INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad -500 043

AERONAUTICAL ENGINEERING

IV B. Tech I semester (JNTUH-R15)

AIRCRAFT MAINTENANCE ENGINEERING

Elective II

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UNIT – 1

Philosophy of Aircraft Maintenance

Aviation Maintenance Program Outlined (AC 120-16D)

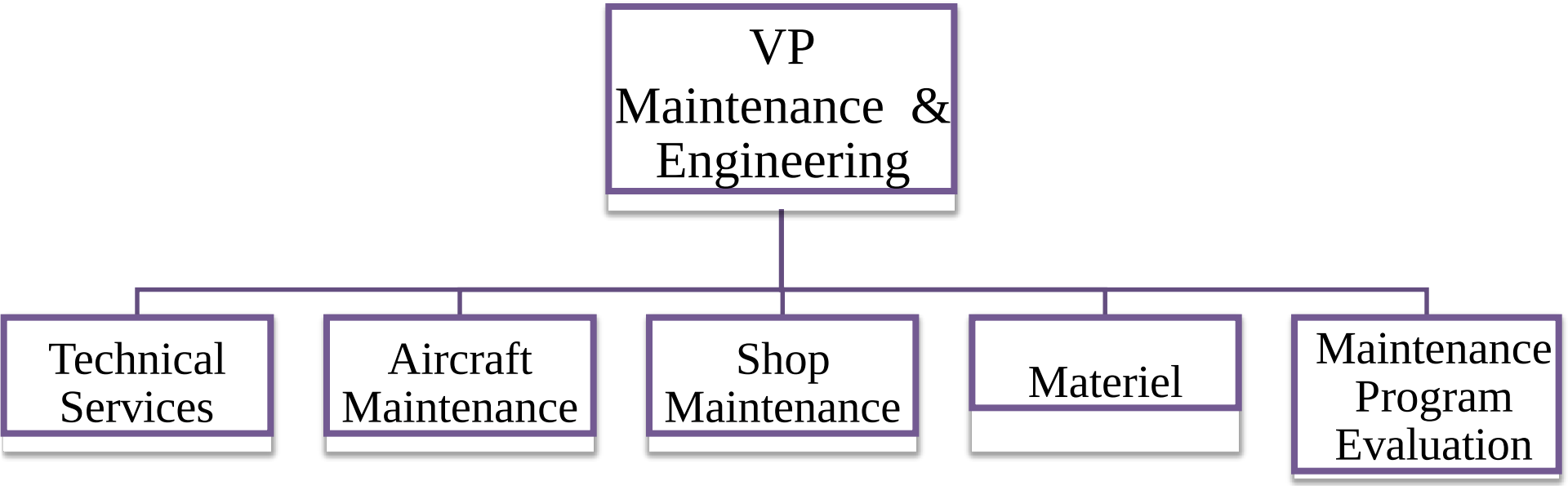
1. Airworthiness responsibility
2. Maintenance manual
3. Maintenance organization
4. Maintenance schedule
5. Maintenance record keeping system
6. Accomplishment and approval of maintenance and alterations
7. Contract Maintenance
8. Continuing analysis and surveillance
9. Personnel training
10. Hazardous materials and dangerous goods

- Additional Maintenance Program Requirements
  - Engineering
  - Material
  - Planning
  - Maintenance control center
  - Training
  - Computing
  - Publications

The Maintenance and Engineering Organization

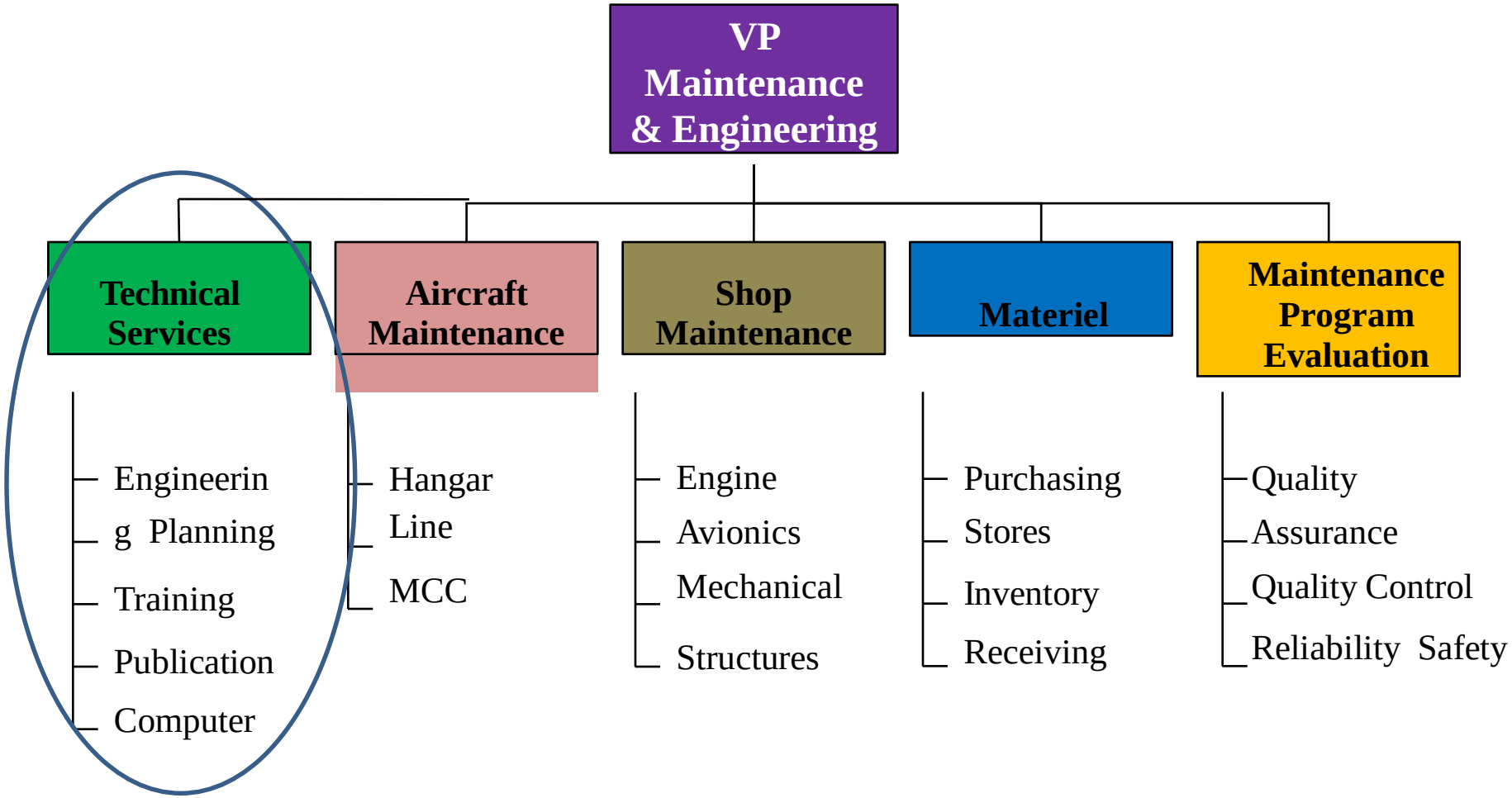
- Organization of Maintenance and Engineering
- Organizational Structure
  - Span of control
  - Grouping of similar functions
  - Separation of production and oversight function

