

Hydraulic and Pneumatic System

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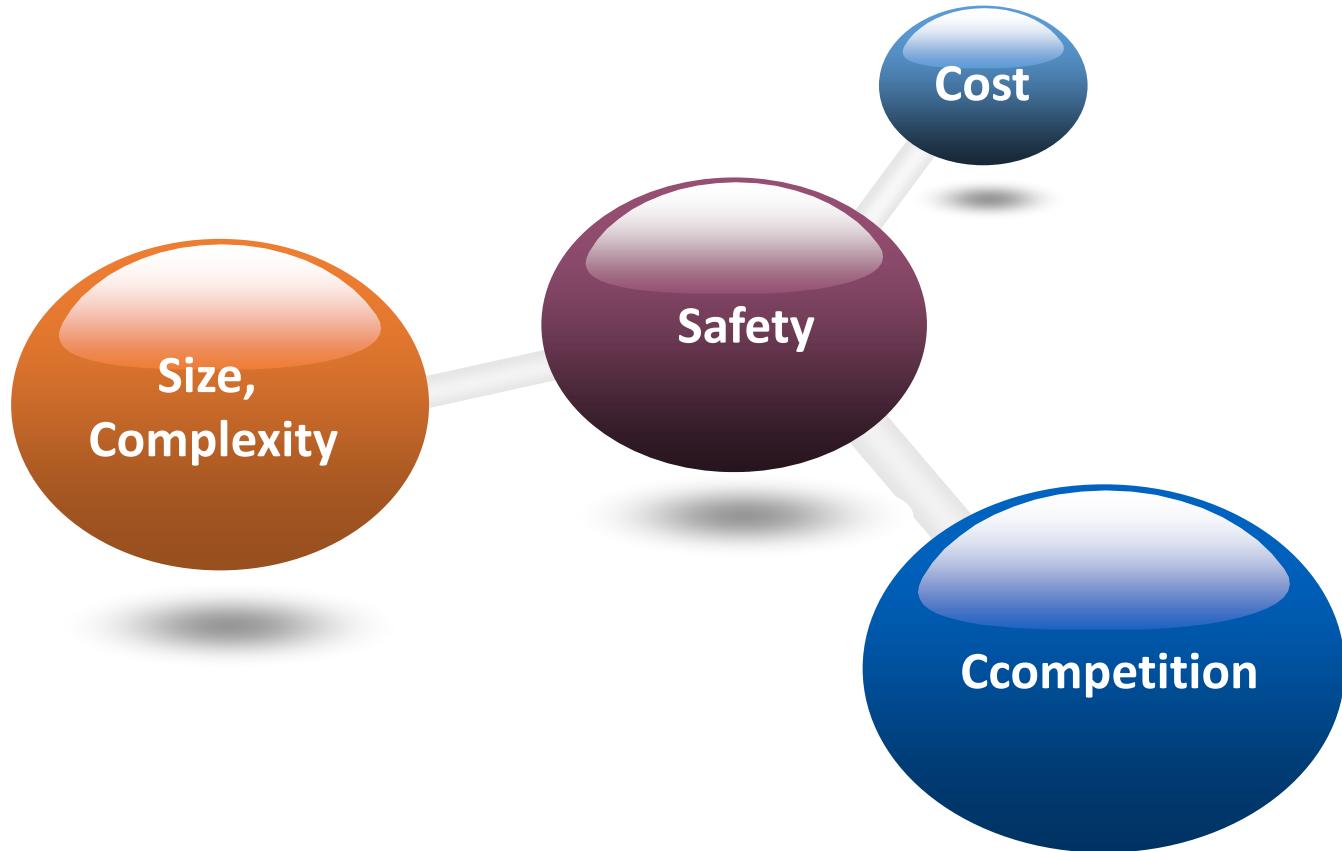


Aircraft Maintenance Engineering

- 1 Background**
- 2 Definition**
- 3 ME Objectives**
- 4 ME General Model**
- 5 ME Development**



Background



Background

Size and Complexity

- Size : the new kind of aircraft becomes very big. For example, the A380 could accommodate as many as 840 passengers, and the A380 would offer 30% - 50% more seating than the Boeing 747-400. The plane can fly nearly 15,000 kilometers without stopping. So Boeing will have competitors to the A380 in the future production.
- Complexity: the allocation of component redundancy is a way of improving the reliability of a system. Industrial standby safety systems, for example, are usually formed by two or three. In addition, there are a lot of safety/emergency systems or equipment in the aircraft.

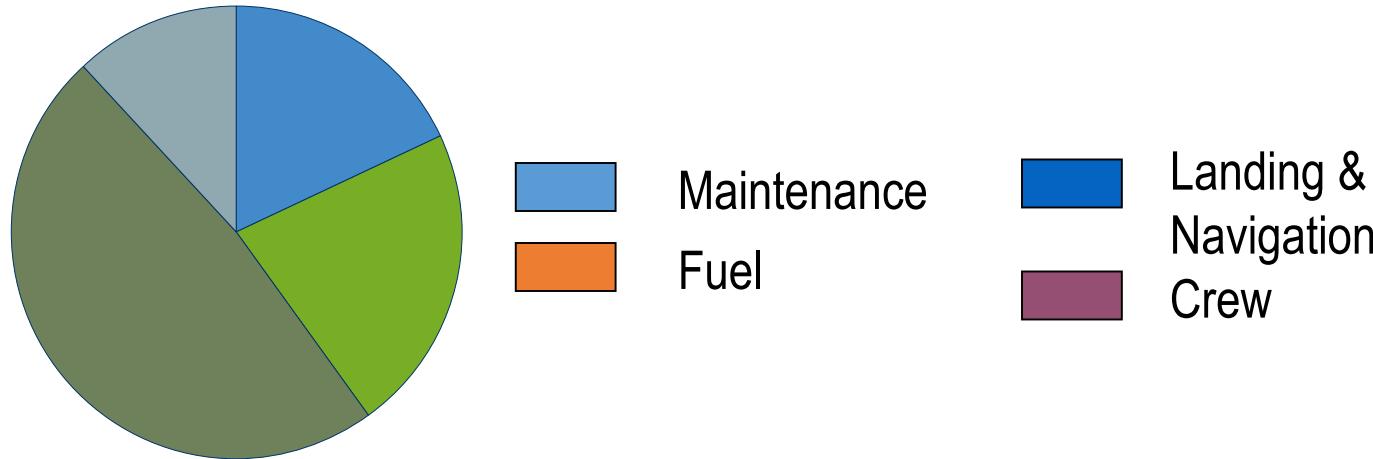
So, maintenance becomes more and more difficult and necessary.



Background

Cost

Each year billions of dollars are spent on equipment maintenance around the world



The maintenance cost of engine is about 2,000,000 dollars one time, and the airlines prove that maintenance cost can only been controlled and saved in the four kinds of costs.



Background

Competition

- Each year over \$300 billion are spent on plant maintenance and operations by U.S. industry, and it is estimated that approximately 80% of this is spent to correct the chronic failure of machines, systems, and people.
- In 1970, a British Ministry of Technology Working Party report estimated that maintenance cost in the United Kingdom (UK) was approximately £3000 million annually.
- Annually, the cost of maintaining a military jet aircraft is around \$1.6 million; approximately 11% of the total operating cost for an aircraft is spent on maintenance activities.
- The typical size of a plant maintenance group in a manufacturing organization varied from 5 to 10% of the total operating force: in 1969, 1 to 17 persons and in 1981, 1 to 12 persons.
- The U.S. Department of Defense is the steward of the world's largest dedicated infrastructure, with a physical plant valued at approximately \$570 billion on approximately 42,000 square miles of land, i.e., roughly the size of the state of Virginia.
- The operation and maintenance budget request of the U.S. Department of Defense for fiscal year 1997 was on the order of \$79 billion.
- Annually, the U.S. Department of Defense spends around \$12 billion for depot maintenance of weapon systems and equipment: Navy (59%), Air Force (27%), Army (13%), and others (1%).
- In 1968, it was estimated that better maintenance practices in the U.K. could have saved approximately £300 million annually of lost production due to equipment unavailability.



