, the airline's reliability program should be able to find and eliminate both types.

Basic concepts of trouble shooting.

- Part of the troubleshooting process is knowledge and experience; the rest is a combination of logical procedure, innovation, and sometimes, luck.
- The simplicity of certain equipment or systems may permit the omission of some of the following steps while the complexity of others may require a more detailed procedure

The following eight concepts should cover the bulk of your troubleshooting efforts.

1. Know your equipment. When it comes to troubleshooting any system—no matter how simple or complex—nothing will serve you better than a good understanding of

how the system works. Know all its functions, its operational modes, and the failure modes and their effects in each mode and function.

2. Know how the controls and displays work. The troubleshooting process often requires you to operate and adjust the various controls and switches on your equipment, to turn it on, run it through various tests, and check out its over-all operation. Know how the operator uses the equipment and what modes or configurations he or she uses. This will help you understand what they tell you in the malfunction reports which are given to you.
3. Know how other equipment interfaces with your own. Know what ancillary equipment is connected to the system or equipment you are working on (including BITE). Many of today's avionics systems rely on inputs from other systems. Sometimes electrical, electronic, and/or mechanical inputs from ancillary equipment affect the operation and function of your own system. These interactions must be known and their effects must be known, both the effect on your system when the interfacing equipment is working properly and when is not. The effect on your system when the input signal is not there or is incorrect must also be known.

   Know the outputs from your system and where they go. Understand how other equipment receiving your outputs can effect your own equipment. Bad or missing inputs from your system can affect return data; shorting out or block-ing of inputs from your system by the ancillary equipment could also affect your system. These differ from system to system.

4. Know and understand the maintenance documents. The maintenance, schematic, and wiring diagram manuals provided with the equipment are your best source of information about how your equipment or system works. They also provide data on equipment that interface with yours and how these work. The documents will tell you how to turn on and operate the equipment (yours and theirs) and what prerequisites and precautions are necessary for safe operation; that is, electrical, hydraulic, or pneumatic systems that need to be on or off, what circuit breakers need to be in or out, and similar setup requirements during testing and troubleshooting.
5. Approach the problem in a systematic and logical manner. Once the neces-sary preparation has been taken to accommodate the above steps, the actual troubleshooting can begin. You must proceed systematically and logically from the known symptoms to the cause. This is easier said than done, of course. The first approach would be to follow the obvious track, then the not so obvious, and finally, if those approaches do not work, start addressing the improbable or the seemingly impossible.
6. Analyze the information available in light of equipment operation. Some basic determinations should be made at the outset of troubleshooting in order to establish the plan of attack. The following five steps are guidelines:
   (a) Determine what is and is not working properly. If two or more modes or functions are faulty, determine if there are any commonalities between (or among) these and look for a common cause.
   (b) Determine whether or not the equipment is operating correctly but inaccurately, or determine if it is operating incorrectly or not at all.

(c) Determine if one, several, or all modes of operation are affected. Based on those symptoms, zero in on the appropriate problem area by determining what area(s) the problem could (or must) be in.

(d) Identify what other systems interface with yours and determine their effects (if any) on the problem at hand.

(e) Analyze how the equipment is used or operated.

7. Be able to perform complete checkout procedures on the equipment and under-stand the results. There are usually established procedures for checking out a system:
(a) ground checks on the aircraft (operational checks, functional tests);
(b) bench checks in the shop;
(c) built-in test equipment (BITE) in the unit itself. The BITE system may have an internal fault that results in an erroneous indication.

8. Be able to use the proper tools and test equipment needed for the job. Many troubleshooting activities are assisted and enhanced by the use of common or specialized tools and/or test equipment. Knowledge and understanding of how these tools should be used and how this equipment works is essential to effective application of them to problem solving. Know the capabilities and limitations of these tools and this equipment as well as that of the system you are troubleshooting. It is equally important that you are able to deter-mine whether or not the tools and test equipment are working correctly.

Code No: **R17A2122** **R17**

MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY

(Autonomous Institution – UGC, Govt. of India)

IV B.Tech I Semester Supplementary Examinations, July/August 2021

Aircraft Maintenance Engineering

(AE)

Roll No										

Time: 3 hours **Max. Marks: 70**

Answer Any **Five** Questions
All Questions carries equal marks.
***

1	Discuss concept of reliability and redesign in context of maintenance	[14M]
2	Explain the following briefly: (a) Process – Oriented maintenance (b) Task- oriented maintenance	[7M] [7M]
3	Explain in detail the manager level functions of aircraft maintenance.	[14M]
4	Explain 'A' check and 'C' check planning in aircraft hangar maintenance	[14M]
5	Explain manager level functions in technical services directorate and outline of aviation maintenance program.	[14M]
6	Explain in detail about the maintenance planning documents.	[14M]
7	What are the problem areas of hangar maintenance? Brief about operation of overhaul shops.	[14M]
8	Explain about basic inspection policies in aircraft management.	[14M]