The Maintenance & Engineering Organizational Chart



General Groupings

The Maintenance & Engineering Organizational Chart



Manager Level Functions

- **Technical Services Directorate**
  - Engineering
  - Production and planning control
  - Training
  - Technical publications
  - Computing services
- **Aircraft Maintenance Directorate**
  - Hangar Maintenance
  - Line Maintenance
  - Maintenance control center
- **Overall Shops Directorate**
  - Engine shops
  - Avionics shop
  - Mechanical component shops
  - structures
- **Materiel Directorate**
  - Purchasing
  - Stores
  - Inventory control
  - Shipping and receiving
- **Maintenance Program Evaluation Directorate**
  - Quality assurance
  - Quality control
  - Reliability
  - Safety

- Summary of Management Levels
- Organizational Structure and the TPPM
- Variations from the Typical Organization
  - Small airlines
  - Large airlines
  - Full versus partial organizational structure

HANGER


MISSION CONTROL CENTER
esa
PAYLOAD DEPLOY/
RETRIEVAL PANEL

ATC

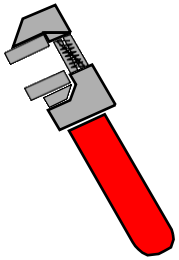
STOCK ROOM

TOOLS

- The Role of the Engineer
- The Role of the Mechanic
- Two Types of Maintenance
- Reliability
- Redesign
- Failure Rate Patterns
- Other Maintenance Considerations
- Establishing a Maintenance Program

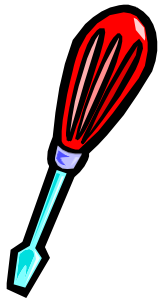
UNIT - 2

Development of Maintenance Program



Development of maintenance program

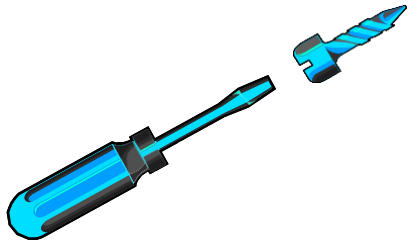
- Introduction
- Maintenance Steering Group (MSG) Approach
- Process-Oriented Maintenance
- Task-Oriented Maintenance
- Maintenance Program Documents
- Maintenance Intervals Defined
- Changing Basic Maintenance Intervals



Introduction

- Two basic approaches to Maintenance
  - Process-oriented
  - Task-oriented

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



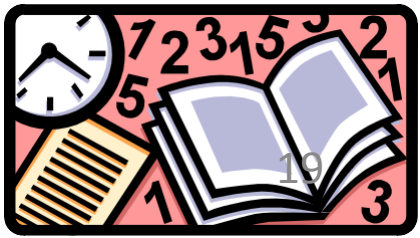
Process-oriented Approach

- Hard time (HT)
  - is the removal of an item at a predetermined interval (hrs, cycles, calendar time).
- On-condition (OC)
  - item will be checked at specific intervals (hrs, cycles, or calendar time).
- Condition monitoring (CM)
  - monitors failure rates, removal rates etc. to facilitate maintenance planning.
- HT and OC are for components or systems that have definite life limits or detectable wear out periods.
- CM items are operated to failure and failure rates are tracked to aid in future prediction or failure rate prevention.

HARD TIME (HT)

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

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



ON-CONDITION (OC)

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

– Examples

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

CONDITION MONITORING (CM)

CM components are operated until failure occurs unscheduled maintenance

- ATA states regarding CM:
  - Item has no direct, adverse effect on safety
  - Must not have any “hidden function” (not evident to crew) that could effect safety
  - Must be in condition monitoring or reliability program
  - Avionics and electronic components
- Basic elements include – data on unscheduled removals, maintenance log entries, on-board data systems, shop findings etc. – can be used to adjust HT and OC intervals
- Only monitors failure not the condition of items

Task-oriented Approach

- Uses predetermined maintenance tasks to avoid in-service failures
- Redundancy and reliability programs utilized
- “Top-down” approach or“ consequence of failure”– safety driven
- Used to identify suitable scheduled maintenance tasks to prevent failures and maintain the inherent reliability of the system
- Three categories:
  - Airframe systems tasks
  - Structural item tasks
  - Zonal tasks

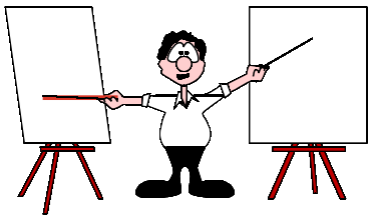
Maintenance Tasks for Airframe Systems

- Lubrication
- Servicing
- Inspection
- Functional Check
- Operational Check
- Visual Check
- Restoration
- Discard

Maintenance Tasks for Structural items

Structural deterioration

- Environmental Deterioration
  - Climate or environment – may be time dependent
  - Accidental Damage
  - Result of human error or impact with an object
  - Fatigue Damage
  - Crack or cracks due to loading or stress



Structural inspection techniques

- General Visual Inspection
  - Visual exam that will detect obvious conditions or discrepancies
- Detailed Inspection
  - Use of inspection aids, (i.e. mirrors, hand lenses) may require surface cleaning and detailed access
- Special Detailed Inspection
  - Use of Nondestructive inspection (NDI): dye penetrant, high- powered magnification, magnetic particle, eddy current

Zonal Maintenance Tasks

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

- Look, listen, and feel test
  - General visual inspection
  - Detailed visual inspection

Maintenance Steering Group Approach (MSG)

- Began in 1968 (B747) with reps from Boeing's design and maintenance groups, from the suppliers, airlines who desired to purchase aircraft and the FAA.
- 6 Industrial Working Groups IWGs:
  - structures
  - mechanical systems
  - engine and auxiliary power plant (APU)
  - electrical and avionics systems
  - flight controls and hydraulics
  - zonal
- Used "bottom-up" review to determine which process to use HT, OC or CM.

