

**Ramaz Urushadze**

# **Aircraft Operational Reliability In Formulas**

## **Part 1**

### **Maintenance Data**

#### **QUICK-REFERENCE HANDBOOK**

More than 500 formulas, equations, tasks, tables, graphs  
with step-by-step explanations and real-life examples

Aircraft Utilization PIREP/MAREP Delays/Cancellations  
Accidents/Incidents LRU Removals  
and Much More

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Aircraft Reliability & Maintenance Programs, Economics



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1. This L&L Session is obtained from the Aircraft Operational Reliability Course, developed and delivered by Avram Aerospace, more information about this and other courses can be found on [www.avramaerospce.com](http://www.avramaerospce.com).
2. This L&L Session serves for only information purposes.
3. The Aircraft Reliability is an extensive topic, in this LL Session we will only cover “a small tip of the iceberg”.
4. This presentation uses USA FAA and TCCA R&R as examples. For more R&R information please visit your local AA web-site.
5. Please, no audio or video recording (with permission of the organizers).
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**Aircraft Operational Reliability**

**Lunch & Learn Session**

**Duration: 1 Hour**

**Prepared By: Ramaz Urushadze**

**2025**

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# AGENDA

**1. Introduction**

**2. History**

**3. Definition  
&  
Regulations**

**4. Reliability**

**5. Book**

**6. Questions**

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## 2. History - Aircraft Operational Reliability

Hot Air  
Ballon

### First Air Safety Regulations

1. 1784
2. (1889)
3. 1910
4. 1919

# DRAFT

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## 2. History - Aircraft Operational Reliability

### (General Info)

1968, **MSG-1**, Handbook, Maintenance Evaluation and Program Development (B747)

1964, 1. AC 120-16 Continues Airworthiness Program  
2. AC 120-17 Handbook for Maintenance Control by Reliability Methods

1961, FAA/Industry Reliability Program, to control reliability through an analysis of the factors that effect reliability and provide a system of actions **to improve low reliability levels...**

#### 1938, Civil Aeronautics Act

- **Accident /Incident investigation**
- Airline fares (economic regulations)
- Routes carrier served

1930, Aeronautical Bulletin 7E.  
First maintenance program regulation

2018, **AC 120-17B** Reliability Program Methods—  
Standards for Determining Time Limitations

1980, **MSG-3**, Aircraft/Manufacturer  
Maintenance Program Document.

1978, **AC 120-17A** Handbook for Maintenance  
Control by Reliability Methods.

1970, **MSG-2**, Aircraft/Manufacturer  
Maintenance Program Document, Lockheed  
1011, DC10

1938

1961

1964

1968

2018

1980

1978

1930

1970

# DRAFT

1903, Dec-17, First (powered) flight  
(120ft (37m) 12 second), Orville Wright  
(and his brother), Kitty Hawk, North  
Carolina, USA

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## 2. History - Aircraft Operational Reliability

(General Info)

Important R&Rs for us is OpSpec

Before (1953) **Operation Specification** reqs:

“Operating certificates and temporary permits accompanied by **competency letters**. Containing information that authorized the air carrier’s services, routes, aircraft, maintenance, airmen, and weather procedures.”

Note: 1953 CARs were amended “to require issuance of air carrier **OpSpecs** that replaced, formalized and standardized the **competency letters**..”

1968, **MSG-1**, Handbook, Maintenance Evaluation and Program Development (B747)

1964, 1. AC 120-16 Continues Airworthiness Program  
2. AC 120-17 Handbook for Maintenance Control by Reliability Methods

1961, FAA/Industry Reliability Program, to control reliability through an analysis of the factors that effect reliability and provide a system of actions **to improve low reliability levels**...

1938, Civil Aeronautics Act

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1930, Aeronautical Bulletin 7E.  
First maintenance program regulation

2018, **AC 120-17B** Reliability Program Methods— Standards for Determining Time Limitations

1980, MSG-3, Aircraft/Manufacturer Maintenance Program Document.

1978, **AC 120-17A** Handbook for Maintenance Control by Reliability Methods.

1970, MSG-2, Aircraft/Manufacturer Maintenance Program Document, Lockheed 1011, DC10

1903, Dec-17, First (powered) flight (120ft (37m) 12 second), Orville Wright (and his brother), Kitty Hawk, North Carolina, USA

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## 2. History - Aircraft Operational Reliability

### Contemporary Aircraft Reliability Statistical Basis.

### Reliability-Centered Maintenance.

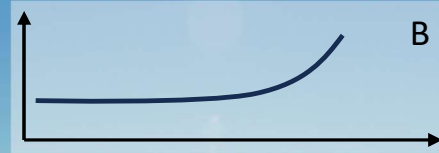
Age reliability patterns. In each case the Y-Axis is Probability of failure, and X-Axis is the operating age since manufacture, overhaul, or repair.

Data was processed in 1960-s, by Nowlan S., Heap H. (UAL) and became one of the basis items for MSG-1.

These six patterns are characterized by the percentage of items that fell into of the basic patterns (UAL). (Not shown).



The bathtub curve: Infant mortality, followed first by a constant or gradually increasing failure probability and then by a pronounced “wearout” region.



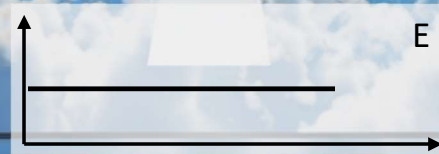
Constant or gradually increasing failure probability, followed by a pronounced “wearout” region.



Gradually increasing failure probability, but with no identifiable “wearout” region (age).



Low failure probability, when the item is new or just out of the shop, followed by a quick increase to a constant level.



Constant probability of failure at all ages (exponential survival distribution).



Instant mortality, followed by a constant or very slowly increasing failure probability (particularly applicable to electronic eqpmnt) .

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## 2. History - Aircraft Operational Reliability

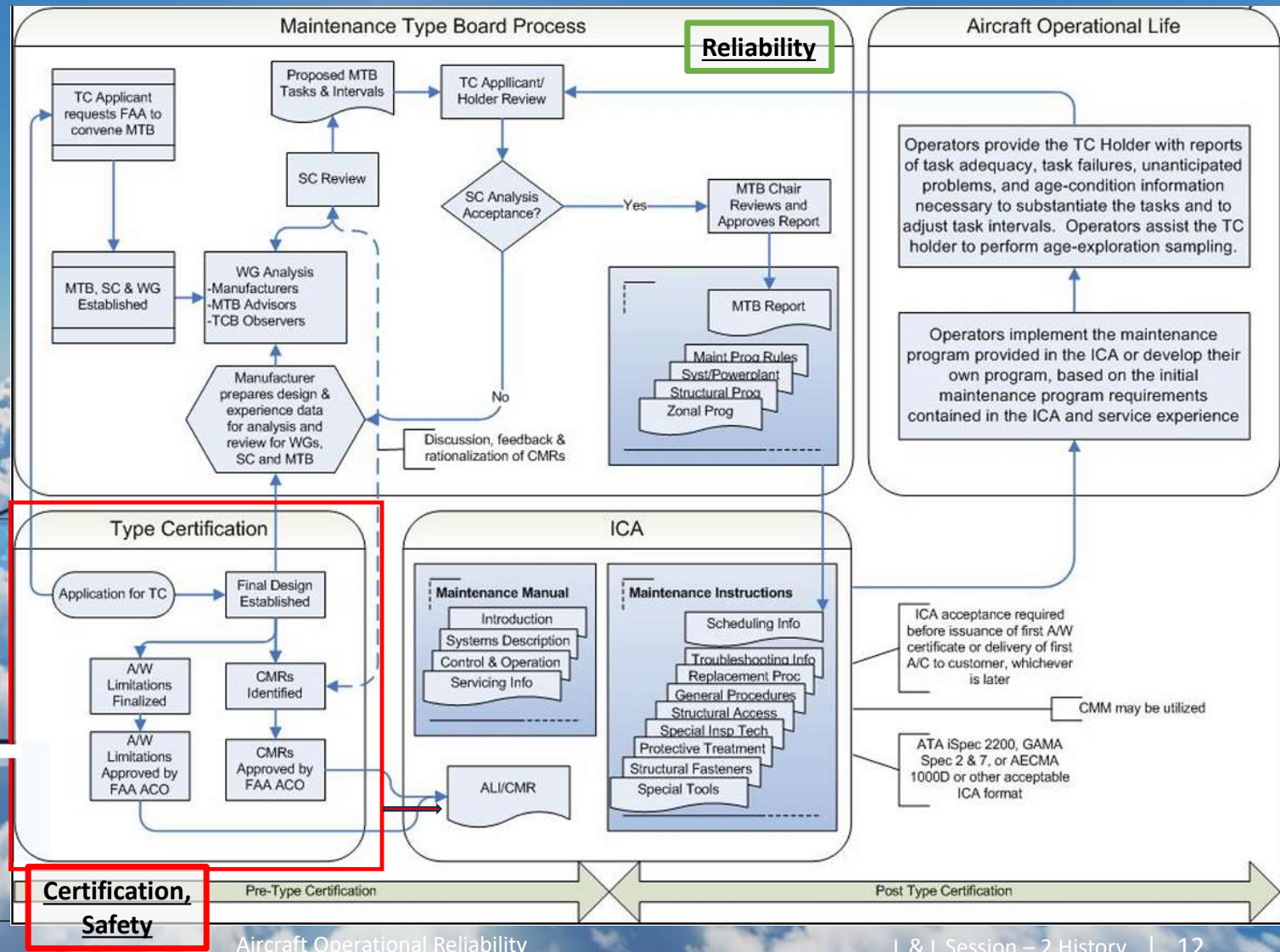
### Yes, RCM is head of everything..., but Aircraft Safety Assessment ...

