Hydraulic and Pneumatic System

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Aircraft Maintenance Engineering**Background**

K. Darlami Basic Aircraft and Airframe

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**Definition** 2

**ME Objectives** 3

**ME General Model** 4

**ME Development** 5

**1**

Background

**Cost**

**Size,**

**Safety**

**Complexity**

**Ccompetition**

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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.

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Background

**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 K. Darlami Basic Aircraft and Airframe

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Background

**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 K. Darlami Basic Aircraft and Airframe

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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) .

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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.

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Background

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

• Although 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 K. Darlami Basic Aircraft and Airframe

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Aircraft Maintenance Engineering**1 Background Definition**

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**2**

K. Darlami Basic Aircraft and Airframe

***ATA***

***Maintenance***

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***Reliability***

***Maintainability***

Definition

**Definition**

**Cost**

**Cost**

***Cost and Relia.***

**Explain**

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

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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**

**77 Engine Indicating Systems**

**32 Landing Gear 78 Engine Exhaust**

**33 Lights 79 Engine Oil**

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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*

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Definition

**Reliability** Operational Reliability

**99.5**

**9998.5 98 *Years in service***

• Industry measure of aircraft availability

• Operational Reliability is a synergy of reliability and maintainability

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Definition

**Airlines usually have the requirement:**

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The reliability of BITE (Built-In Test Equipment )

1

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

2

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)

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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.

Lubrication/ServicingInspection/Functional Check \* General Visual

Operational/Visual Check

Inspection \* Detailed Inspection \* Special Detailed

TYPE

InspectionRestoration

Discard

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Definition

**Maintenance**

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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.

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Definition

**Cost**

***Frequency***

**Preventive**

**Corrective (repair)**

**Material Costs**

**Unscheduled**

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**Labour Costs X =**

**Maintenance cost**

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

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Definition

**Cost** DMC projections by ATA Chapter (Airframe)

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

**Engines not**

***Air Conditioning***

**included *Flight ControlsLine 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***

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Definition

**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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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

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Definition

**Maintainability**

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**how not to do it!**

**Poor maintainability**

Definition

**Maintainability**

Generic Maintainability Overview

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 K. Darlami Basic Aircraft and Airframe

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Definition

**Cost and Reliability**

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Aircraft Maintenance Engineering**1**

**Background** 2 **Definition ME Objectives**

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Maintenance Engineering Objectives Maintenance

**External Objectives**

**Maintain Airworthiness**

**Management Objectives**

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

**High Availability**

**High Safety**

**Low Maintenance Costs**

Maintenance Engineering Objectives

**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*∫ 0 *t*

*ph* ( *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 K. Darlami Basic Aircraft and Airframe

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Aircraft Maintenance Engineering**1**

**Background** 2 **Definition** 3

**ME Objectives ME General Model**

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**4**

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***Authorities***

***Customer Services***

***Airlines***

***Maintenance Requirements***

ME General Model

***Design Process***

***Maintenance***

***Airline participation Concept***

***Design Review***

***Maintenance Characteristics***

***Team Work Service Experience***

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***Maintenance Programme development***

***Logistics Support Inputs***

ME General Model

**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

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ME General Model

**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 Concept**

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

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ME General Model

**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

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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

**Corrective Preventive CBM** Condition-Based

Maintenance

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ME Development

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