MSG-2

- **Systems and components**
- **Structures**
- **Engines**

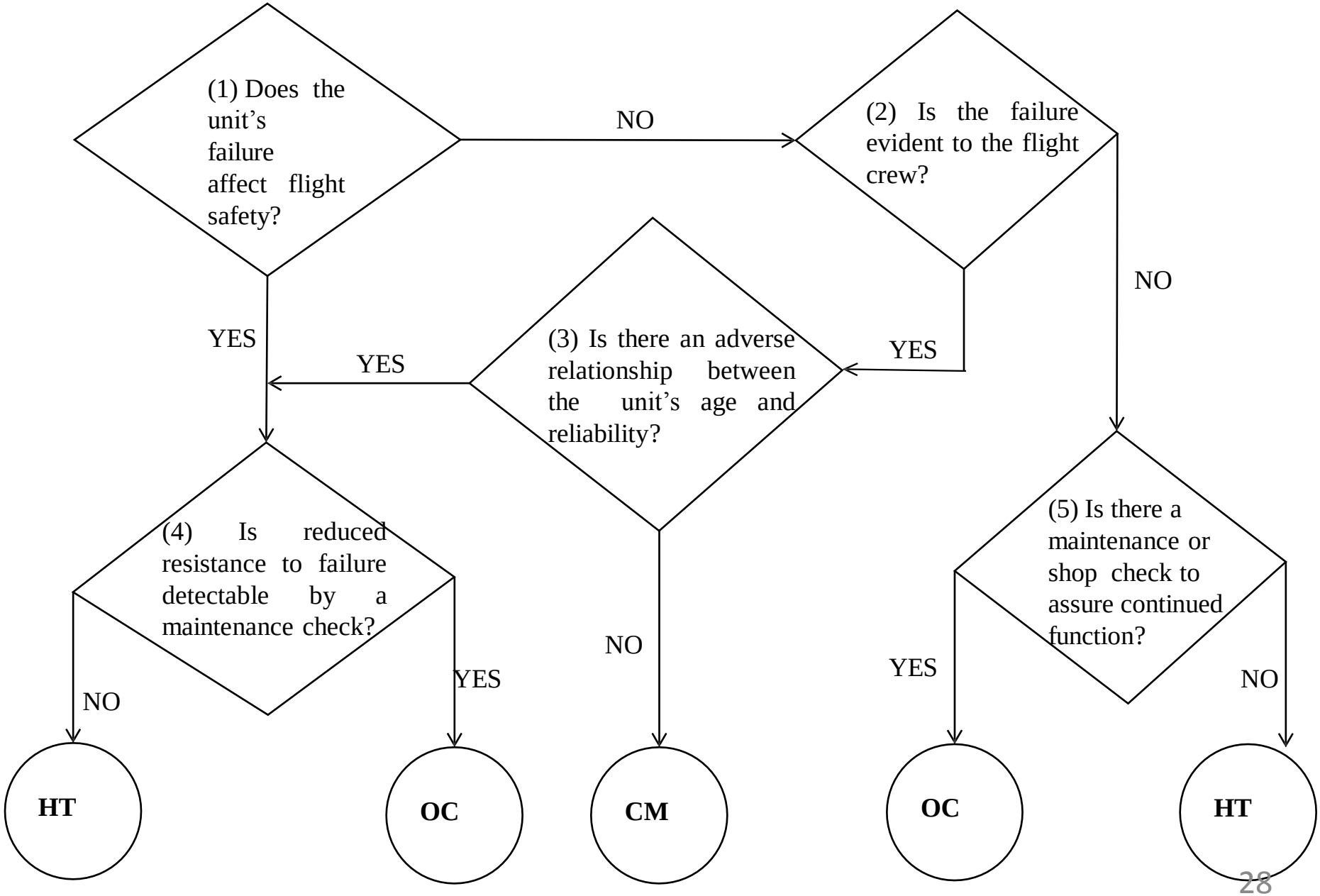
Step1 identify the maintenance or structure items requiring analysis.

Step2 identify the functions and failure modes associated with the item and the effect of a failure.

Step3 identify those tasks which may have potential effectiveness.

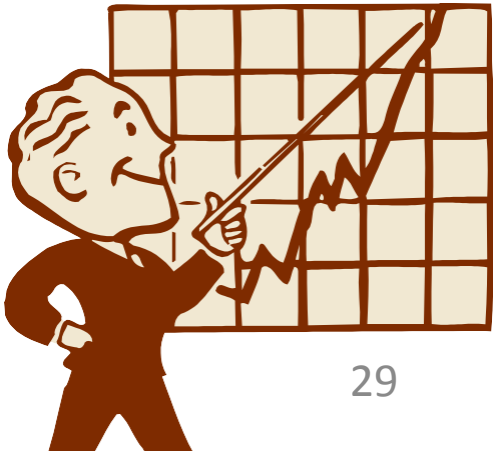
Step4 assess the applicability of those tasks and select those deemed necessary.