AC: 121-22. Maintenance Review Boards, Maintenance Type Boards, and OEM/TCH Recommended Maintenance Procedures  
FIGURE 8-1. MAINTENANCE TYPE BOARD FLOWCHART

**2-6. CMRs.** During aircraft design certification and concurrent with the MRB process, leading up to the type certification process, the OEM/TCH accomplishes an analysis, in accordance with Title 14 of the Code of Federal Regulations (14 CFR) part 23, § 23.1309; part 25, § 25.1309; part 27, § 27.1309; and part 29, § 29.1309. The analysis intends to detect any safety-significant latent failures that would, in combination with one or more other specific failures or events, result in a hazardous or catastrophic condition. This system safety assessment leads to a design decision to create candidate Certification Maintenance Requirements (CCMR).

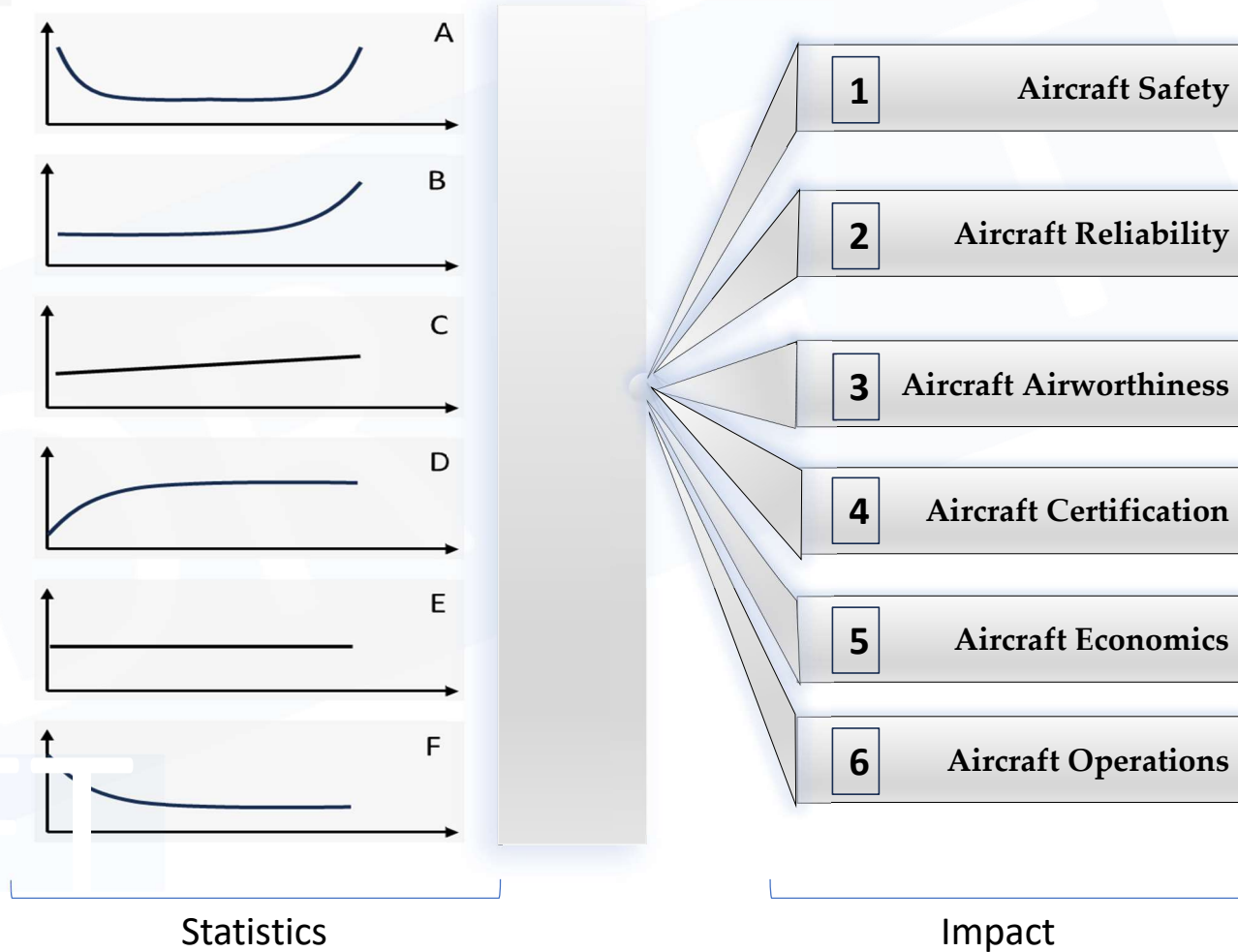
**a. Additional Information.** For further information regarding this subject, please see the current editions of AC 23.1309-1, System Safety Analysis and Assessment for Part 23 Airplanes; AC 25.1309-1, System Design and Analysis; AC 25-19, Certification Maintenance Requirements; AC 27-1, Certification of Normal Category Rotorcraft; and AC 29-2, Certification of Transport Category Rotorcraft.

**b. Limitations.** If a CCMR may be satisfied by an MSC 3 task, the following limitations apply: (1) Only MSC 3 Category 1 tasks may be considered a CCMR. (2) If certification transfers a CCMR to the ISC base, the balancing MR task, the ISC manages that task from that point forward (see subparagraph 6-3(n)(7)).



## 2. History - Aircraft Operational Reliability

**Aircraft Reliability (Failure) Impact.**  
(Combination of previous 2 slides).



# AGENDA

1. Introduction

2. History

**3. Definition  
&  
Regulations**

4. Reliability

5. Book

6. Questions

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### 3. Definition and Regulations

#### Before Definition, let's talk about Ops Reliability R&R-s.

- ◆ 1964, AC 120-16 Continues Airworthiness Program
- ◆ 1964, AC 120-17 Handbook for Maintenance Control by Reliability Methods
- ◆ 1968, MSG-1, Handbook, Maintenance Evaluation and Program Development (B747)  
MSG-1. Safety – Reliability level oriented
- ◆ 1970, MSG-2, Aircraft/Manufacturer Maintenance Program Document, Lockheed 1011, DC10  
MSG-2. Safety – Reliability level and maintenance process oriented
  - Hard-Time (HT), Overhaul Time Limit, or Part Life-Limit.
  - On-Condition (OC). “Requires a system, component, or appliance be inspected periodically or checked against some appropriate physical standard to determine if it can continue in service.” (FAA 8300.10, Chapter 66)
  - Condition Monitoring (CM) (Introduced in MSG2) “This process is for systems, components, or appliances that have neither HT nor OC maintenance as their primary maintenance process. It is accomplished by appropriate means available to an operator for finding and solving problem areas. The user must control the reliability of systems or equipment based on knowledge gained.” (FAA 8300.10, Chapter 66)
- ◆ 1978, AC 120-17A Handbook for Maintenance Control by Reliability Methods
- ◆ 1980, MSG-3, Aircraft/Manufacturer Maintenance Program Document
- ◆ 2018, AC 120-17B Reliability Program Methods— Standards for Determining Time Limitations

