Hydraulic and Pneumatic System

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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 difficulty and necessary.

Cost Each world
year billions of dollars are spent on equipment
maintenance around the Maintenance Fuel
Landing &

Navigation Crew

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

Competition

• Each industry, failure year of and machines, over it $300 is estimated systems, billion are that and spent approximately people. on plant maintenance 80% of this is and spent operations to correct by the U.S. chronic • In cost 1970, in the a British United Ministry Kingdom of (UK) Technology was approximately Working Party £3000 report million estimated annually. that maintenance • Annually, 11% of the the total cost operating of maintaining cost for a an military aircraft jet is aircraft spent on is around maintenance $1.6 million; activities. approximately • The to 10% typical of the size total of a operating plant maintenance force: in 1969, group 1 in to a 17 manufacturing persons and in organization 1981, 1 to

12 varied persons. from 5 • The infrastructure, 42,000 U.S. square Department miles with a of of physical land, Defense i.e., plant is roughly the valued steward the at size approximately of of the the world's state $570 of largest Virginia. billion dedicated on approximately • The fiscal operation year 1997 and was maintenance on the order budget of $79 request billion. of the U.S. Department of Defense for • Annually, maintenance and others the (1%). of U.S. weapon Department systems of and Defense equipment: spends around Navy (59%), $12 billion Air Force for (27%), depot Army (13%), • In approximately 1968, it was £300 estimated million that annually better of maintenance lost production practices due to in equipment the U.K. could unavailability. have saved

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) .

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.

• Since equipment the (especially Industrial civil Revolution, aircraft)in maintenance the field has been of a engineering challenge.

• Although equipment equipment equipment complexity, impressive and is in still the competition. a field challenge progress in an effective due has to been factors manner, made such maintenance in as maintaining size, cost, of • Needless particular to for say, the today’s manufacturing, maintenance service practices suppliers, are and market so on. driven, in • An or safety event implication. may present an immediate environmental, performance, • Thus, maintenance factors

profitability, there such is and as practices a safety, definite reliable product that delivery. need will for quality, positively effective speed influence asset of management innovation, critical success price, and

1 Background Definition

ME Objectives

ME General Model

ME Development

Explain

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

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

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

Reliability Operational Reliability

99.5

99 98.5 98 ***Years in service***

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

and maintainability

Airlines usually have the requirement:

The reliability of BITE (Built-In Test Equipment)

systems shall be at least one order The target for operational reliability, attributable to

The target for engine in-flight shut down The No Fault Found

shall be less than ratio in equipment
0.005 per 1000 removals shall be
engine hours

of magnitude higher than the significantly monitored reduced.
systems design, shall be 99% (1 delay per 100 take- offs)

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.

Lubrication/ServicingInspection/Functional Check * General Visual

Operational/Visual Check
Inspection * Detailed Inspection * Special Detailed

TYPE

InspectionRestoration

Discard

Maintenance

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.

Cost

Frequency

Preventive

Corrective (repair)

Material Costs

Unscheduled

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Labour Costs X =

Maintenance cost

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

Cost DMC projections by ATA Chapter (Airframe)

$ per FH ***Cabin/Cargo***

Engines not
Air Conditioning
included ***Flight Controls*** ***Line Landing Gear*** **0 5 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 38 42 44 45 46 49 50 52 53 54 55 56 57** ***ATA Chapter***

Maintainability What simple repair is equipment one meant is that by safely maintainability? maintainability in the least amount is Several the ease of definitions time. with which are useful. you can A We designed-in ability fewer can tools to be **qualitatively** and characteristic maintained support equipment, define with that reduced maintainability imparts and person-hours reduced to a machine of safety equipment and risks. an skill inherent levels, as a We

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

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Maintainability

- Efficient Ground Support Equipment and Tools
- Human Factors: maintenance friendly, reduce maintenance faults

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Good maintainability concerns :

- Ease of Maintenance (Accessibility - Skills)
- Effective Fault Diagnosis

Maintainability

how not to do it!

Poor maintainability

Maintainability

Generic Maintainability Overview

Cost and Reliability

Aircraft definition

Maint analysis

Maint reviews

Maint reviews

Flight test

Maint Demo

Maint Demo

Maint Demo

In service operation

In service operation

In service operation

In service operation

Design iterations

Modifications

1

Background Definition ME Objectives

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ME General Model

ME Development

Maintenance

Objectives

External Objectives

Maintain Airworthiness

Management

To achieve External Objectives at lowest reasonable costs (resources, overheads, etc.)

High Availability

Low Maintenance Costs

High Safety

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

Availability :

= MTTF+MTTR

MTTF

$= t_p - t_b \int_0^t$

$_p h (t) dt$

$t_p + t$

a

MTTF: Mean Time To Failure MTTR: Mean

Time to Repair The schedules availability and

the of these owner's aircraft requirements.
depends on their maintenance

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Background Definition
ME Objectives ME General Model

ME Development

Authorities

Customer Services

Airlines

Maintenance Requirements

Design Process

Maintenance

Concept

Design Review

Maintenance Characteristics

Team Work Service Experience

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Maintenance Programme development

Logistics Support Inputs

ME - Maintenance Concept The satisfy basic customer data on requirements how the aircraft including: needs to be maintained to • 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

Maintenance Requirements

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Detail Maintenance Requirements

Delay rate Task times LRU change NFF Component Fault Classification BITE concept Servicing ACM Data loading Access Validation Labour Skills Deferred maintenance GSE/Tools Documentation

Top Level Aircraft Requirements (TLARs)

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 – Service Experience

• Create mistakes “Lessons Learned” culture so as not to repeat same •

Drawn previous

from aircraft service

types experience from manufacturer’s

• For new aircraft take benefit from similar aircraft types

problems (excluding engines) are:

• Passenger Cabin

• Lavatories

• Air Conditioning

• Fuel and Hydraulic Leaks

• Landing Gear

• Cargo Compartment

• Electrical Generation

ME – Service Experience Most significant in-service

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Background Definition ME Objectives ME General Model ME Development

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Maintenance

Condition-Based

Maintenance

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