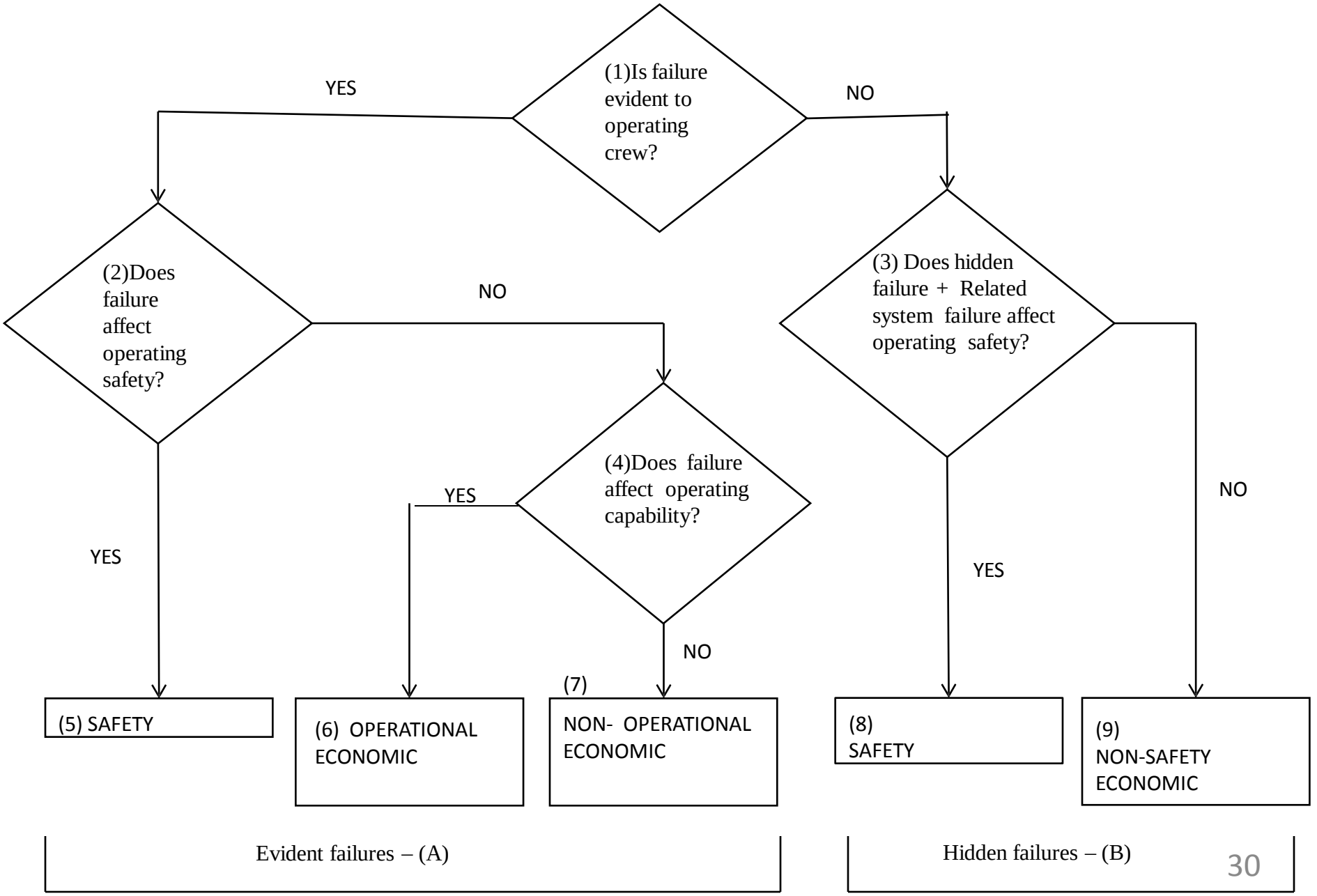
Step5 for structures only, evaluate initial sampling thresholds.

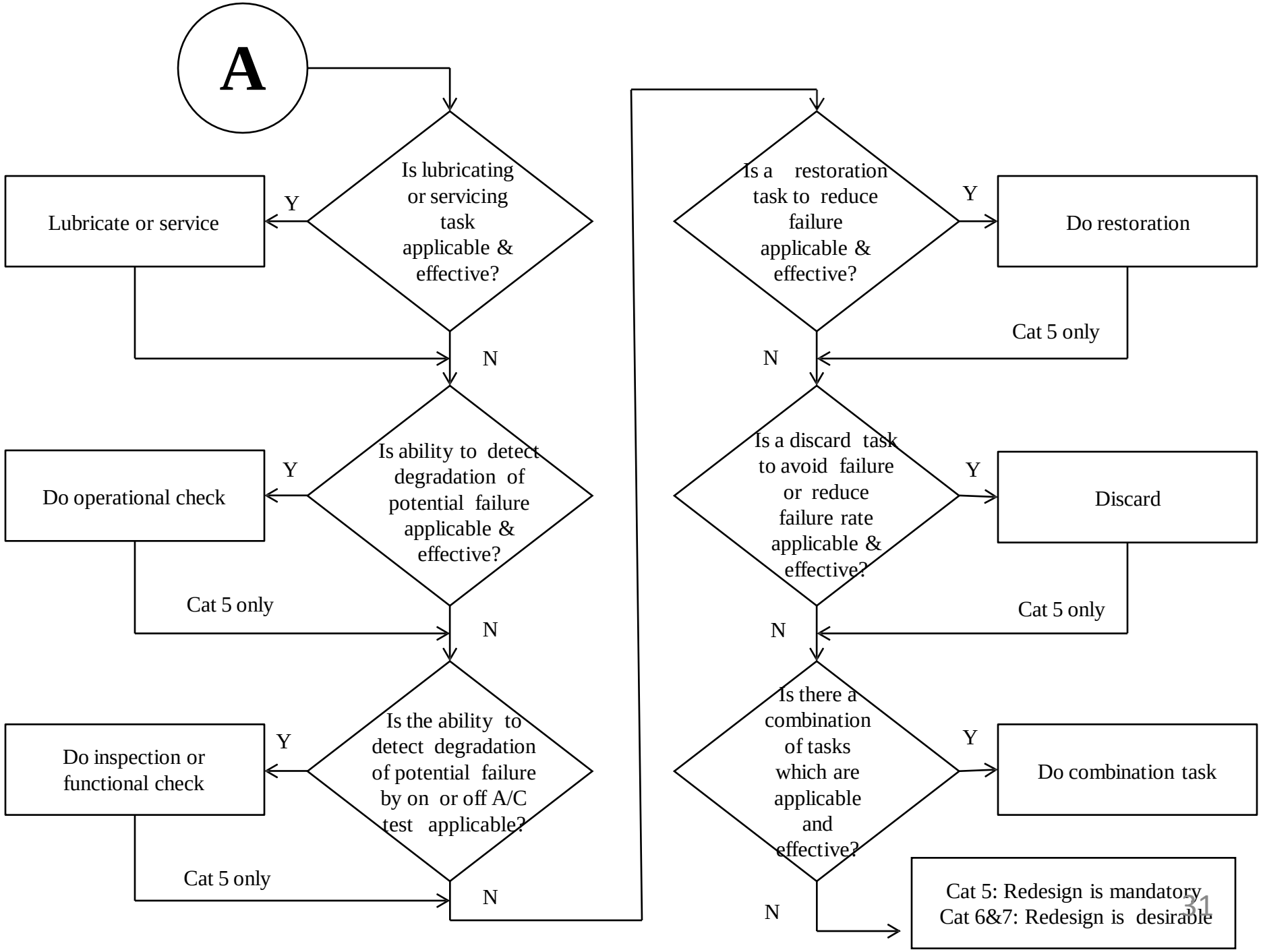

(1) Does the unit's failure affect flight safety?
NO
(2) Is the failure evident to the flight crew?
YES
NO
YES
YES
(3) Is there an adverse relationship between the unit's age and reliability?
(4) Is reduced resistance to failure detectable by a maintenance check?
(5) Is there a maintenance or shop check to assure continued function?
NO
YES
NO
YES
NO
HT
OC
CM
OC
HT