Background

Competition

- Manufacturers need reduce the DMC (direct maintenance cost) to make the aircraft popular, and sale more aircrafts .
- Airlines need make the maintenance easily and quickly to enhance availability and reduce cost. Thus ticket price will be low, and make more profit.
- Passengers want low ticket price (fare) .



Background

Safety

For civil aircraft, safety is important all along.

FAA (Federal Aviation Administration), EASA (European Aviation Safety Agency) and CAAC (Civil Aviation Administration of China) have made many regulations and Requirements about safety. all the measures have an effect on safety.

In experience, Operational safety can be guaranteed when aircraft is in perfect condition, so it is inevitable to be for maintenance to ensure safety.



Background

- Since the Industrial Revolution, maintenance of engineering equipment (especially civil aircraft) in the field has been a challenge.
- Although impressive progress has been made in maintaining equipment in the field in an effective manner, maintenance of equipment is still a challenge due to factors such as size, cost, complexity, and competition.
- Needless to say, today's maintenance practices are market driven, in particular for the manufacturing, service suppliers, and so on.
- An event may present an immediate environmental, performance, or safety implication.
- Thus, there is a definite need for effective asset management and maintenance practices that will positively influence critical success factors such as safety, product quality, speed of innovation, price, profitability, and reliable delivery.

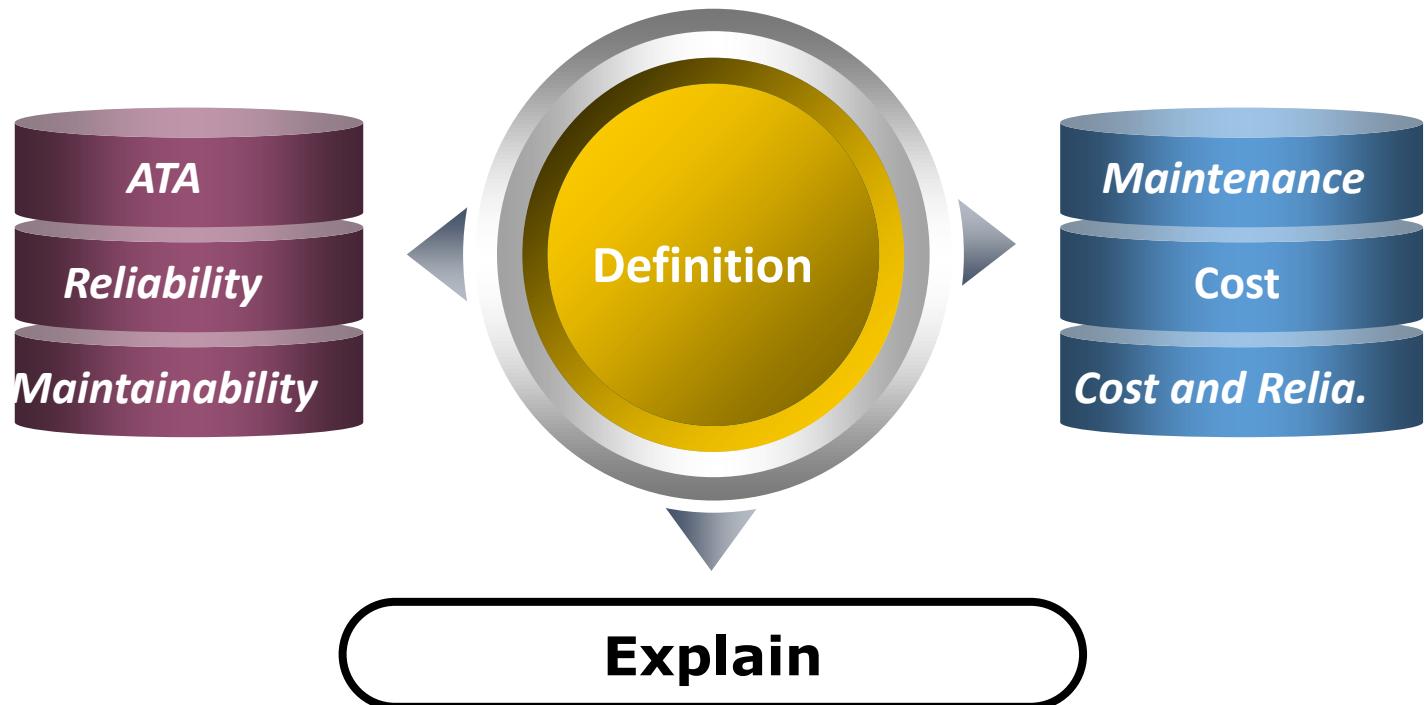


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Definition



Definition

ATA (Air Transport Association of America)

ATA100 is a criterion constituted by Air Transport Association of America. The criterion is for signing the systems, subsystems and parts of the aircraft with uniform number, in order to make communication easy among designer, maintenance men, manufactories and airlines



Definition (ATA)

ATA	TITLE	ATA	TITLE	ATA	TITLE
21	Air Conditioning	34	Navigation	80	Starting
22	Auto Flight	35	Oxygen		
23	Communications	36	Pneumatic		
24	Electrical Power	45	Central Maintain System		
25	Equipment/Furnishings	49	Airborne Power		
26	Fire Protection	52	Doors		
27	Flight Controls	54	Nacelles/Pylons		
28	Fuel	57	wings		
29	Hydraulic Power	71	Power Plant		
30	Ice and Rain Protection	75	Bleed Air		
31	Indication/Recording Systems	77	Engine Indicating		
32	Landing Gear	78	Engine Exhaust		
33	Lights	79	Engine Oil		



Definition

Reliability

Reliability is the probability that the machine will perform its intended function for a specified interval of time under stated operating conditions.