#### 120-16. 6. ANALYSIS AND SURVEILLANCE SYSTEM.

a. The analysis of the following to determine the effectiveness of the operator's maintenance and inspection programs and for the correction of any deficiency in these programs:

- (1) Frequency of parts replacement;
- (2) The degree and frequency of adjustment or calibration; and
- (3) The deterioration or improvement of operational capability or reliability. *Note: CASS AC120-79*

120-17 PURPOSE: This handbook provides information and guidance material which may be used to design or develop maintenance reliability programs which include a standard for determining time limitations. *Note: Birth of contemporary reliability program*

“The impact of MSG-1 and MSG-2 on the resulting programs is apparent from the number of items assigned scheduled removal tasks – eight in the Boeing 747 and seven on the Douglas DC-10, in contrast to 339 in the earlier program for the Douglas DC-8.” F. S. Nowlan “Reliability Centered Maintenance”

#### MSG-3. Safety – Task oriented (FAA 8300.10, Chapter 66) :

1. Lubrication/Servicing (LU/SV)
2. Operational/Visual Check (OP/VC).
3. Inspection/Functional Check (IN/FC)
  - a) Inspections.
    - i. Detailed inspection.
    - ii. General visual (surveillance) inspection.
    - iii. Special detailed inspection.
  - b) Functional Check.
4. Restoration (RS)
5. Discard (DS)

Summary: Airline reliability system tells how effective maintenance system is



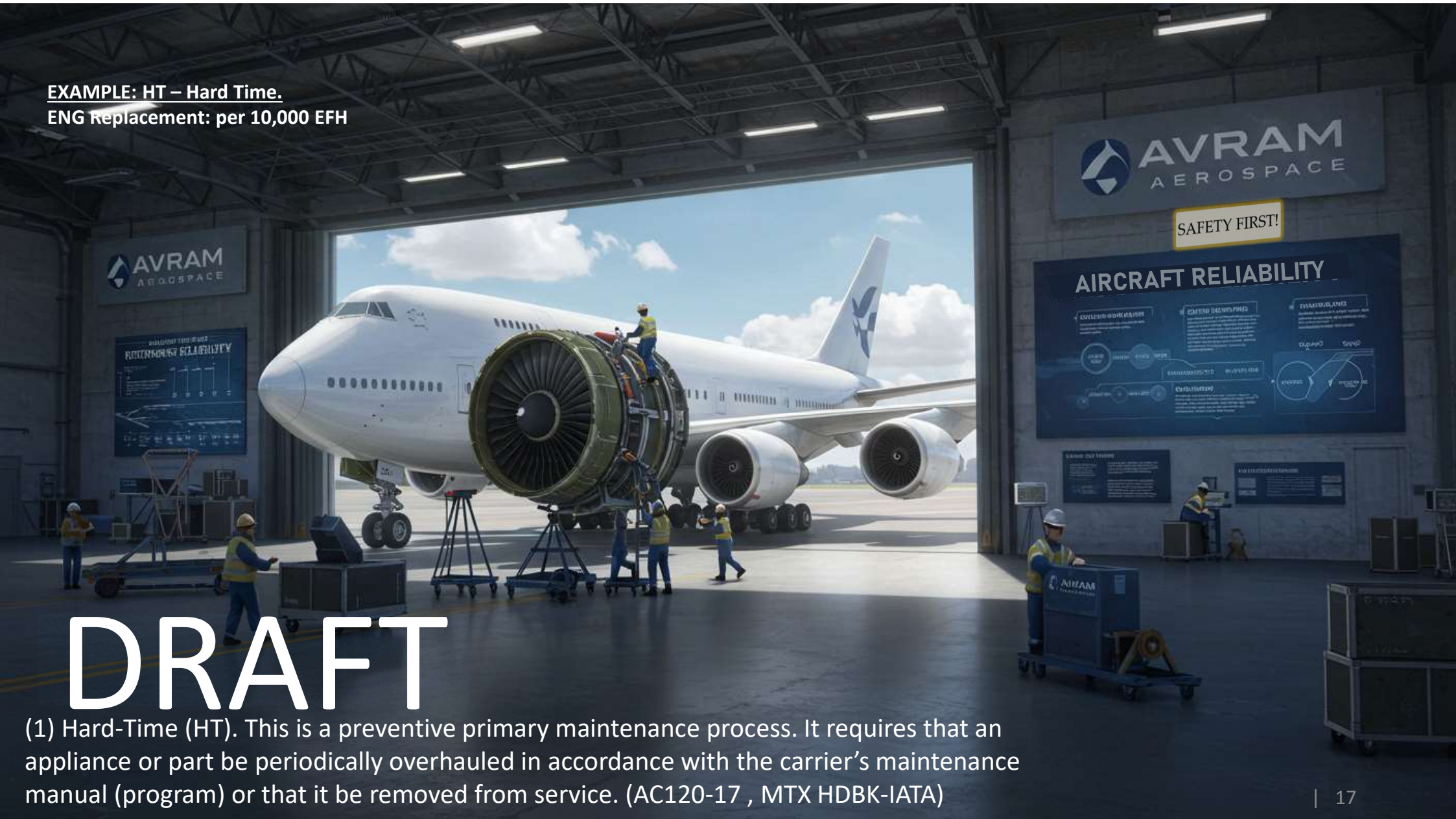
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PRIMARY MAINTENANCE PROCESSES. The three primary maintenance processes utilized by maintenance programs are (1) Hard-Time, (2) On-Condition, and (3) Condition-Monitoring. (AC120-17, MTX HDBK-IATA)

Image is generated by AI



EXAMPLE: HT – Hard Time.  
ENG Replacement: per 10,000 EFH



(1) Hard-Time (HT). This is a preventive primary maintenance process. It requires that an appliance or part be periodically overhauled in accordance with the carrier's maintenance manual (program) or that it be removed from service. (AC120-17 , MTX HDBK-IATA)

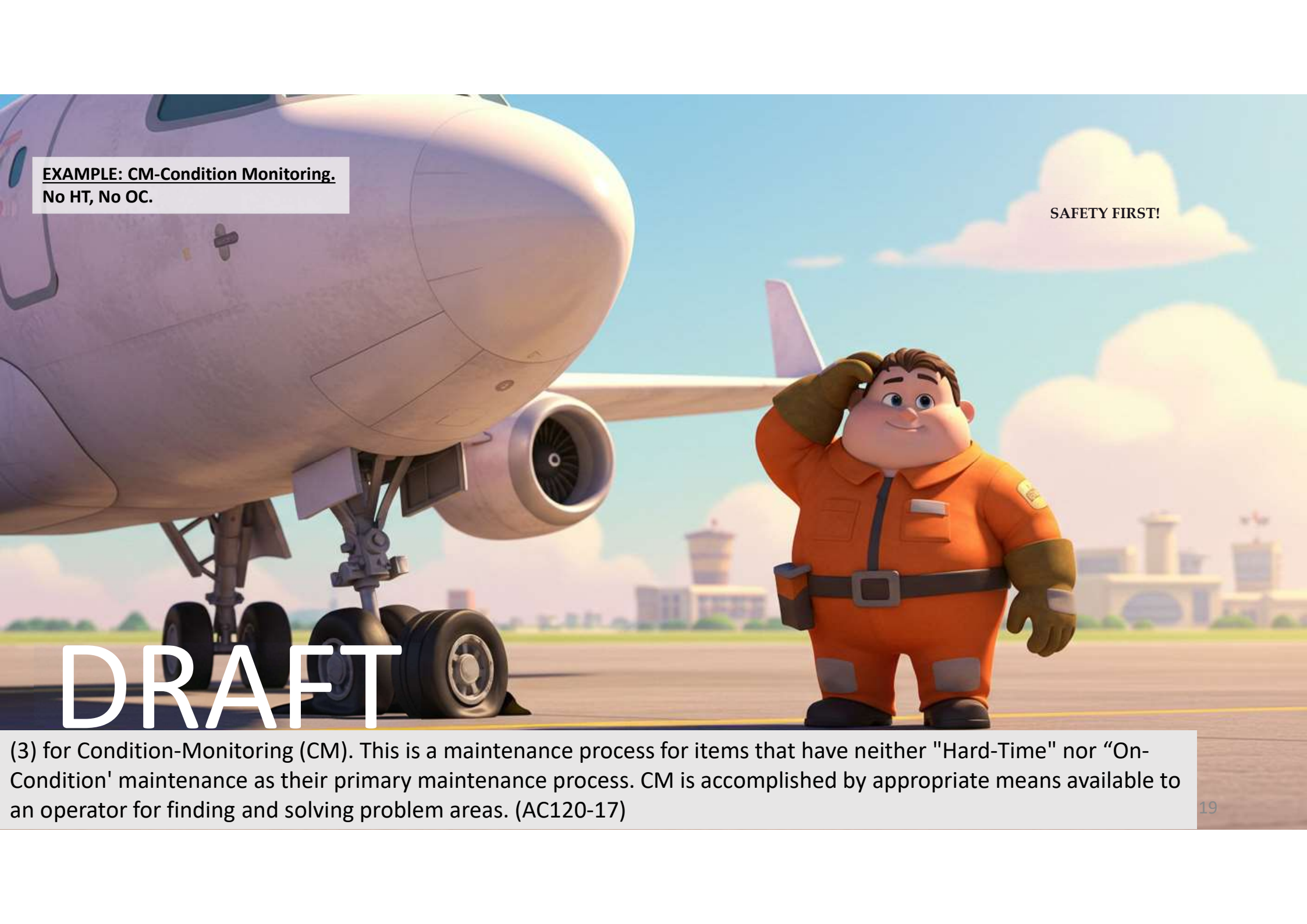
EXAMPLE: OC - On-Condition.  
Inspected periodically