MSG-3

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




(1)Is failure evident to operating crew?
YES
NO
(2)Does failure affect operating safety?
NO
(3) Does hidden failure + Related system failure affect operating safety?
(4)Does failure affect operating capability?
YES
YES
NO
YES
NO
(5) SAFETY
(6) OPERATIONAL ECONOMIC
(7)
NON- OPERATIONAL ECONOMIC
(8)
SAFETY
(9)
NON-SAFETY ECONOMIC
Evident failures – (A)
Hidden failures – (B)


A
Is lubricating or servicing task applicable & effective?
Y
Lubricate or service
N
Is ability to detect degradation of potential failure applicable & effective?
Y
Do operational check
Cat 5 only
N
Is the ability to detect degradation of potential failure by on or off A/C test applicable?
Y
Do inspection or functional check
Cat 5 only
N
Is a restoration task to reduce failure applicable & effective?
Y
Do restoration
Cat 5 only
N
Is a discard task to avoid failure or reduce failure rate applicable & effective?
Y
Discard
Cat 5 only
N
Is there a combination of tasks which are applicable and effective?
Y
Do combination task
N
Cat 5: Redesign is mandatory
Cat 6&7: Redesign is desirable

Maintenance Program Documents

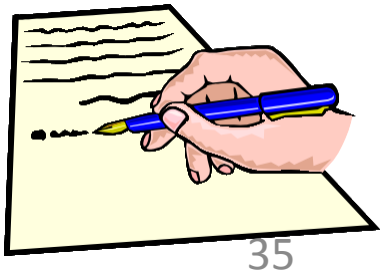
- Maintenance Review Board Report (MRBR)
  - Contains the initial scheduled maintenance program for US certificated operators
  - Includes the systems and power plant maintenance program, the structural inspection program, and the zonal inspection program
  - Also includes aircraft zone diagrams, a glossary, and list of abbreviations and acronyms

- **Maintenance Planning Document (MPD)**
  - Contains all the maintenance task information from the MRBR report plus additional tasks by the airframe manufacturer
  - At Boeing, Maintenance Planning Data(MPD)
  - At McDonnell-Douglas, On Air Maintenance Planning(OAMP)
  - At Airbus, Maintenance Planning Document(MPD)
  - Includes diagrams showing locations and numbering of access doors and panels, aircraft dimensions, planning for maintenance checks – to include man-hour requirements

Maintenance Interval Defined

- Most intervals are standard but airlines can create own intervals as long as the integrity of the original task is maintained or receive FAA approval
- Transit Check – pre-flight and turn
  - Visual, open/loose panels, fluid leaks
- 48 hour Checks – “daily”
  - Wheels, brakes, fluid levels, hydraulic fluid
- Hourly limit Checks – (100, 200, 250 etc.)
  - Engines, flight control systems

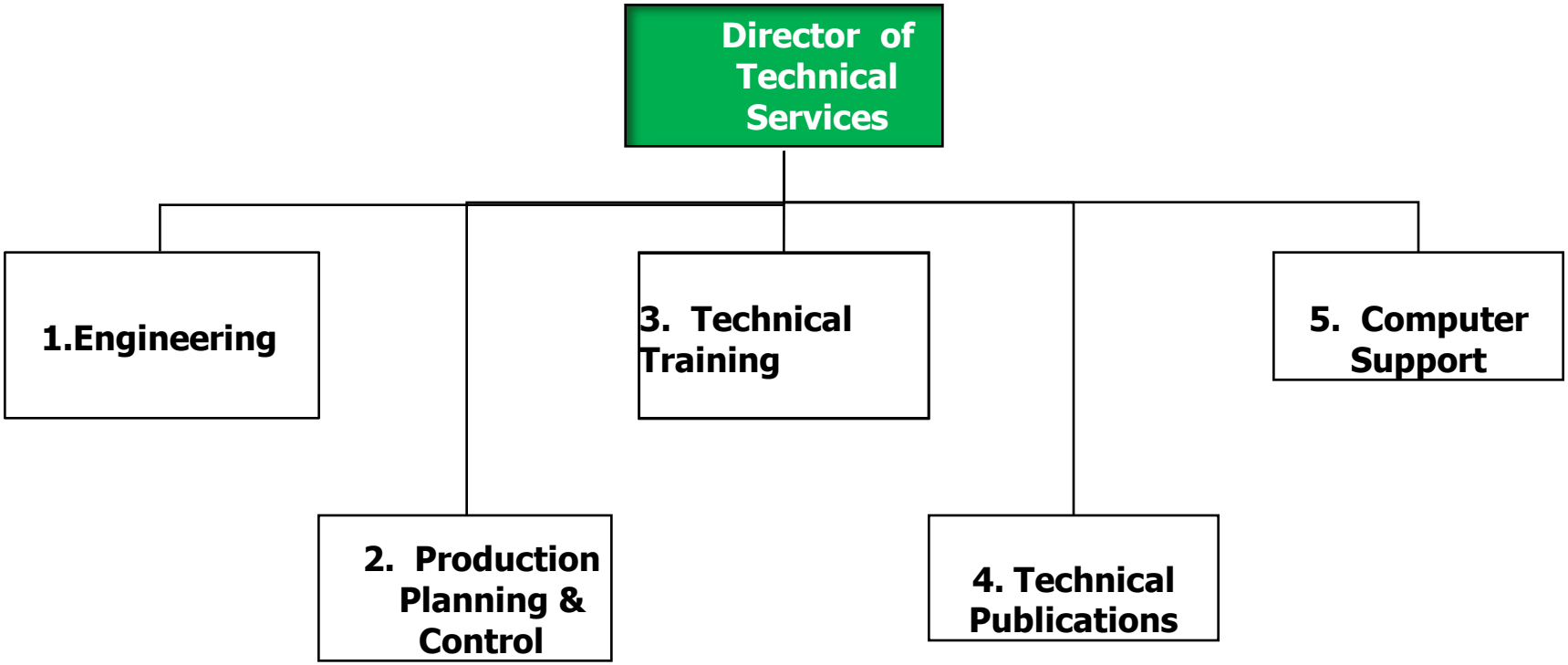
- Operating cycle limit Checks
  - Tires, brakes, landing gear, airframe structures
- Letter Checks – (A, B, C, and D)
  - Development of 777, MSG-3 eliminated checks
- Changing Intervals
  - Hot, humid climates – more CC
  - Dry, desert climates – check for sand and dust
  - As aircraft age, intervals for some items may shorten while others may lengthen