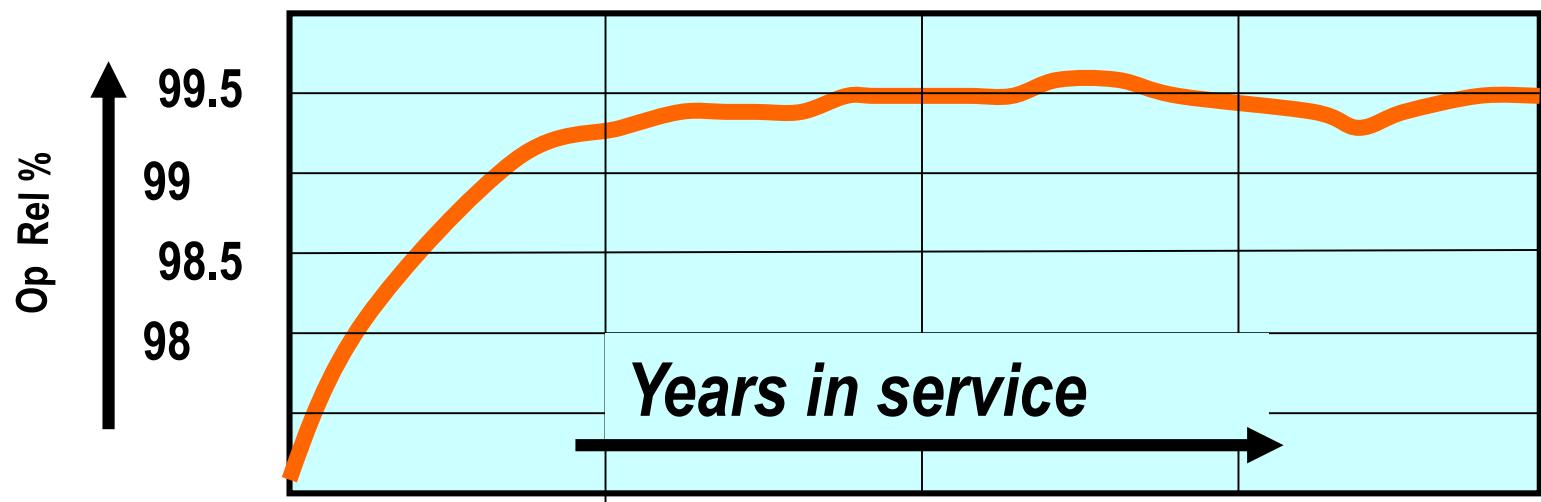
*We will learn “reliability”
in detail in following lecture*



Definition

Reliability

Operational Reliability



- Industry measure of aircraft availability
- Operational Reliability is a synergy of reliability and maintainability



Definition

Airlines usually have the requirement:

1
The target for operational reliability, attributable to design, shall be 99% (1 delay per 100 take-offs)

2
The No Fault Found ratio in equipment removals shall be significantly reduced.

3
The target for engine in-flight shut down shall be less than 0.005 per 1000 engine hours

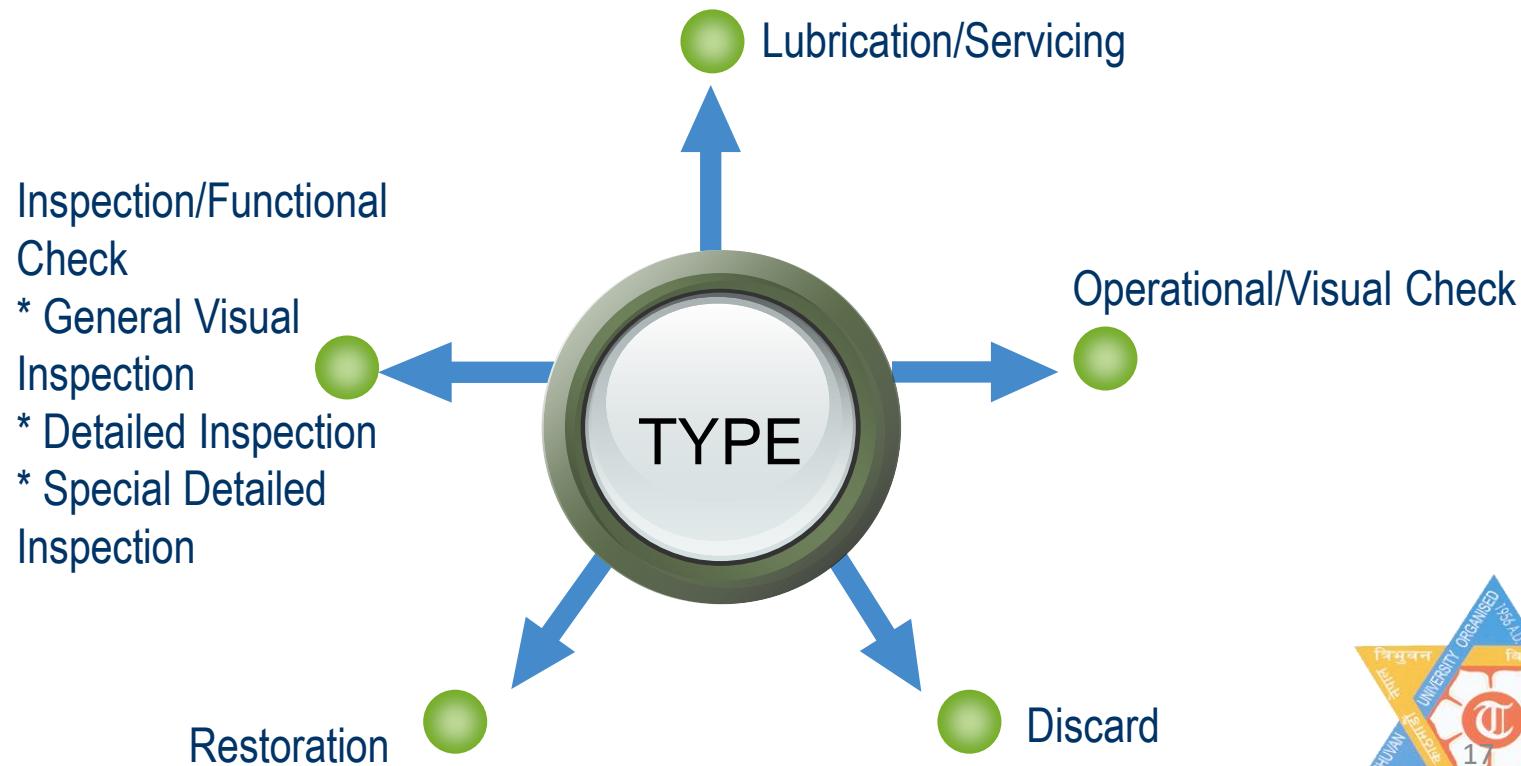
4
The reliability of BITE (Built-In Test Equipment) systems shall be at least one order of magnitude higher than the monitored systems