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(2) On-Condition (OC). This is a preventive primary maintenance process. It requires that an appliance or part be periodically inspected or checked against some appropriate physical standard to determine whether it can continue in service. The purpose of the standard is to remove the unit from service before failure during normal operation occurs. (AC120-17, MTX HDBK-IATA)



A 3D animated scene showing the nose and landing gear of a white airplane on a tarmac. A ground crew member in an orange jumpsuit and gloves is saluting with his right hand. The background features a clear blue sky with soft, white clouds and a distant airport terminal.

**EXAMPLE: CM-Condition Monitoring.**  
**No HT, No OC.**

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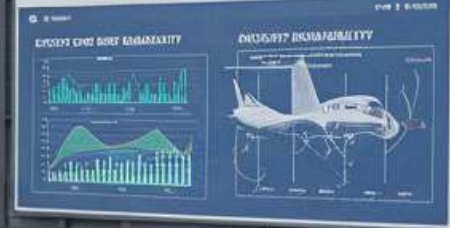
# DRAFT

(3) for Condition-Monitoring (CM). This is a maintenance process for items that have neither "Hard-Time" nor "On-Condition" maintenance as their primary maintenance process. CM is accomplished by appropriate means available to an operator for finding and solving problem areas. (AC120-17)



**Aircraft Safety!**

**Aircraft Reliability**



Airline Aircraft Operational Reliability is a complex property of subject (Aircraft, System, Component, etc.) that depends on its working environment, and combines characteristics such as safety, availability, maintainability, operability, etc.

**Aircraft Availability**



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**Operational Reliability Definition**

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# AGENDA

1. Introduction

2. History

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&  
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6. Questions

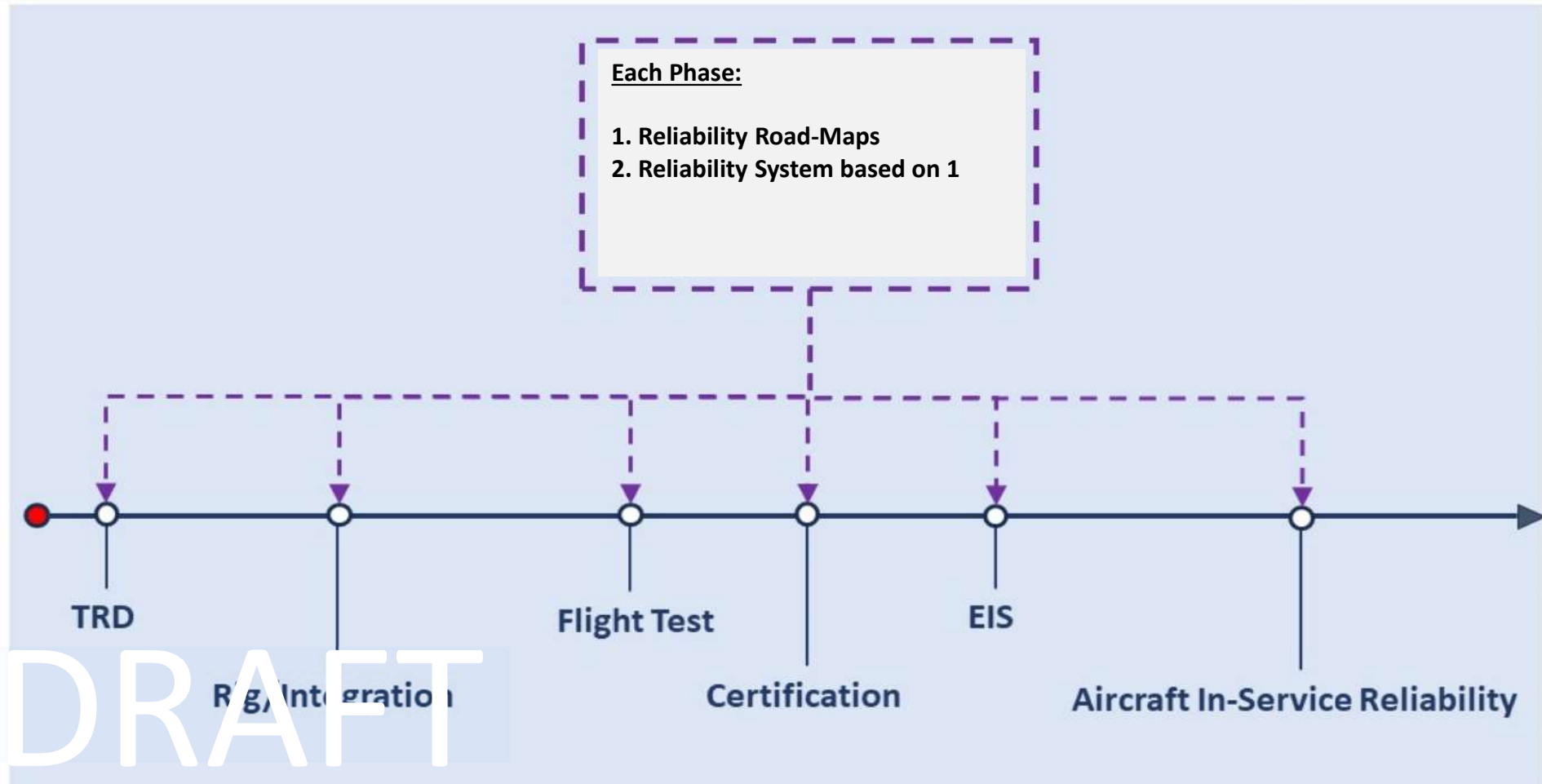
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## 4. Reliability

Ops RP System:  
Where it starts from?