UNIT - 3

Technical Services

Organization Structure



Technical Services

1. Engineering department

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

Technical Service

2. Production planning and control

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

Technical Service

3. Training

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

Technical Service

4. Technical publications

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

Technical Service

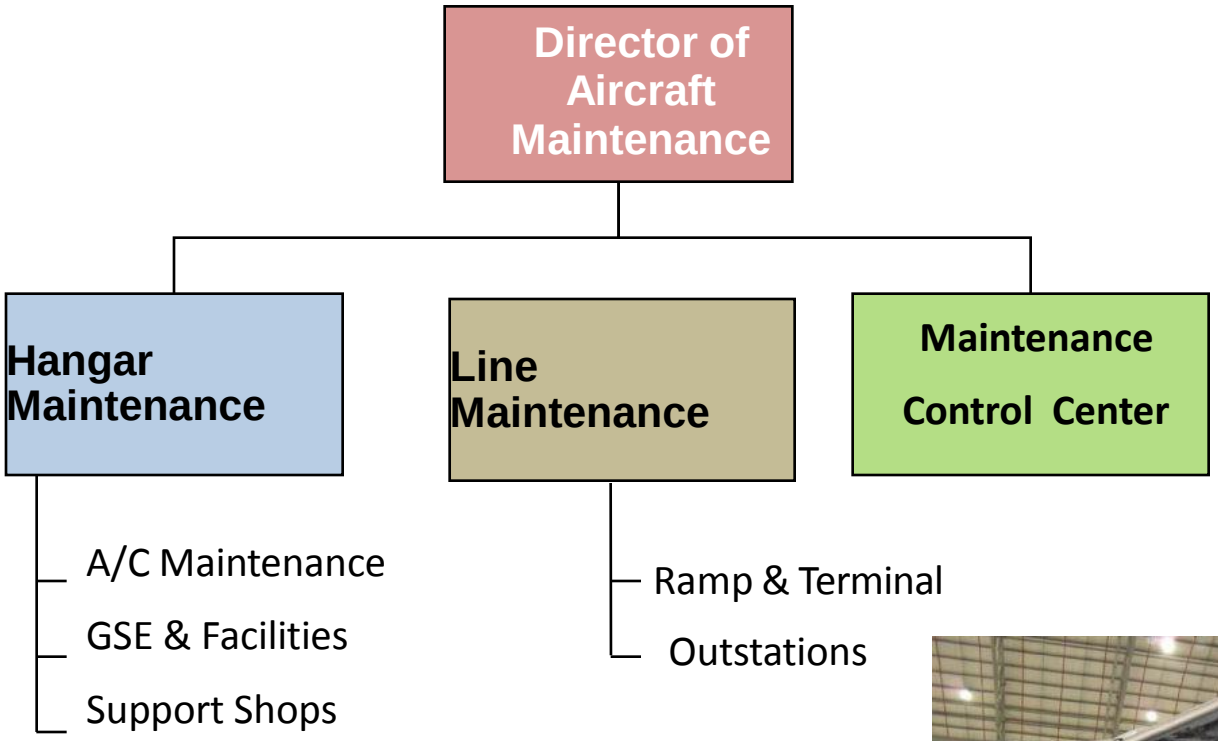
5. Computing services

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

UNIT - 4

Maintenance and Materiel Support

Organization Structure



Aircraft Maintenance Operations

1. Hangar maintenance

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

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

Aircraft Maintenance Operations

2. Line Maintenance

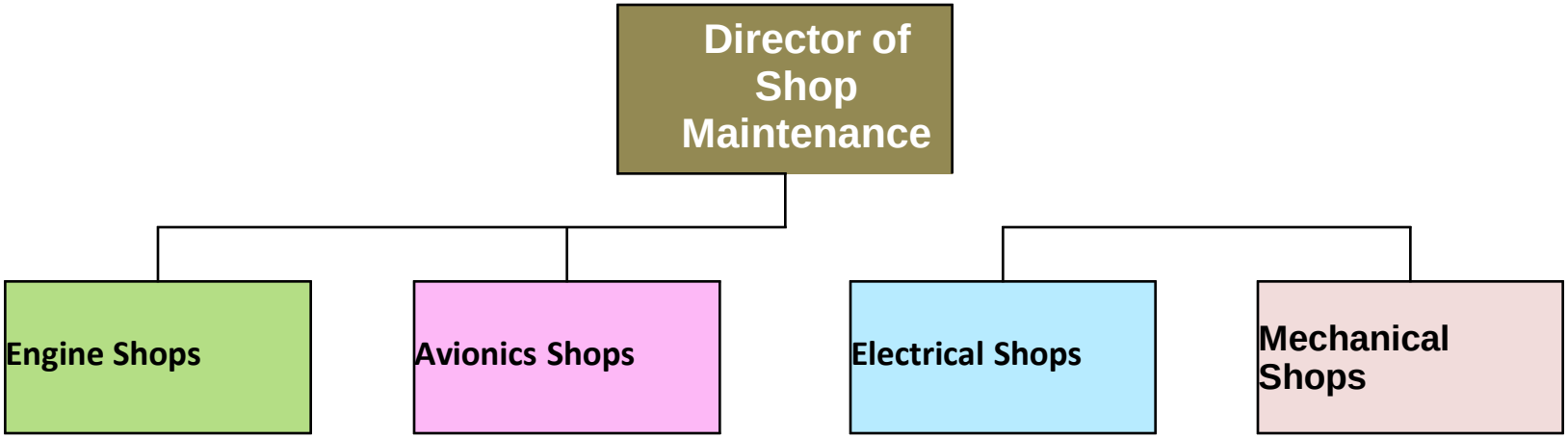
- Responsible for compliance with the airline's policies and procedures relative to the work done on the aircraft on the flight line while the aircraft is in service
  - Turnaround maintenance and servicing
  - Daily checks
  - Short interval checks (less than "A" check interval), and "A" checks. Sometimes
  - Simple modifications
  - Perform line maintenance activities for other airlines under contract

Aircraft Maintenance Operations

3. Maintenance Control Center - MCC

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

Organization Structure



1. Engine shops

Maintenance and repair done on the organization's engines and auxiliary power units (APUs).May be a separate engine shop for each type

2. Avionics (Electrical and electronics) shops All off-aircraft maintenance of electrical and electronics omponents and systems

May be several shops (radio, navigation, communications, computers, electric motor-driven components, etc.)