Definition

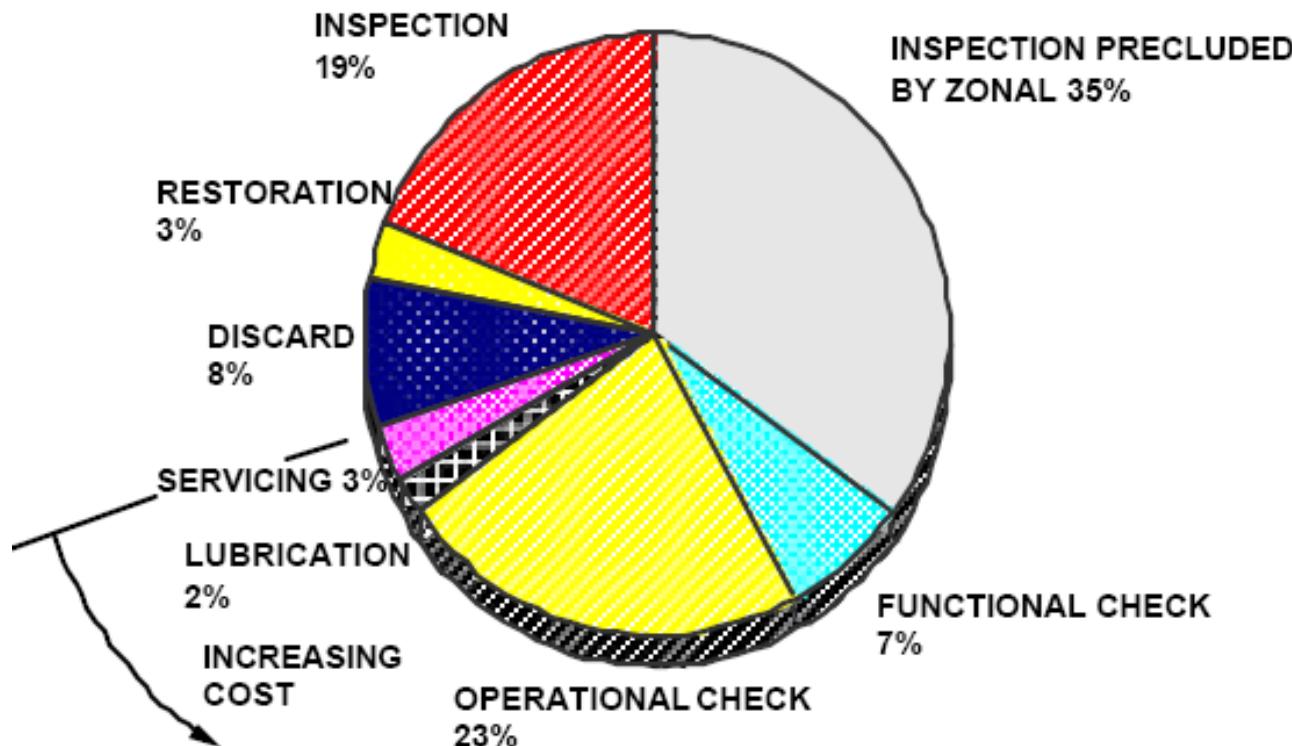
Maintenance

Maintenance is a series of specific actions taken to restore a machine to full operational status. These actions may include servicing, troubleshooting, inspection, adjustment, removal and replacement, or in-place repair of components or systems on a machine.



Definition

Maintenance



Definition

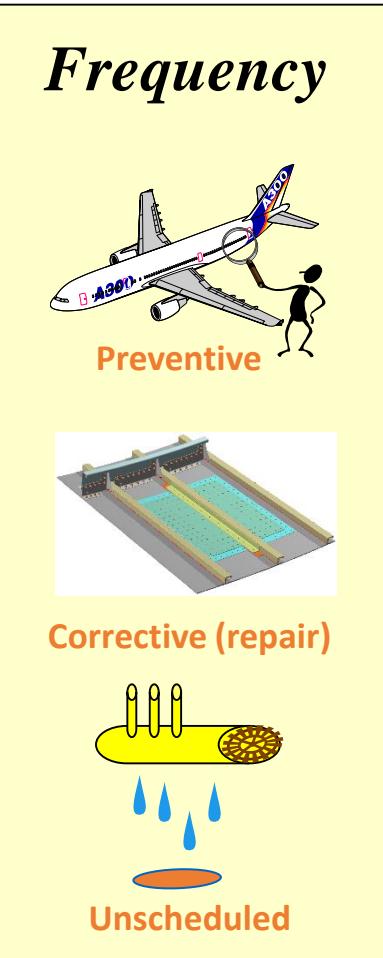
Maintenance

- **Preventive maintenance** refers to the actions taken to retain a machine at a specified level of performance. It includes routine servicing and replacement of parts that are likely to fail during the next operational cycle
- **Corrective maintenance** represents actions taken to restore a machine to an operational state after it is disabled due to a part or system failure.

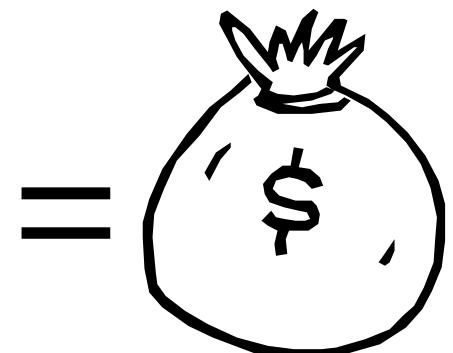


Definition

Cost



X



Definition

Cost

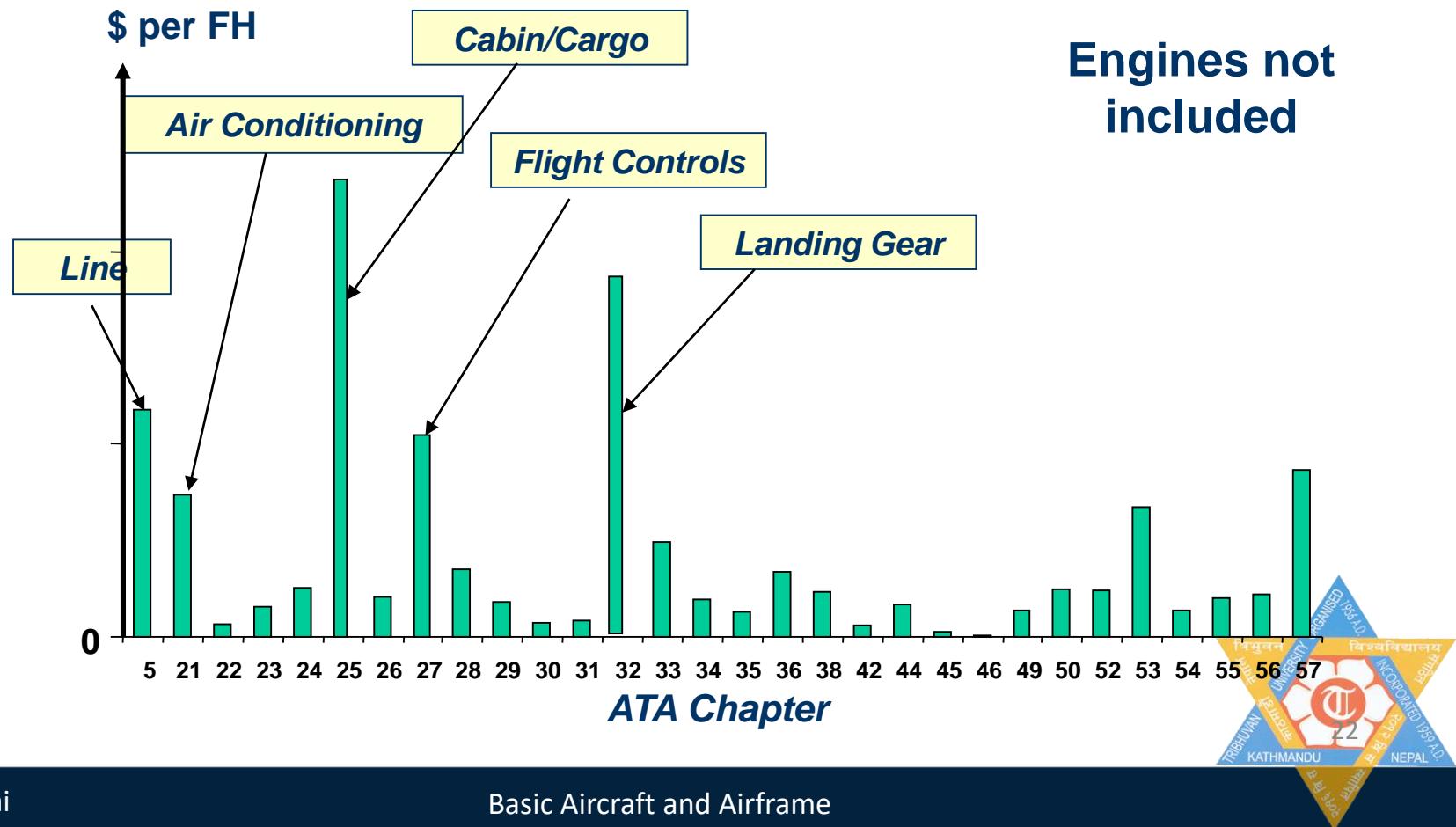
- Direct Maintenance Cost (DMC)
 - Airframe maintenance
 - Powerplant maintenance
- Indirect Maintenance Cost (IMC)
 - Commercial cleaning and painting
 - Customer Modifications/SBs
 - Non productive staff
 - Ground support equipment (GSE)
 - Spares holding
 - Facilities
 - Shipping



Definition

Cost

DMC projections by ATA Chapter (Airframe)



Definition

Maintainability

What is meant by maintainability? Several definitions are useful. A simple one is that maintainability is the ease with which you can repair equipment safely in the least amount of time.