### Operational Reliability - From Aircraft Design To In-Service

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## 4. Reliability

### Ops RP System development

**Ops Specs is a “head” of everything.  
And developed for each type of Aircraft**



**RP (Engineer) is part of the M&E  
department. Reliability System Road-  
Map describes RP activities**



**Technical Policies and Procedures  
Manual is “head” of the RP Document.  
RP Approved by AA (PMI- Principal  
Maintenance Inspector).**



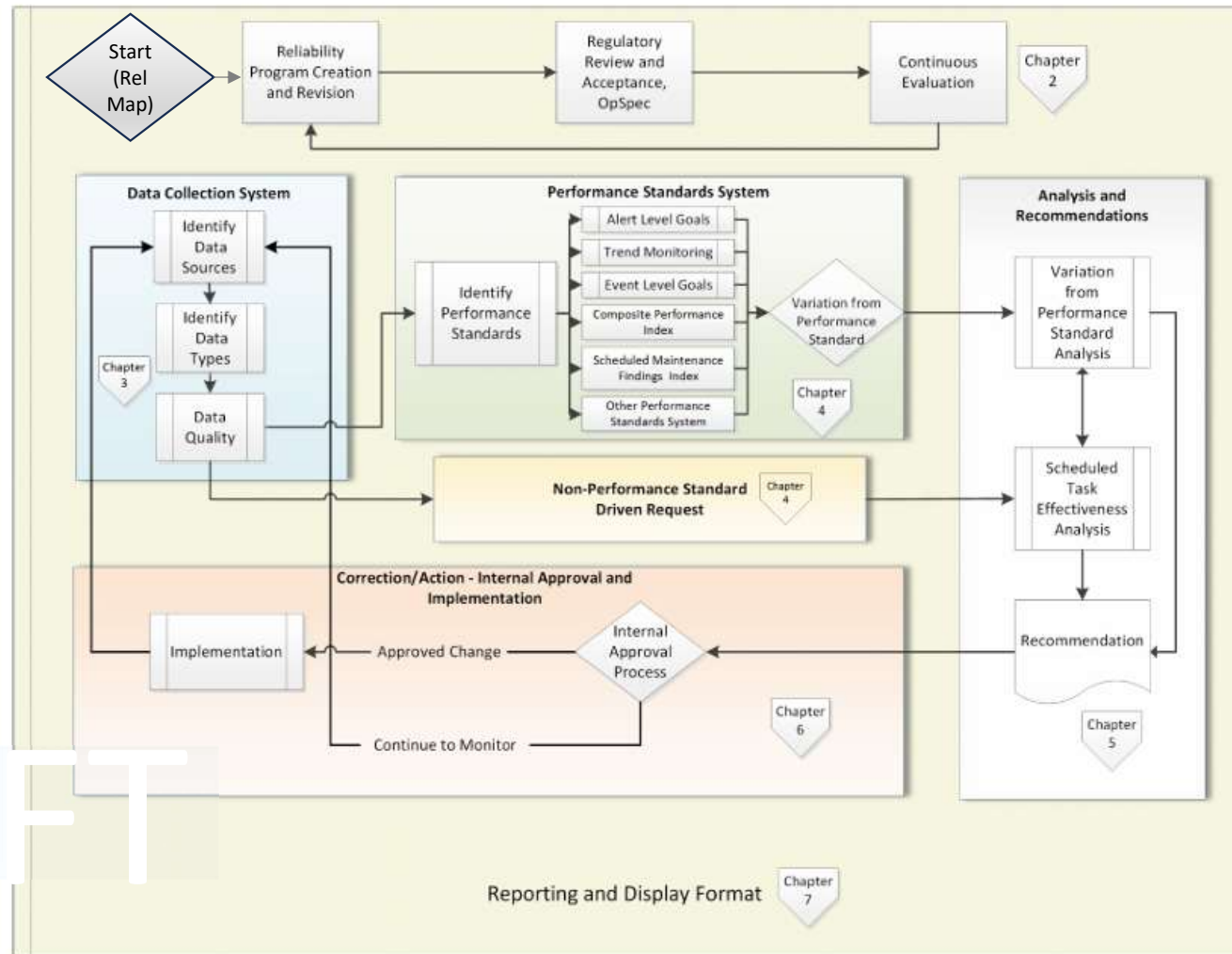
## 4. Reliability

**Reliability System, AC 120-17.**

**Q> What is missed ?**

**The next slide – details.**

**Figure 2-1. Reliability Program Management and Administration**





Reliability System, AC 120-17.



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Data Collection, Major.