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R17

Code No: R17A2122

MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY

(Autonomous Institution – UGC, Govt. of India)

IV B.Tech I Semester Regular Examinations, February 2021

Aircraft Maintenance Engineering

(AE)

Roll No										

Time: 2 hours 30 min **Max. Marks: 70**

Answer Any **Five** Questions
All Questions carries equal marks.
***

1	Explain in detail about establishing a maintenance program in aircraft industry.	**[14M]**
2	Explain maintenance steering group (MSG) approach in steps in aircraft maintenance management with the help of line diagram	**[14M]**
3	Outline and briefly explain the aviation maintenance programme	**[14M]**
4	Explain in detail the managerial functions of overhaul shops directorate.	**[14M]**
5	Explain about multiple checks in production planning	**[14M]**
6	Explain about the airframe manufacturers training course and airline maintenance training.	**[14M]**
7	Explain about Maintenance Control Center responsibilities.	**[14M]**
8	What are the elements of reliability program? Explain in brief about safety regulations.	**[14M]**

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Code No: **R15A2125**

MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY

(Autonomous Institution – UGC, Govt. of India)

IV B.Tech I Semester Supplementary Examinations, October 2020

Aircraft Maintenance Engineering

(AE)

Roll No										

Time: 2 hours **Max. Marks: 75**

Answer Any **Four** Questions

All Questions carries equal marks.

***

1 Explain the following:
   a) Hard Time (HT) process
   b) On-condition (OC) process
   c) Condition Monitoring (CM) process

2 Explain about three types of structural inspection techniques.

3 What are the types of documentation? Explain

4 Why do you require aircraft certification? Explain.

5 Explain about airframe manufacturer`s training courses.

6 Explain the concept of engineering order preparation.

7 What are the functions of material directorate? Explain.

8 What are the basic inspection policies? Explain.

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MALLAREDDY COLLEGE OF ENGINEERING AND TECHNOLOGY
(UGC- AUTONOMOUS –Govt. OF INDIA)
IV-B.TECH – I SEMESTER AERONAUTICAL ENGINEERING
AIRCRAFT MAINTENANCE ENGINEERING (R15A2125)

Model Paper-I
MAXIMUM MARKS: 75

PART A **Max Marks: 25**

i. All questions in this section are compulsory
ii. Answer in TWO to FOUR sentences.

1.

a) Define Maintenance (3)
b) Mention two types of maintenance (2)
c) What is MSG approach (3)
d) Define hard time Process (2)
e) State two maintenance tasks for Structural task items (3)
f) Define Quality Assurance (2)
g) Define reliability (3)
h) What is meant by line maintenance (2)
i) Write contents of Airframe log book (2)
j) State purpose of certificate of personnel (3)

PART B **Max Marks: 50**

a. Answer only one question among the two questions in choice.
b. Each question answer (irrespective of the bits) carries 10M.

2. Explain failure rate pattern with a neat sketch [10]

OR

3. Explain Manager level Functions of aircraft maintenance [10]

4. Explain maintenance steering group (MSG) approach in steps in aircraft maintenance management with the help of line diagram [10]

OR

5. Explain Process oriented approach [10]

6. Explain necessity of development of maintenance program [10]

OR

7. Explain functions of engineering department in tech service. [10]

8. Draw the M & E Organization chart and explain its features in detail [10]

OR

9. What are the problem areas of hangar maintenance? Brief about operation of overhaul shops [10]

10. Explain about ground support equipment (GSE) in hangar maintenance of aircraft [10]

OR

11. Explain about basic inspection policies in aircraft management [10]

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(UGC- AUTONOMOUS –Govt. OF INDIA)
IVB.TECH – I SEMESTER AERONAUTICAL ENGINEERING
AIRCRAFT MAINTENANCE ENGINEERING (R15A2125)

Model Paper-II
MAXIMUM MARKS: 75

PART A **Max Marks: 25**

i. All questions in this section are compulsory
ii. Answer in TWO to FOUR sentences.

a) Outline any two maintenance objectives (2)
b) Write ant two FAA requirements (3)
c) Define OC activity (2)
d) Mention any maintenance tasks for aircraft systems (3)
e) Write any two differences of Engineer & Mechanics in their role (2)
f) Define Quality Control (3)
g) State any two functions of MCC (2)
h) Mention contents of engine log book (3)
i) Differentiate between line & hangar maintenance (2)
j) State about technical records (3)

PART B **Max Marks: 50**

a. Answer only one question among the two questions in choice.
b. Each question answer (irrespective of the bits) carries 10M.