We can **qualitatively** define maintainability of equipment as a designed-in characteristic that imparts to a machine an inherent ability to be maintained with reduced person-hours and skill levels, fewer tools and support equipment, and reduced safety risks.

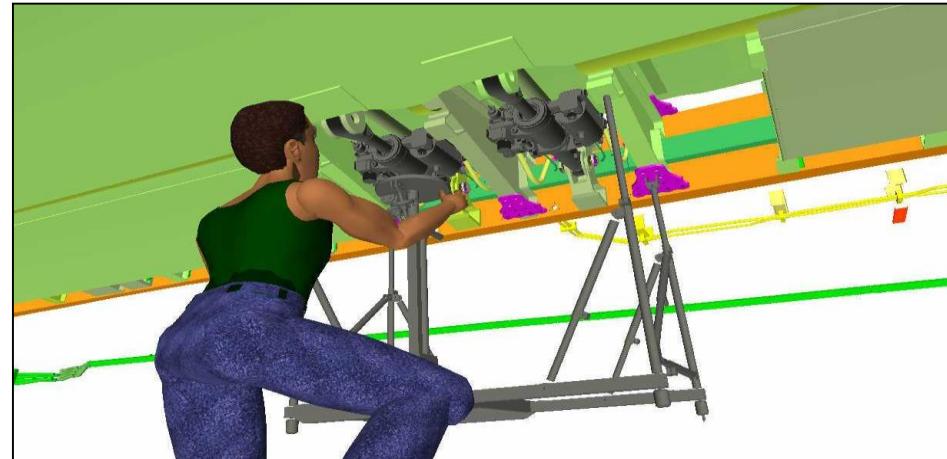
We can **quantitatively** define it as a measure of the speed with which you can restore a machine to operational status following a failure or removal from operation for servicing. We may also define it as the probability that a machine can be kept in an operational condition or restored to that condition within a given time when you design it properly or you do the maintenance according to prescribed procedures and tools.

Maintainability is often confused with maintenance.



Definition

Maintainability



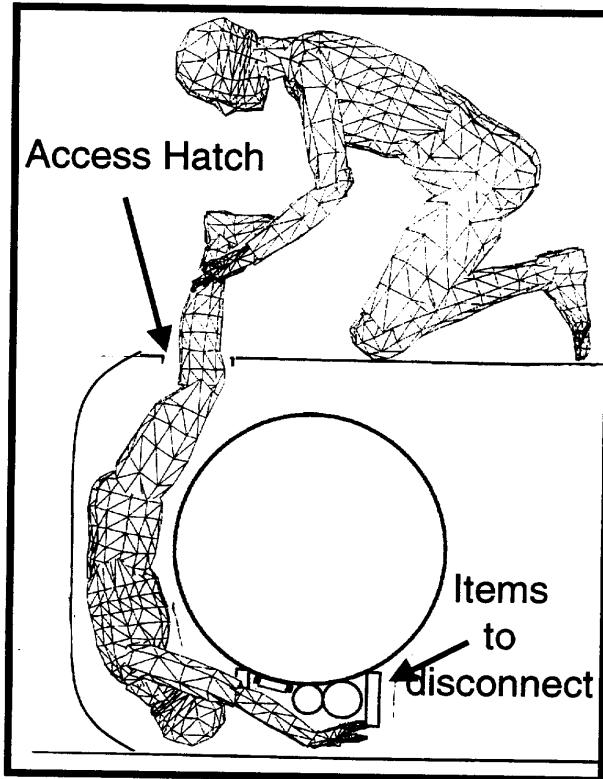
Good maintainability concerns :

- Ease of Maintenance (Accessibility - Skills)
- Effective Fault Diagnosis
- Efficient Ground Support Equipment and Tools
- Human Factors: maintenance friendly, reduce maintenance faults



Definition

Maintainability

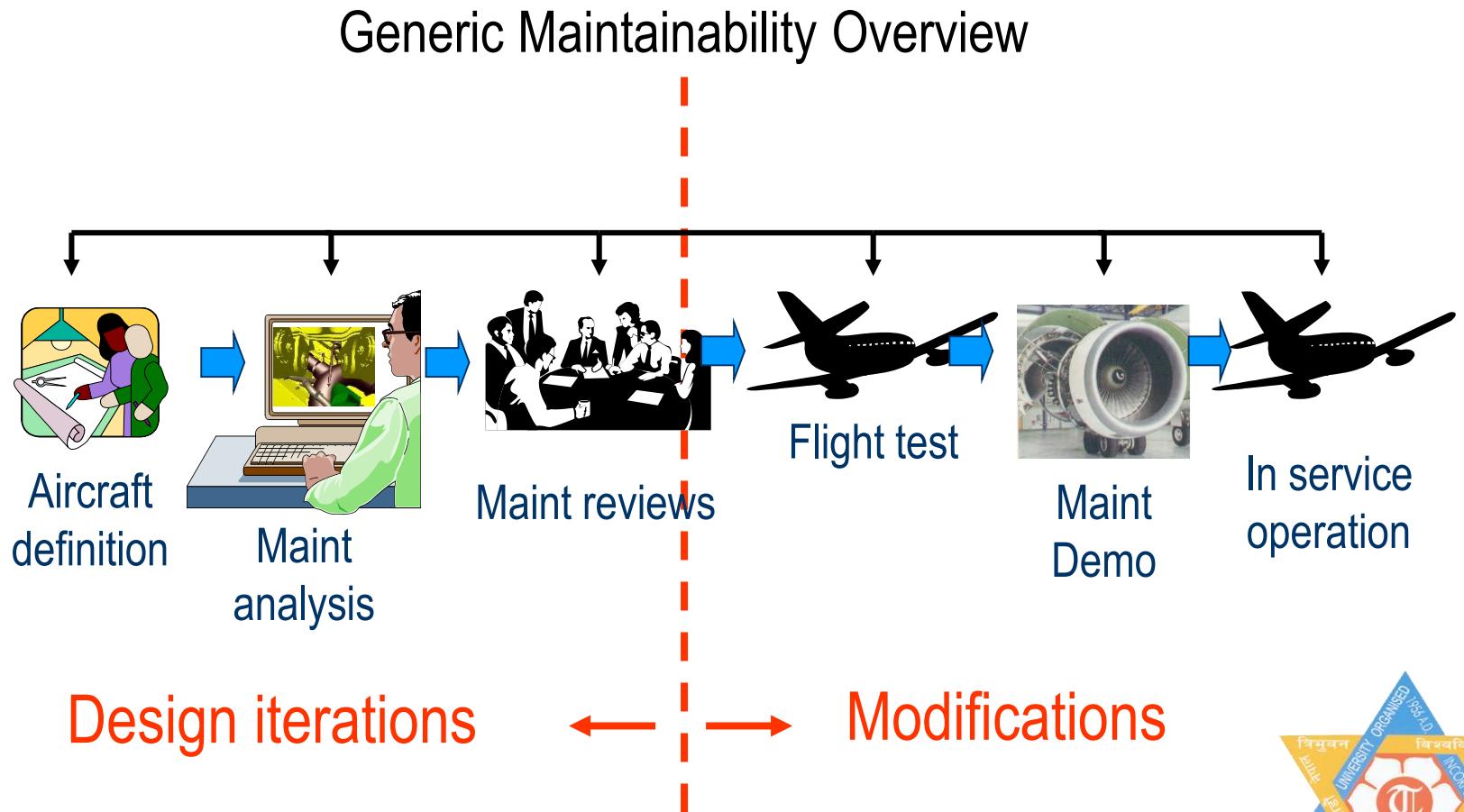


how not to do
it!