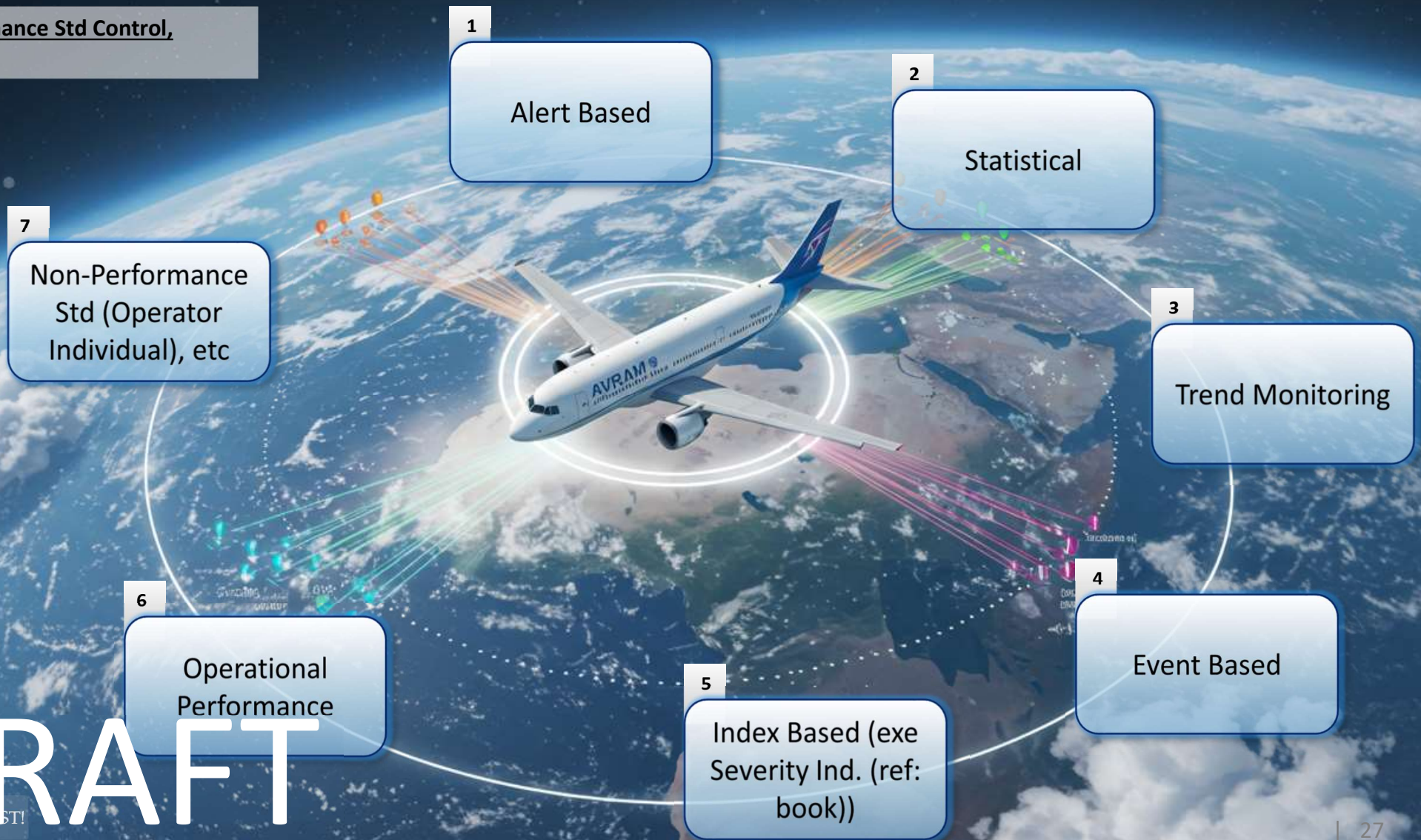


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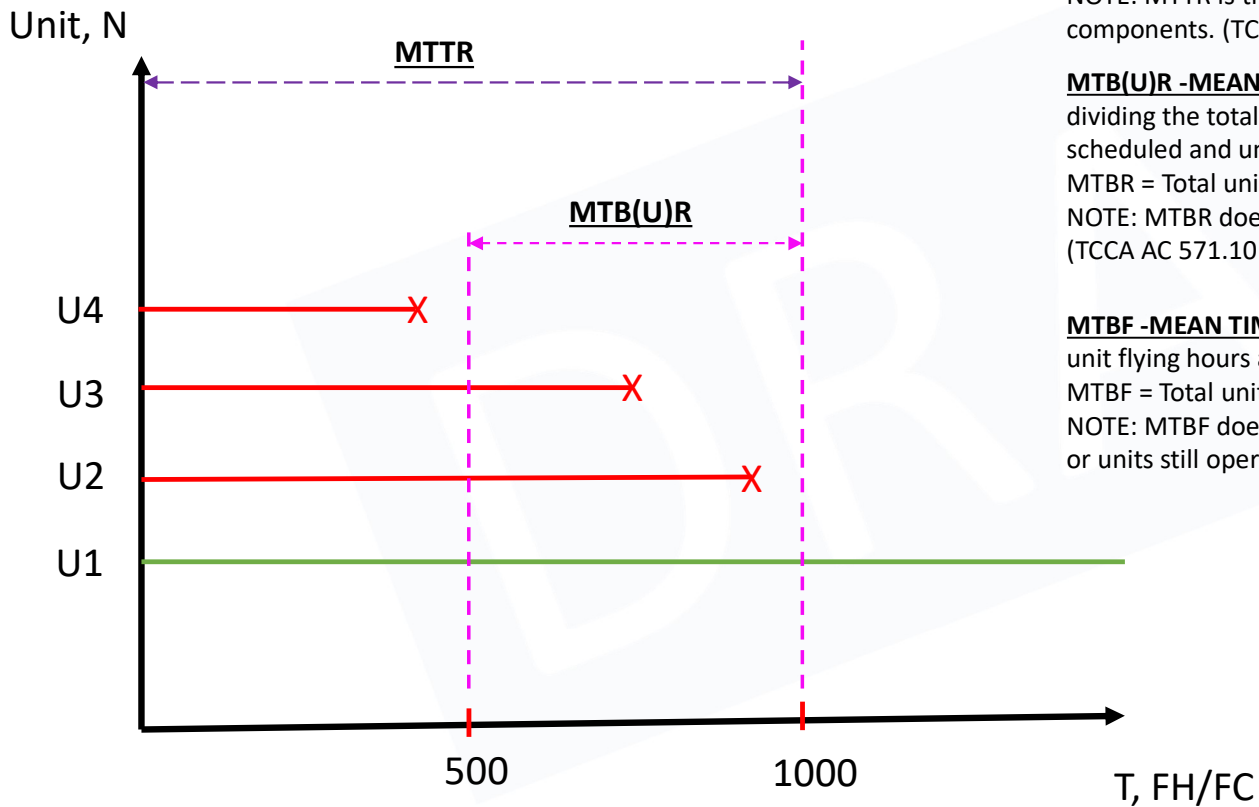
RP Performance Std Control,  
120-17.





## 4. Reliability

### MTB(U)R vs MTTR.



**MTTR -MEAN TIME TO REMOVAL.** A performance figure calculated by computing the average of the total unit operating hours at removal for both scheduled and unscheduled removals.

(RU: Requires excellent LRU tracking system. Can be done as different options.)

Formula:  $MTTR = \frac{\text{Total unit hours accrued by all removed units}}{\text{Total number of units removed}}$

NOTE: MTTR is the most accurate performance figure for the average "life" realized for all components. (TCCA AC 571.101/1)

**MTB(U)R -MEAN TIME BETWEEN (U/S) REMOVALS .** A performance figure calculated by dividing the total unit flying hours accrued in a period by the total unit removals (both scheduled and unscheduled) in that period.

MTBR =  $\frac{\text{Total unit hours this period}}{\text{Number of units removed this period}}$

NOTE: MTBR does not account for unit hours flown in other periods nor for units still operating. (TCCA AC 571.101/1)

**MTBF -MEAN TIME BETWEEN FAILURES.** A performance figure calculated by dividing the total unit flying hours accrued in a period by the number of unit failures in that period.

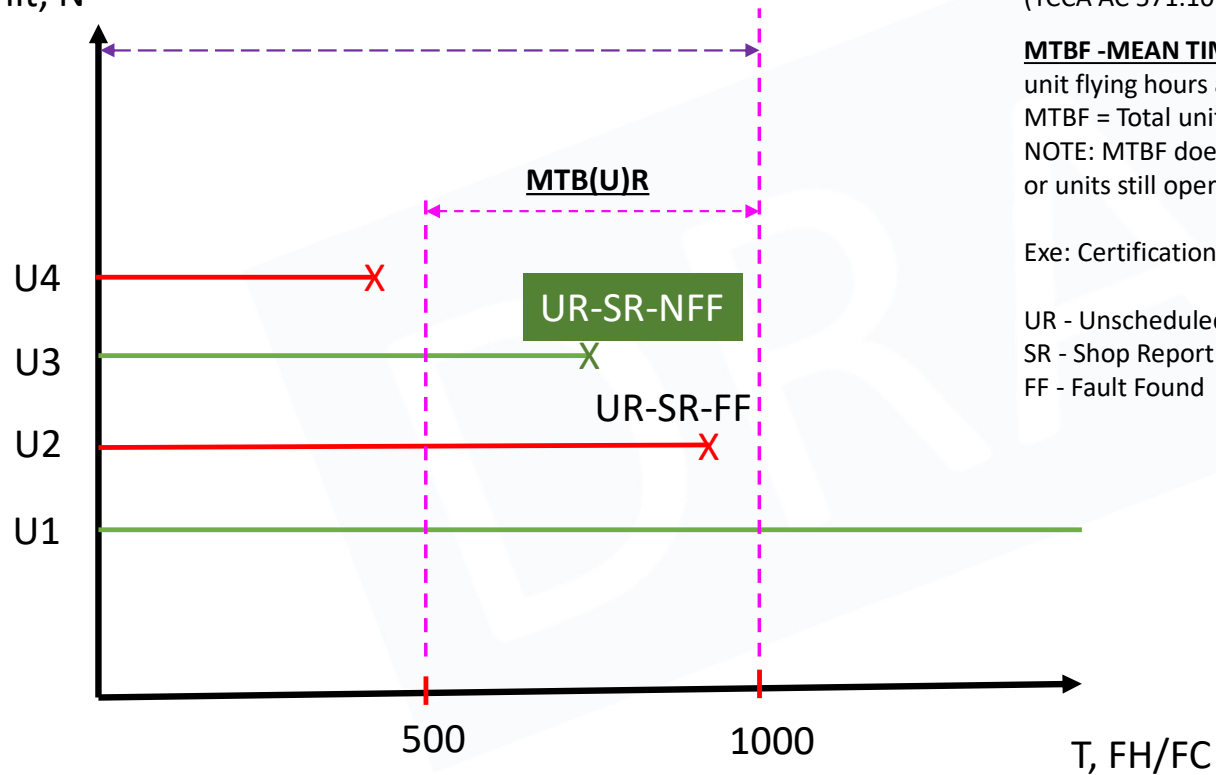
MTBF =  $\frac{\text{Total unit hours this period}}{\text{Number of units failed this period}}$

NOTE: MTBF does not account for unit hours flown in other periods, scheduled unit removals, or units still operating. (TCCA AC 571.101/1)

## 4. Reliability

### MTB(U)R vs MTBF.

Unit, N



**MTB(U)R - MEAN TIME BETWEEN (U/S) REMOVALS.** A performance figure calculated by dividing the total unit flying hours accrued in a period by the total unit removals (both scheduled and unscheduled) in that period.

MTBR = Total unit hours this period / Number of units removed this period

NOTE: MTBR does not account for unit hours flown in other periods nor for units still operating. (TCCA AC 571.101/1)

**MTBF - MEAN TIME BETWEEN FAILURES.** A performance figure calculated by dividing the total unit flying hours accrued in a period by the number of unit failures in that period.

MTBF = Total unit hours this period / Number of units failed this period

NOTE: MTBF does not account for unit hours flown in other periods, scheduled unit removals, or units still operating. (TCCA AC 571.101/1).

Exe: Certification, ETOPS. (General Formula:  $K = \text{REM\_FF} / \text{REM\_US}$ ).

UR - Unscheduled Removals

SR - Shop Report

FF - Fault Found

Q: What is the “Alert Level (%)” for K?

# AGENDA

1. Introduction

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&  
Regulations

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Where is the book?

RP Performance Std Control, AC120-17.

