



REPORT ON MAINTENANCE ECONOMICS MODEL DISSEMINATION

By

All WP1.6.3 partners

Abstract:

The objective of WP1.6.3 dealing with Maintenance Economic Models is to develop/improve methods and tools for On-Aircraft DMC Projections. As defined in the previous reports, two main axes were treated within this subtask structure DMC and trouble-shooting DMC for system.

This report summarizes the main results of this work-package WP1.6.3, which are:

- a state of the art on Maintenance Cost assessment practices (internal and external),
- an analysis of all in-service data that can be gathered and used in the field,
- specifications of methods/models that are addressing the two main axes,
- tests on these methods/models

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6.2.	<i>ACRONYMS AND ABBREVIATIONS</i>	Erreur ! Signet non défini.

1. EXECUTIVE SUMMARY

The objective of WP1.6.3 dealing with Maintenance Economic Models is to develop/improve methods and tools for On-Aircraft DMC Projections. As defined in the previous reports, two main axes were treated within this subtask structure DMC and trouble-shooting DMC for system.

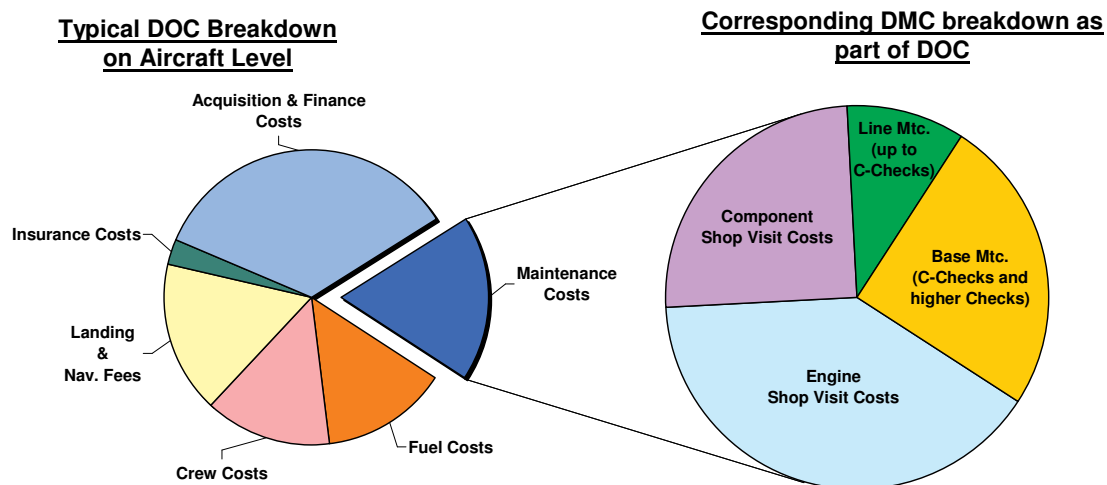
This report summarizes the main results of this work-package WP1.6.3, which are:

- a state of the art on Maintenance Cost assessment practices (internal and external),
- an analysis of all in-service data that can be gathered and used in the field,
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- tests on these methods/models.

2. INTRODUCTION

The three major concerns of airlines are safety, operational reliability and operating costs. Maintenance Economics are one of the major operating cost drivers that can be **influenced by design**. During aircraft life, accumulated maintenance costs are in the order of magnitude of the aircraft acquisition costs. Due to the different origins of maintenance costs, Direct Maintenance Cost (DMC) as a predominant driver of maintenance cost can be influenced by design.

During aircraft life, Direct Operating Costs (DOC) and Direct Maintenance Cost (DMC) have the following breakdown:



Maintenance Cost (MC) is decomposed in Direct Maintenance Cost (DMC) and Indirect Maintenance Cost (IMC) as follow: $MC = DMC + IMC$

With:

DMC: Maintenance labour and material costs directly expended in performing maintenance on an item or aircraft

IMC: Maintenance costs not considered to be DMC but which contribute to the overall maintenance program costs through overhead operation, administration, engineering, record keeping, supervision, tooling, test equipment, facilities, etc.

So the origin of DMC is the labour and material costs caused by aircraft systems, engines and structures on scheduled and unscheduled basis to keep the aircraft in an operational state.

There are hundreds of COTS providers and associated tools for the implementation of DOC and LCC methodology. In the state of the art, some software have been analysed according to real experimentations, demonstrators (functional limitations) or details provided by suppliers:

Software	Provider
CAME, CARE, CAFDE	BQR company
SIMFIA, SIMLOG	APSYS / SOFRETEN

But none of them are addressing the full aspect of the structure DMC and trouble-shooting DMC for system.