2. List out differences between intra flight (TRS) & last flight servicing [10]

OR

3. Explain Manager level Functions of aircraft maintenance [10]

4. Explain task oriented maintenance approach [10]

OR

5. Explain HT and OC process [10]

6. Explain about production control & feedback for planning [10]

OR

7. Explain about multiple checks in production planning [10]

8. What are the functions of material directorate [10]

OR

9. Discuss about fault isolation and fault report manual [10]

10. What are the elements of reliability program? Explain in brief about safety regulation [10]

OR

11. Explain about Aircraft Certification & ATA document standards. [10]

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(UGC- AUTONOMOUS –Govt. OF INDIA)
IVB.TECH – I SEMESTER AERONAUTICAL ENGINEERING
AIRCRAFT MAINTENANCE ENGINEERING (R15A2125)

Model Paper-III
MAXIMUM MARKS: 75

PART A **Max Marks: 25**

i. All questions in this section are compulsory
ii. Answer in TWO to FOUR sentences.

1.
a) Write goals of maintenance (3)
b) Define CM activity (2)
c) Define Zonal maintenance task (3)
d) State two functions of technical service directorate (2)
e) What is the main role of MCC (2)
f) State line station activity (3)
g) What is type ‘C’ check (3)
h) Write any two functions of material directorate. (2)
i) Define maintenance (3)
j) Define aircraft certification (2)

PART B **Max Marks: 50**

a. Answer only one question among the two questions in choice.
b. Each question answer (irrespective of the bits) carries 10M.

2. Explain role of an engineer of aircraft maintenance. [10]

OR

3. Explain role of mechanic in aircraft maintenance. [10]

4. Explain steps in detail about MSG approach .[10]

OR

5. Explain in detail about process oriented approach .[10]

6. Explain the role of Quality control organization in aircraft maintenance Management .[10]

OR

7. Explain about requirement of Quality Assurance .[10]

8. Explain about makeup of line maintenance .[10]

OR

9. Write functions of MCC .[10]

10. What are the elements of reliability program? Explain in brief about safety regulation .[10]

OR

11. Write short notes on .[10]
    a) Aircraft certification
    b) ATA document standards.
    .

MALLAREDDY COLLEGE OF ENGINEERING AND TECHNOLOGY

(UGC- AUTONOMOUS –Govt. OF INDIA)

IVB.TECH – I SEMESTER AERONAUTICAL ENGINEERING

AIRCRAFT MAINTENANCE ENGINEERING (R15A2125)

Model Paper-IV

MAXIMUM MARKS: 75

PART A **Max Marks: 25**

i. All questions in this section are compulsory
ii. Answer in TWO to FOUR sentences.

1.

a) Define reliability (2)
b) Write goals of maintenance (3)
c) Define CM activity (2)
d) What is current MSG process (3)
e) Define engineering order (2)
f) Draw organization chart of technical services directorate (3)
g) Define Quality control (2)
h) What do you understand by Ground service equipments (3)
i) Define maintenance (2)
j) Define aircraft certification (3)

PART B **Max Marks: 50**

a. Answer only one question among the two questions in choice.
b. Each question answer (irrespective of the bits) carries 10M.

1. Explain about establishing a maintenance program. [10]

OR

2. Explain the managerial functions of overhaul shops directorate. [10]

3. Explain MSG-3 level –I analysis failure category approach [10]

OR

4. Explain MSG-3 level –II analysis hidden failure. [10]

5. Explain the role of Production planning & control in maintenance Management [10]

OR

6. Explain about Maintenance Control Center responsibilities. [10]

7. Explain about makeup of line maintenance. [10]

OR

8. Explain about overhaul shop operations [10]

9. Explain about requirement of Quality assurance. [10]

OR

10. Write short notes on [10]
    a) Statistical reliability
    b) Dispatch reliability.

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(UGC- AUTONOMOUS –Govt. OF INDIA)

IVB.TECH – I SEMESTER AERONAUTICAL ENGINEERING

AIRCRAFT MAINTENANCE ENGINEERING (R15A2125)

Model Paper-V

MAXIMUM MARKS: 75

PART A **Max Marks: 25**

i. All questions in this section are compulsory
ii. Answer in TWO to FOUR sentences.

1.
a) Define redesign (2)
b) State two failure pattern (3)
c) Define HT activity (2)
d) Define Zonal maintenance task (3)
e) Define engineering order (2)
f) Draw organization chart of technical services directorate (3)
g) Define quality assurance (2)
h) Write three differences of FAA & JAA (3)
i) Define maintenance (2)
j) State any two QC inspector qualifications (3)

PART B **Max Marks: 50**

a. Answer only one question among the two questions in choice.
b. Each question answer (irrespective of the bits) carries 10M.

2. Explain goals & objectives of maintenance [10]

OR

3. Discuss concept of reliability and redesign in context of maintenance [10]

4. Explain maintenance task for airframe systems in task oriented maintenance [10]

OR

5. Explain task for structural items for task oriented maintenance [10]

6. Explain manager level functions in technical services directorate. [10]

OR

7. Explain ‘A’ check and ‘C’ check planning in aircraft hangar maintenance [10]

8. Explain about maintenance planning document [10]

OR

9. Explain about overhaul non-routine parts, parts availability & saga of parts robbing [10]

10. Explain about organization structure &TPPM [10]

OR

11. Explain about ISO-9000 quality standards in aircraft maintenance management [10]