Poor
maintainability

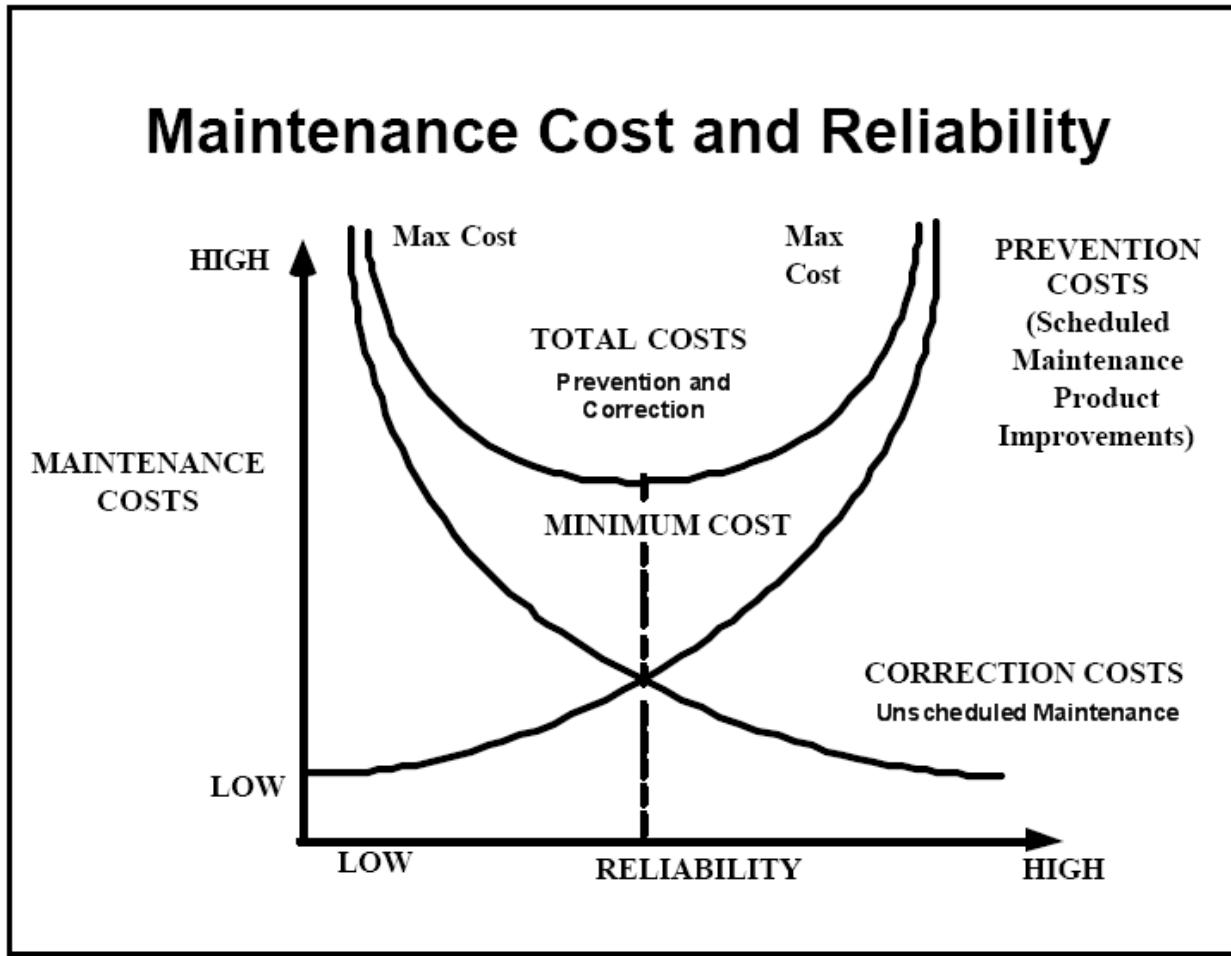
Definition

Maintainability



Definition

Cost and Reliability



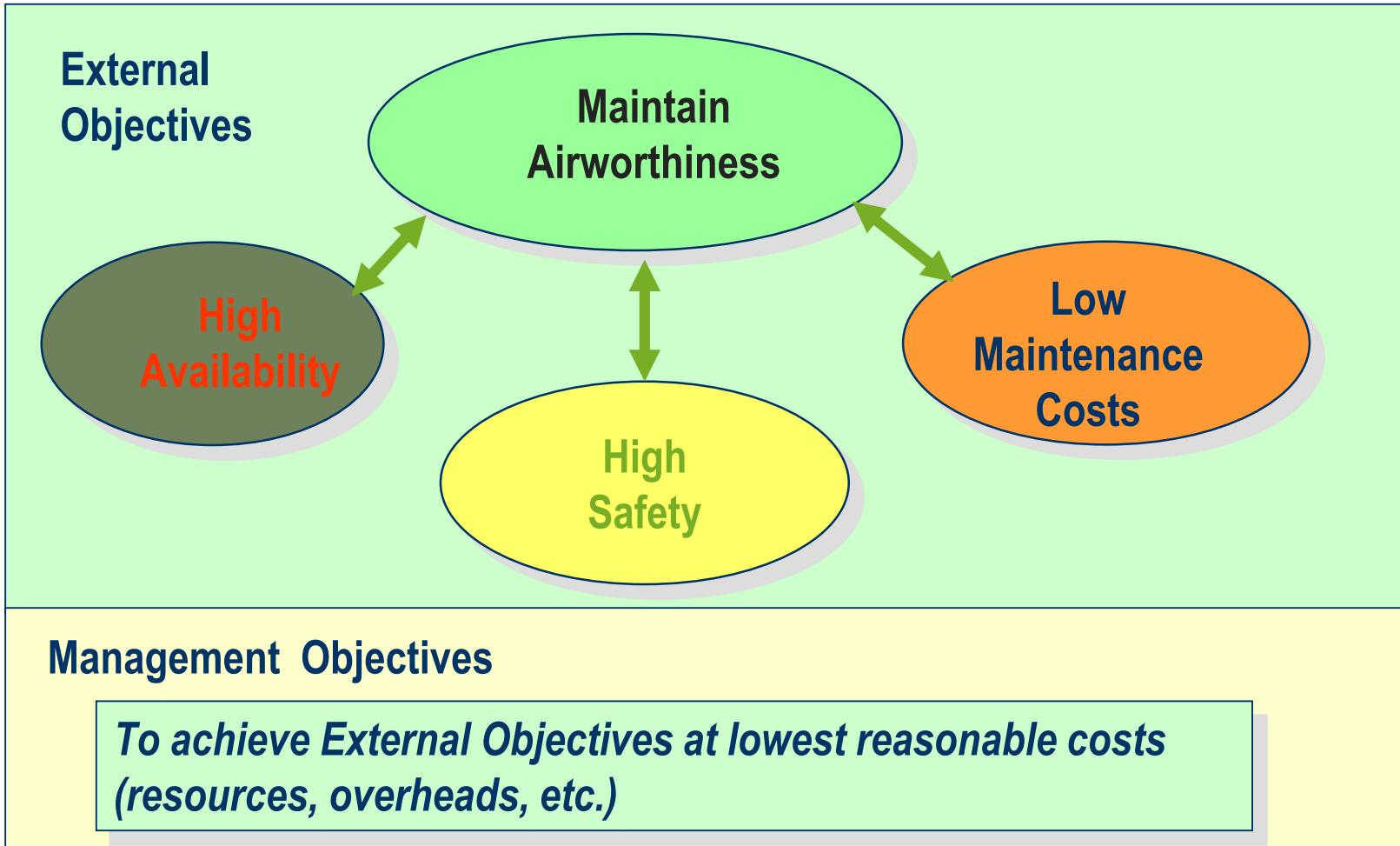
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Maintenance Engineering Objectives