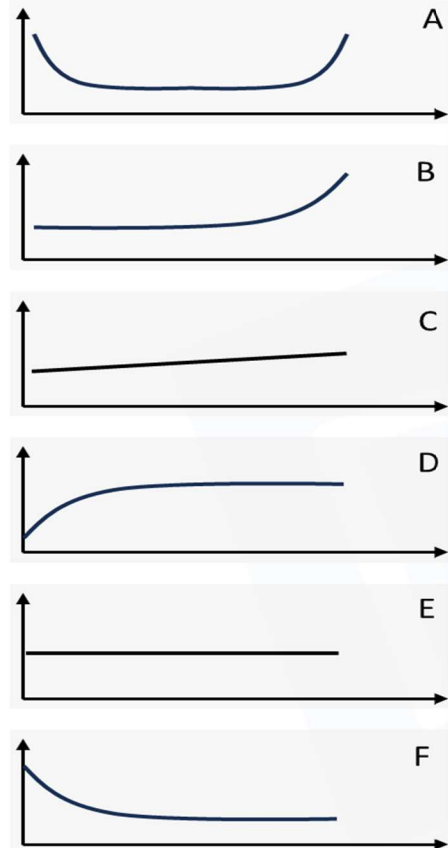


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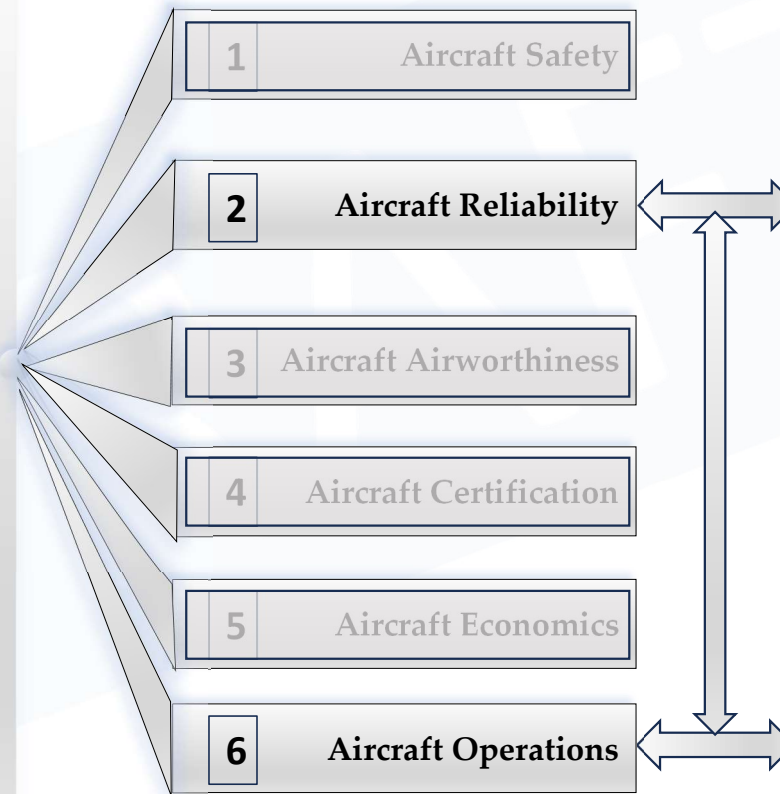
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## 5. Book

**Aircraft Reliability (Failure) Impact. (Combination of previous 2 slides).**  
**Book – Assessment Section.**



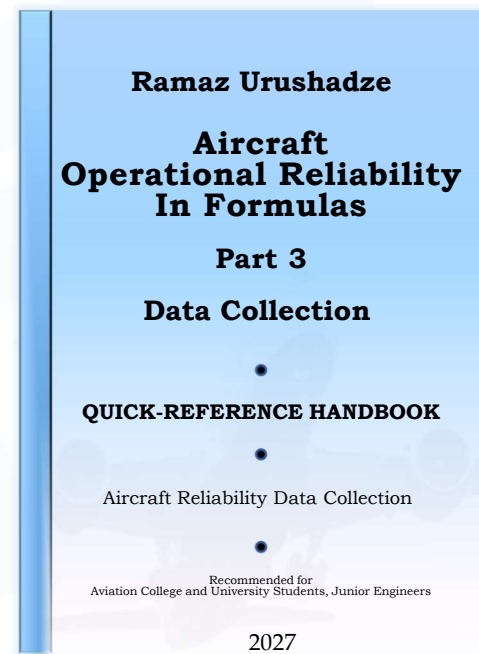
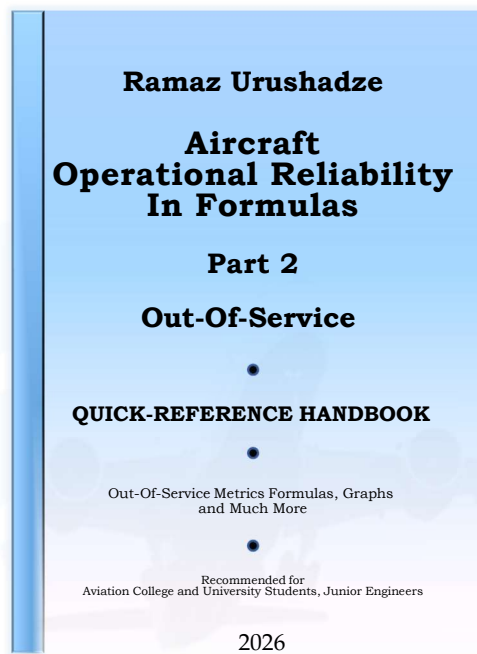
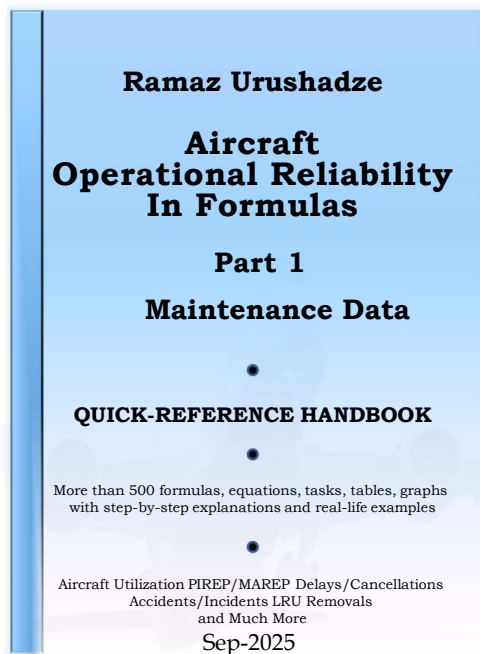
Statistics



Impact

- ✓ Revenue and Non-Revenue FH/FC
- ✓ PIREP/MAREP Rates
- ✓ MEL Rates
- ✓ Alert Levels (4 types, inc Rems)
- ✓ DEL & CNX Rates
- ✓ Dispatch Reliability
- ✓ Dispatch Interruptions
- ✓ Dispatch Performance (Del, Cnx)
- ✓ Inc / Acc Rates
- ✓ IFSD Rates (A/C, Engine)
- ✓ Severity Index (with “new” items)
- ✓ Fleet Ops Reliability
- ✓ Removals
- ✓ MTBUR, MTBF, Alert Levels
- ✓ Engine Operational Reliability Summary
- ✓ APU High Altitude Start Reliability
- ✓ 500 Metrics & Formulas, Graphs, Examples, and much more...

Assessment (Book)



Book Series: Aircraft Operational Reliability In Formulas



**Ramaz Urushadze**

# **Aircraft Operational Reliability In Formulas**

## **Part 1**

### **Maintenance Data**

#### **QUICK-REFERENCE HANDBOOK**

More than 500 formulas, equations, tasks, tables, graphs  
with step-by-step explanations and real-life examples

Aircraft Utilization PIREP/MAREP Delays/Cancellations  
Accidents/Incidents LRU Removals  
and Much More

## Book - Chapters

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## 5. Book

### Book – Exe: Severity Index

T4.52. Refer to the maintenance data in Tbl 4.15, calculate the Fleet Severity Index per 100 Aircraft FC, for JKL-Airlines Fleet. RTP: Jan-2021.

#### Severity Index:

This metric calculates the Fleet Severity Index per 100 Aircraft FC, per RTP.

Tbl 4.15 Severity Index Data

Item	Time Group, Min	Number of Total Delay	Severity Weight
Delay, Min	1-15	5	0.0
Delay, Min	16-45	16	0.1
Delay, Min	46-90	4	0.2
Delay, Min	91-150	1	0.5
Delay, Min	151-210	1	1.0
Delay, Min	211+	1	2.0
CNX	NA	5	2.0
SUB	NA	1	4.0
ATB	NA	1	5.0
Diversion	NA	1	5.0

#### Delay Severity:

$$SEV\_DEL = \text{SUM}(\text{DEL\_NUMB} * \text{DEL\_SEV\_WEIGHT}) \quad (4.58)$$

Where:

1. SEV\_DEL - Fleet Severity Index, Delay, per RTP.
2. DEL\_NUMB - Number of Delays, per RTP.
3. DEL\_SEV\_WEIGHT - Delay Severity Weight, per RTP.