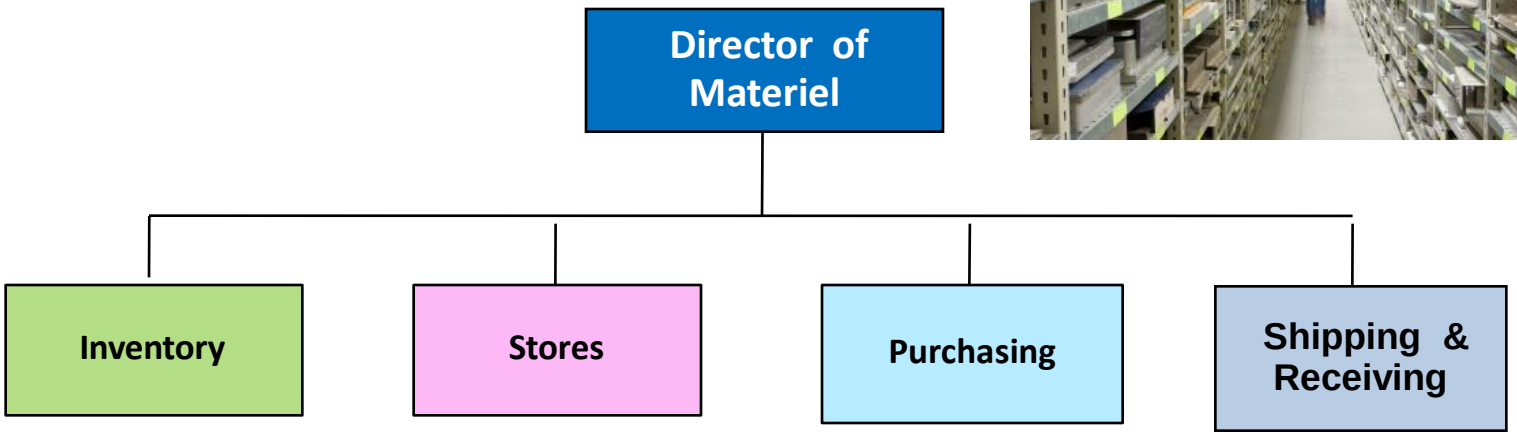
3. Mechanical component shops

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

4. Structures

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

Organization Structure



1. Inventory control

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

2. Stores

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

3. Purchasing

Buying parts and supplies and tracking these orders through the system.

Handling warranty claims and contract repairs

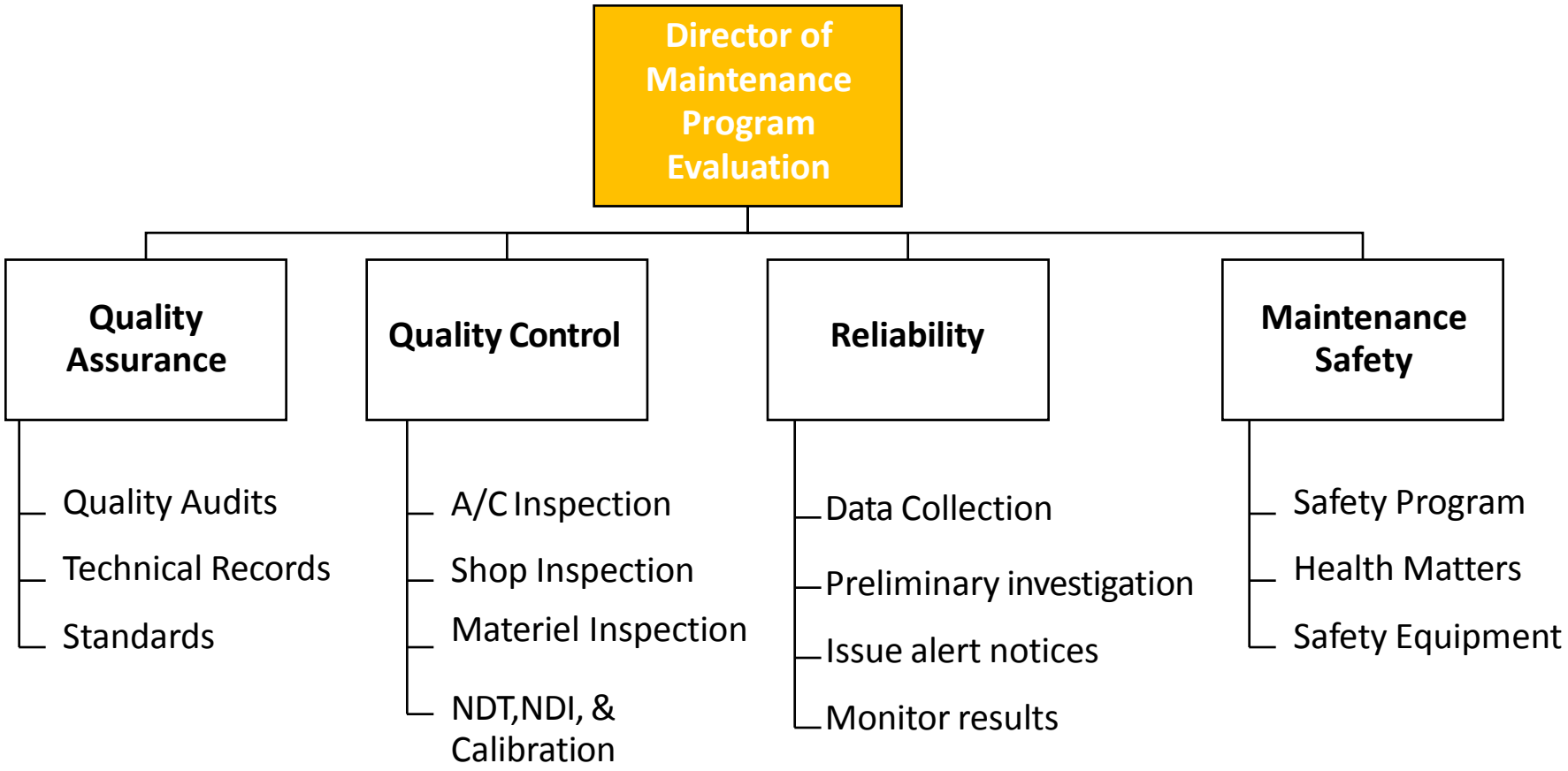
4. Shipping and receiving

Packing, waybill preparation, insurance, customs, etc. for outgoing materials as well as customs clearance, unpacking, receiving inspection, tagging, etc. for incoming materials.