Maintenance



Maintenance Engineering Objectives

Airworthiness

Airworthiness: Fit to fly

When a plane has passed all the test, it can get a government certificate of airworthiness, without which it is illegal to fly, except for test flying.

Availability

$$\text{Availability : } = \frac{\text{MTTF}}{\text{MTTF} + \text{MTTR}} = \frac{t_p - t_b \int_0^{t_p} h(t) dt}{t_p + t_a}$$

MTTF: Mean Time To Failure

MTTR: Mean Time to Repair

The availability of these aircraft depends on their maintenance schedules and the owner's requirements.

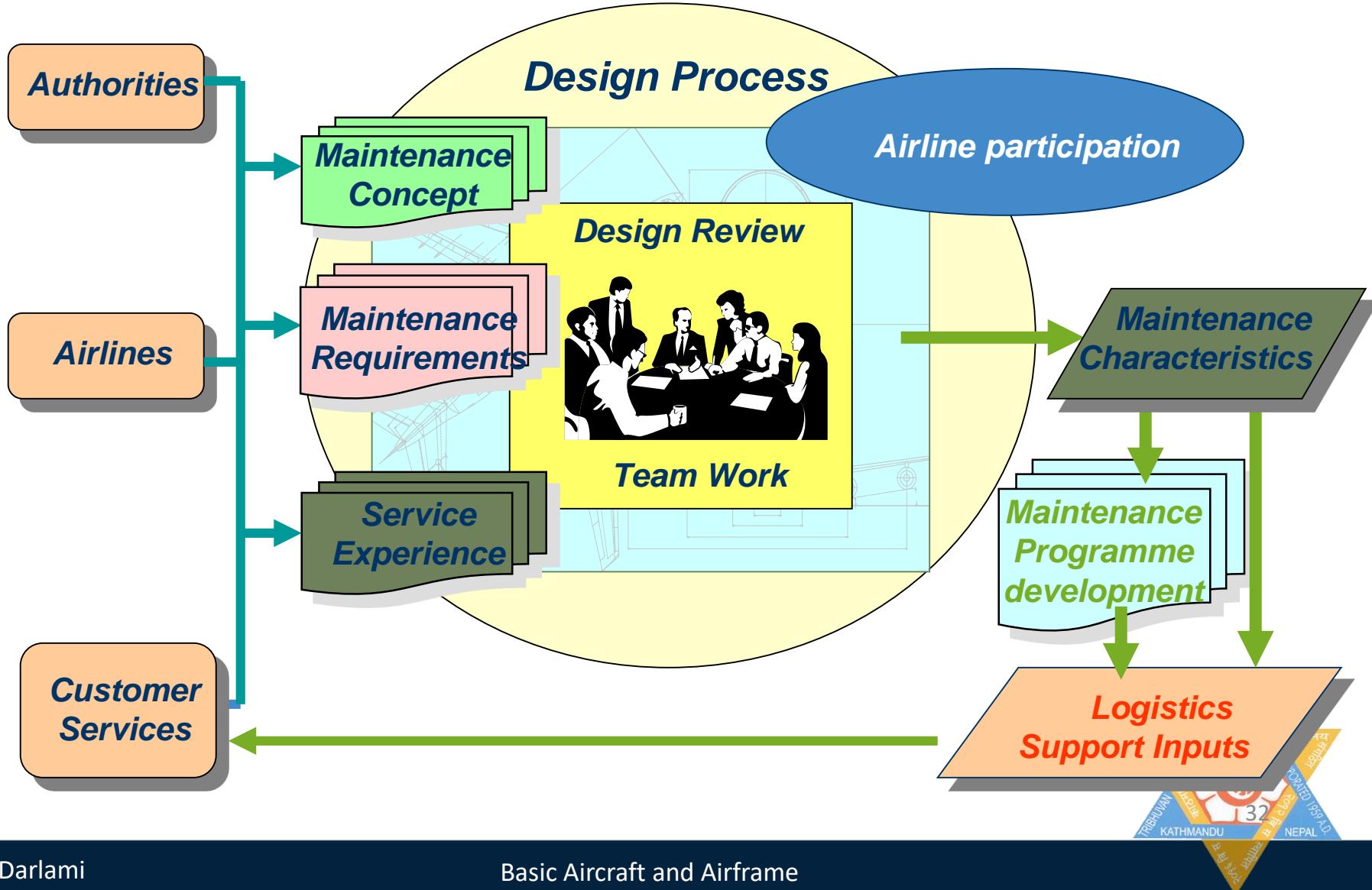


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ME General Model



ME General Model

ME - Maintenance Concept

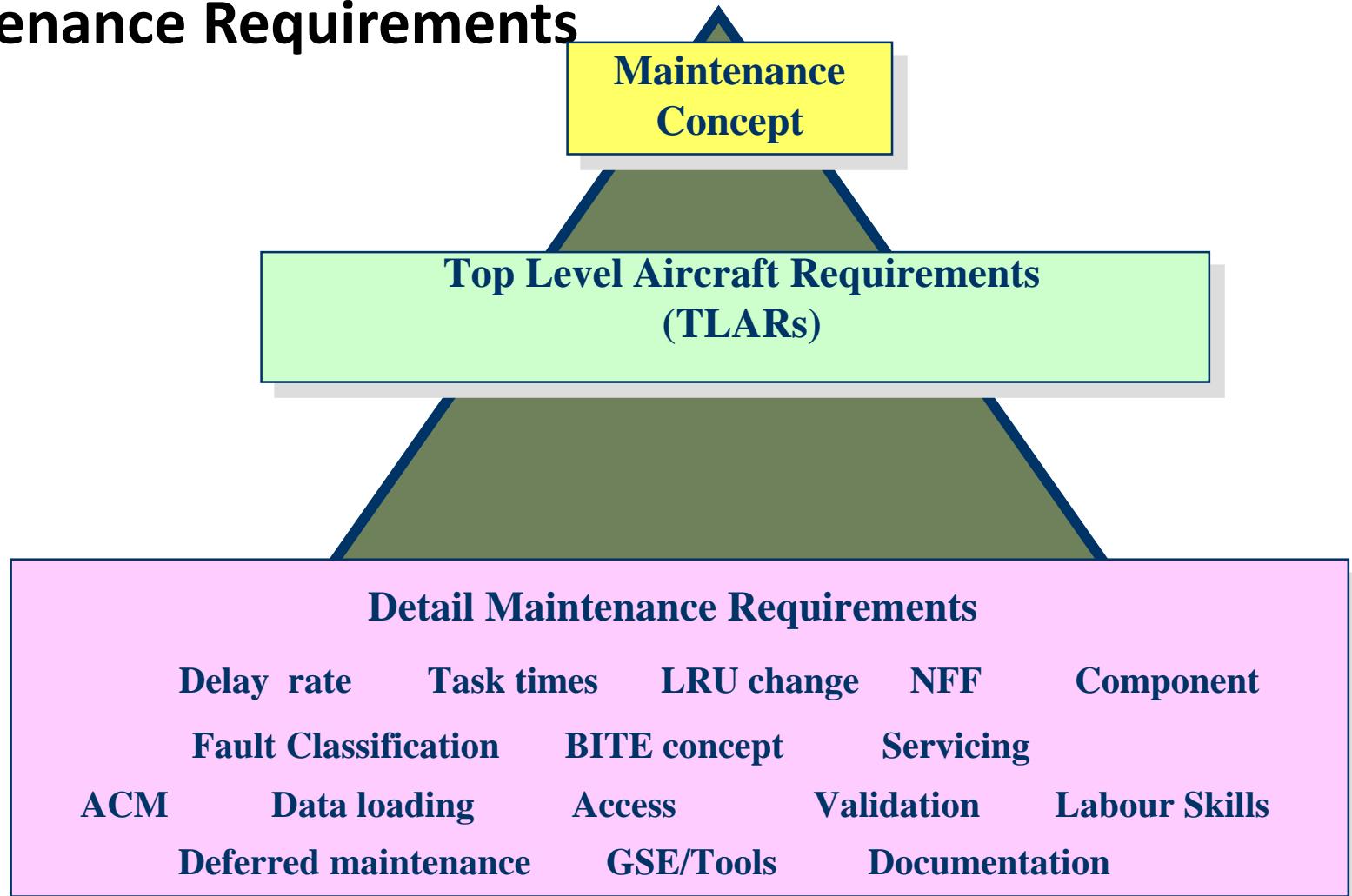
The basic data on how the aircraft needs to be maintained to satisfy customer requirements including:

- Check Interval Framework
- On Condition/Condition Monitoring
- Line Maintenance Philosophy
- Fault Diagnosis (OMS)
- Operational Reliability objectives
- Maintenance Cost objectives
- Maintainability Features
- Guidance for GSE/tools and Airport Facilities



ME General Model

Maintenance Requirements