Thus,

$$SEV\_DEL = (5*0) + (16*0.1) + (4*0.2) + (1*0.5) + (1*1.0) + (1*2.0) = 0 + 1.6 + 0.8 + 0.5 + 1.0 + 2.0 = 5.9$$

#### Cancellation Severity:

$$SEV\_CNX = \text{CNX\_NUM} * \text{CNX\_SEV\_WEIGHT} \quad (4.59)$$

Where:

1. SEV\_CN - Cancellation Severity Index, Cancellation, per RTP.
2. CNX\_NUM - Number of Cancellations, per RTP.
3. CNX\_SEV\_WEIGHT - Cancellation Severity Weight, per RTP.

Thus,

$$SEV\_CNX = 5*2.0 = 10.0$$

#### Substitute Aircraft Severity:

$$SEV\_SUB = \text{SUB\_NUM} * \text{SUB\_SEV\_WEIGHT} \quad (4.60)$$

Tbl 4.16 Severity Index Formula (Operations, Interruptions etc.) contributors, from T4.45 to T4.52

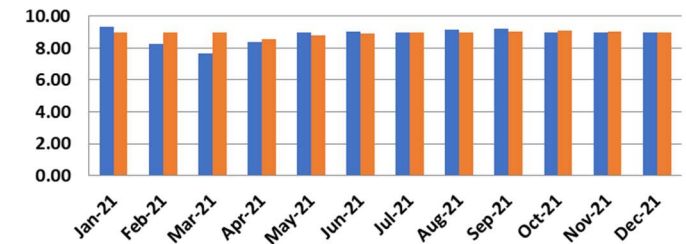
Interruption	Fleet SCHD Interruption Rate, Y_N, 100DEP	Fleet SCHD REL, Y_N, 100%	Fleet SCHD Non-Completion Rate, Y_N, 100DEP	Fleet SCHD Completion Rate, Y_N, 100%	Fleet Operation Interruption Rate, Y_N, 100DEP	Fleet Operation Reliability, Y_N, 100%	Operation Performance, Y_N, 100%	Severity Index
IFSD	N	N	N	N	N	N	N	N
RTG	Y	Y	N	N	Y	Y	Y	N
RTO	Y	Y	N	N	Y	Y	Y	N
ATB	Y	Y	Y	Y	Y	Y	Y	Y
DIV	Y	Y	Y	Y	Y	Y	Y	Y
AAP	Y	Y	N	N	Y	Y	Y	N
GAI	N	N	N	N	Y	Y	Y	N
GGI	N	N	N	N	N	N	Y	N
DEL	Y*	Y*	N	N	Y**	Y**	Y	Y
CNX	Y	Y	Y	Y	Y	Y	Y	Y
SUB	N	N	N	N	N	N	Y	Y
ACFT								

\*Note: Include all delays.

\*\*Note: Excludes delays 15 minutes and less.

Note: All numbers and data are generated using the random functions in MS Excel

SEVERITY IND, 100 DEP **Severity Index, JKL-Airlines vs W/WIDE, 12MO, RTP: Dec-21**



	Jan-21	Feb-21	Mar-21	Apr-21	May-21	Jun-21	Jul-21	Aug-21	Sep-21	Oct-21	Nov-21	Dec-21
SEVERITY, 100 DEP, JKL	9.32	8.26	7.69	8.36	8.95	9.01	9.00	9.15	9.23	9.00	8.95	8.96
SEVERITY, 100 DEP, W/WIDE	9.00	8.99	8.96	8.56	8.78	8.94	8.95	9.00	9.01	9.10	9.05	8.99

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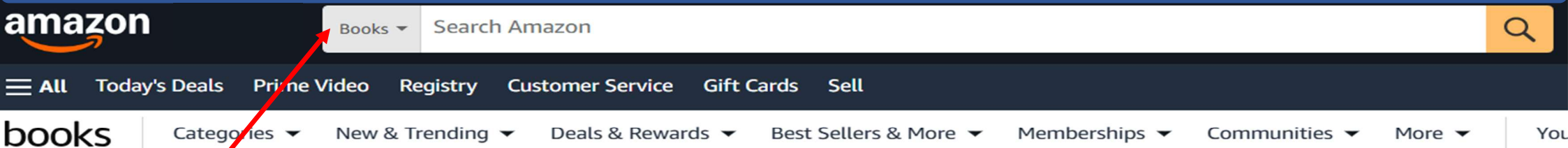
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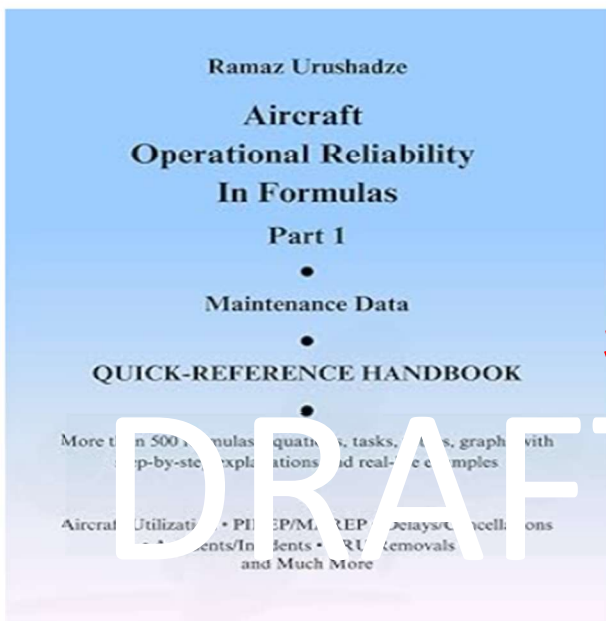
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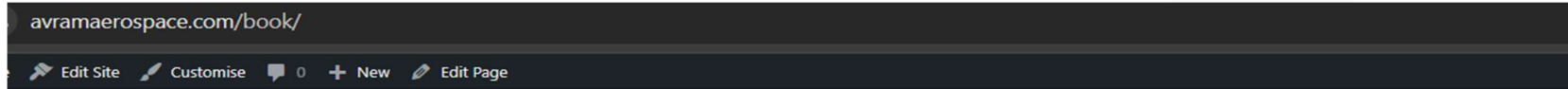
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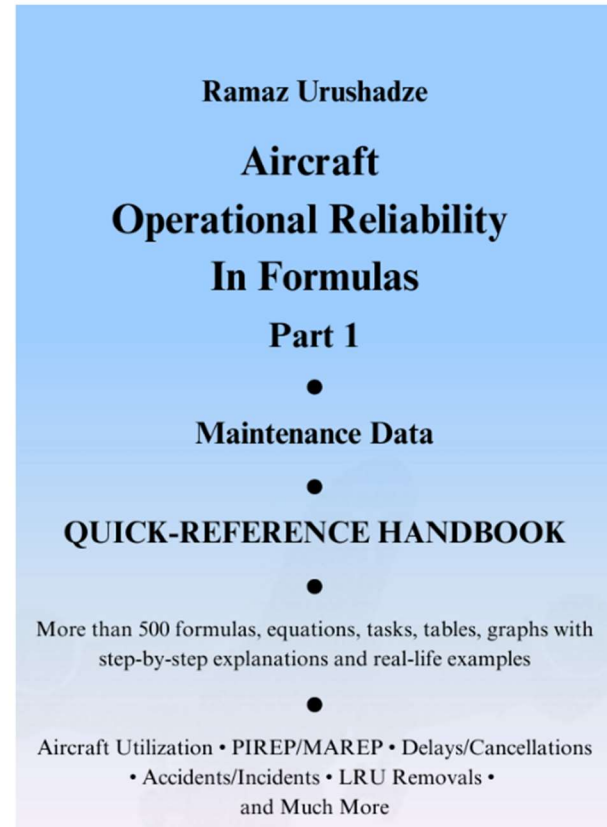
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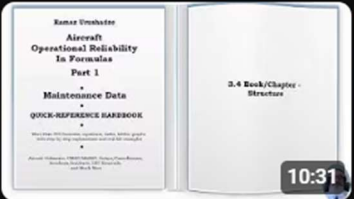
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