UNIT - 5

Maintenance Documentation and Quality Assurance

Organization Structure



Function Quality program

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

Quality Assurance

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

Support

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

Safety

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

Supervision

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

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

What is Quality

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

Reliability

Definition (in statistical term):

'the probability of failure free operation of an item in a specified environment for a specified amount of time'

Examples:

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

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

Two main approaches of reliability in the aviation industry

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

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

Reliability Program (for maintenance)

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

Additional functions:

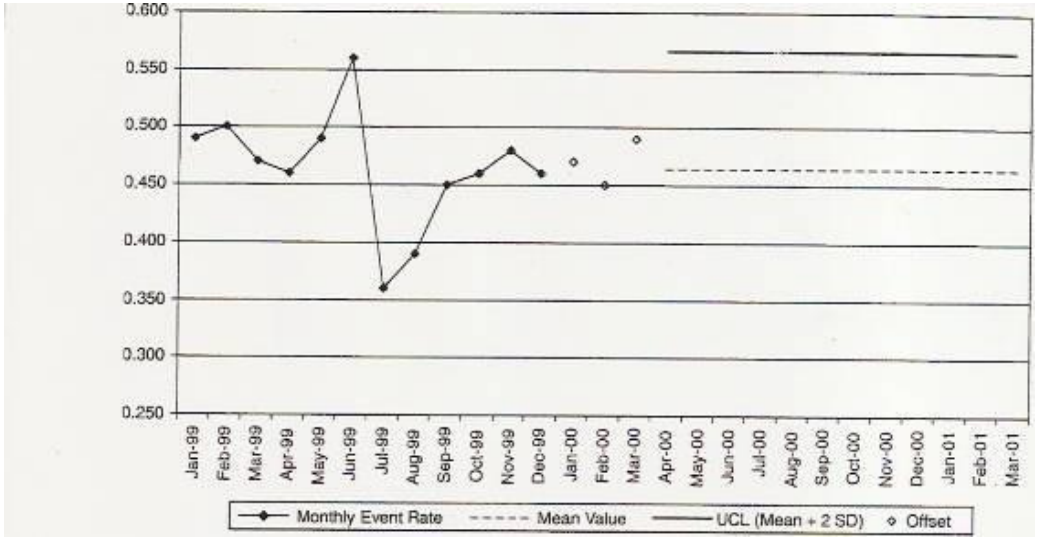
- Monitor the effectiveness of those corrective actions
- Provide data to justify adjusting the maintenance interval or maintenance program procedure as appropriate

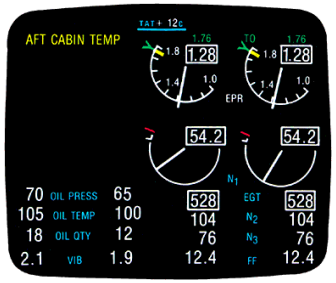
Maintenance programs have four types of reliability

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

Statistical reliability

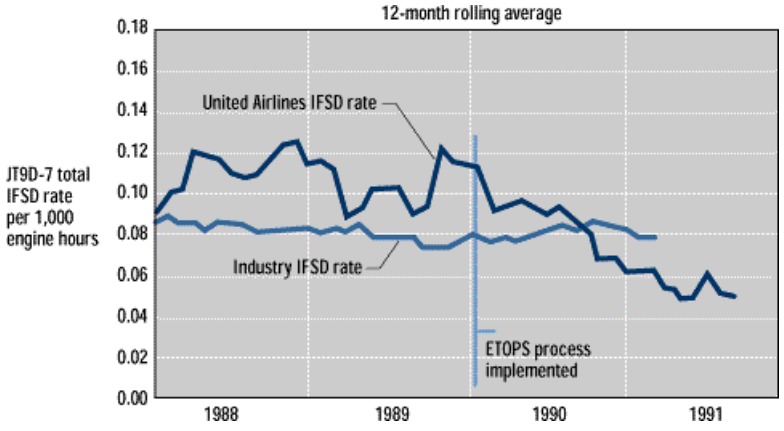
- Based upon collection and analysis of ‘events’ such as failure, removal, and repair rates of systems or components.

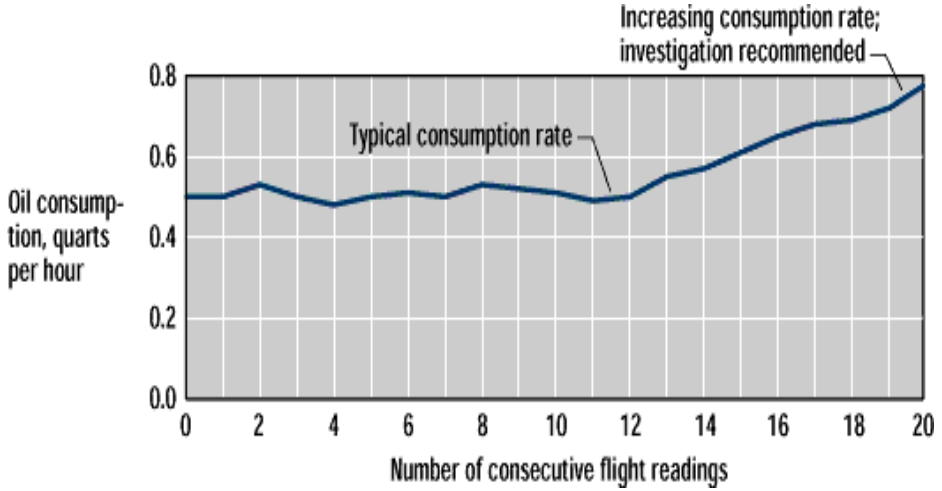




Historical reliability

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





Event-oriented reliability

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

Dispatch reliability

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

Danger of misinterpreted reliability data

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

Danger of misinterpreted reliability data (2)

- If the pilot and the flight operation unit knew the problem and informed the maintenance two hours before landing, the maintenance people can spent the time prior to landing to perform troubleshooting analysis and the delay could have been prevented. So, an alter in airline procedure can avoid the delay.
- A good reliability program should avoided same delay in the future by altering the procedure, not regardless of who or what is to blame.

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

1. The delay, which may/or may not be caused by rudder the problems
2. The 12 rudder write-ups that may ,in fact, be related to an underlying maintenance problem.

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

Elements of a Reliability Program

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

Data Collection:allows operator to compare present performance with the past, typical data type are:

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

Maintenance Safety

Aviation Safety Organization (AVS) Approach

- Incorporate SMS into our internal FAA Aviation Safety processes first and study requirements for industry
- Establish requirements
  - FAA Aviation Safety SMS Requirements Order contains both FAA Aviation Safety and industry requirements

FAA Aviation Safety SMS Program Office

- Supports the development and implementation of an integrated SMS for FAA

Aviation Safety

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