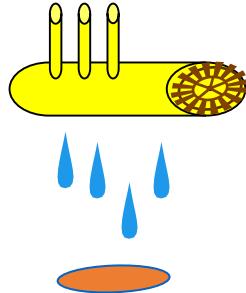
ME General Model

Maintenance Requirements

- Top Level Maintenance Requirements derived from Maintenance Concept focusing on the major items required to fulfil airline expectations such as:
 - Maintenance Programme Check Intervals
 - Operational Reliability and Maintenance Cost A/C Targets
 - Certification Maintenance Requirement issues
 - Basic Maintainability and Repair features
- Detailed Maintenance Requirements are cascaded down from Top Level and presented under ATA Chapter



ME General Model



ME – Service Experience

- Create “Lessons Learned” culture so as not to repeat same mistakes
- Drawn from service experience from manufacturer’s previous aircraft types
- For new aircraft take benefit from similar aircraft types



ME General Model

ME – Service Experience

Most significant in-service problems (excluding engines) are:

- Passenger Cabin
 - Lavatories
 - Air Conditioning
 - Fuel and Hydraulic Leaks
 - Landing Gear
 - Cargo Compartment
 - Electrical Generation



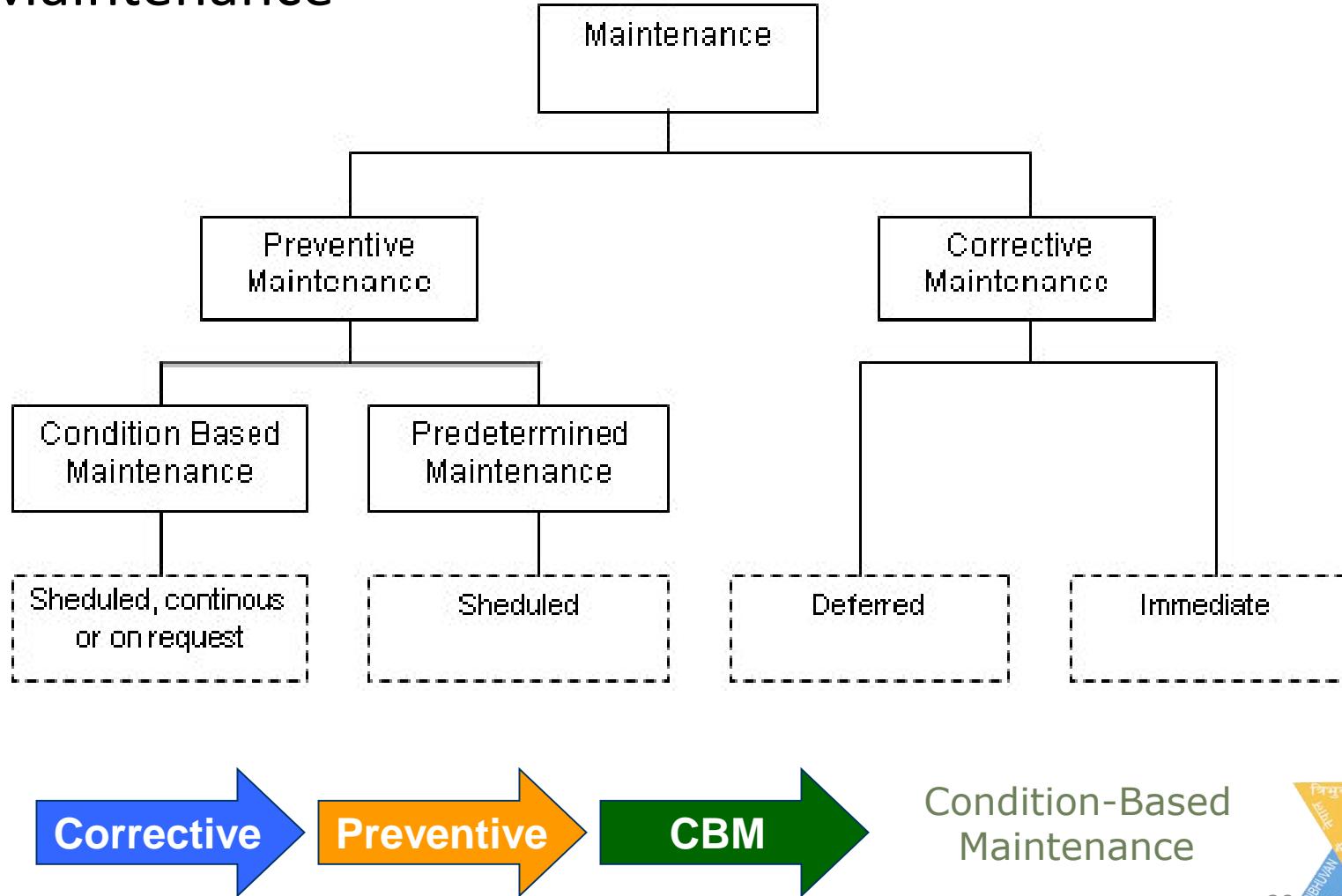
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ME Development

Maintenance



ME Development

FAILURE RATE