3. DISSEMINATION ON STRUCTURE DMC METHOD

During this study, several data source were analysed for in-service data analysis. The following table summarize the available data source and their contribution to MEM for structure DMC:

Name	Content
FORDS	Database containing the detail description of Operational Interruptions (OI)
Structural Repair Manual (SRM)	Allowable damages and associated repairs on aircraft structure
Structure Damage Management System (SDMS)	Database of Repair design Approval Sheet (RAS) for repairs beyond of SRM, SB limits.
In-service DMC benchmark	Operator specific information maintenance cost for specific aircraft types. (Total Costs for scheduled checks, in some cases split between material and labour costs)
MSG-3 analysis	Maintenance documentation describing the maintenance tasks related to a Structural Significant Item (SSI) and considering the design parameters.

The study aims at providing a methodology to ease the unscheduled DMC assessment for structure, to allow a better evaluation of the DMC on A/C.

Following the methodology explained in the report D1.6.2.3., the current estimation of the structure DMC is based on the following formulae:

$$DMC = DMC_{scheduled} + DMC_{unscheduled}$$

where: $DMC_{scheduled} = DMC_{MH_scheduled} + DMC_{mat_scheduled}$

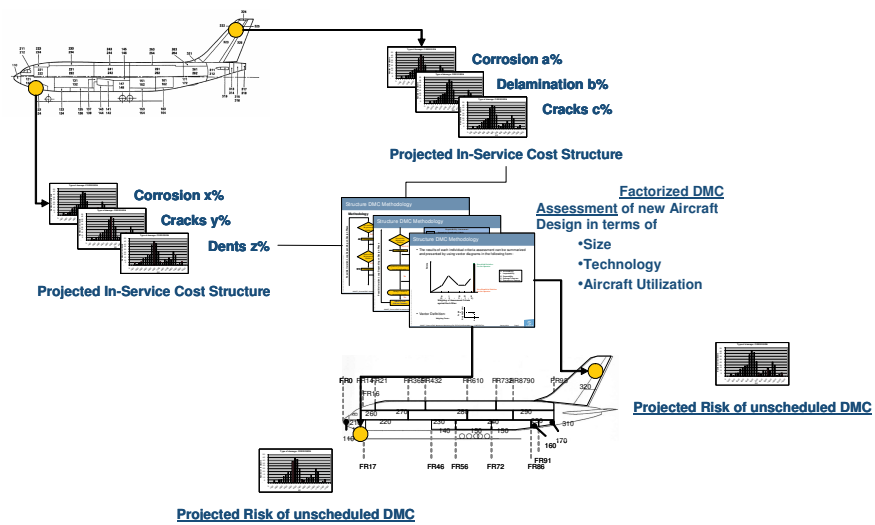
$$DMC_{unscheduled} = DMC_{MH_unscheduled} + DMC_{mat_unscheduled}$$

thus, $DMC = DMC_{MH_scheduled} + DMC_{mat_scheduled} + DMC_{MH_unscheduled} + DMC_{mat_unscheduled}$

- DMC is assessed by the reporting figures from the operators (refer to D1.6.2.3 - §2.2.4. – “In-service DMC benchmark”)
- $DMC_{mat_scheduled}$ is not assessed in detail due to the fact, that scheduled material cost are
 - minor in comparison to unscheduled costs
 - lack of in-service data for scheduled material consumption
- $DMC_{MH_scheduled}$ is assessed by a projection of the Maintenance Planning Document (MPD) for the future A/C.

$$\Rightarrow DMC_{unscheduled} = DMC - DMC_{scheduled}$$

Then we developed a method to assess the unscheduled structure DMC, method based on in-service experience and factorized approach:



This methodology is breakdown into 5 steps:

- Step 1: Identify the main factors contributing to DMC,
- Step 2: Estimate DMC for an established aircraft (baseline),
- Step 3: Evaluate the DMC for new aircraft utilization (use impact),
- Step 4: Analyze the impact of scaling effects,
- Step 5: Evaluate the impact of new technology application.

Several tests have been performed with real values, but the methodology requires a validation steps to link the incidents reported to the cost of repairs and then to the DMC. The average repair cost assumptions per type of repair and severity of repair has to be further validated.

4. DISSEMINATION ON TROUBLE SHOOTING DMC METHOD

During this study, several data source were analysed for in-service data analysis. The following table summarize the available data source and their contribution to MEM for systems:

Name	Content
FORDS	Nb of OI per ATA (2D & 6D), nb of revenue T/O for A/C type (A330, A340, ..). For each OI: date, operator, MSN, engine type, station, time of detection, effect, delay duration if applicable, textual description.
COREAS	Component Fleet MTBF/MTBUR per PN
Airbus Supplier Rating	Airbus Supplier In-service data on Repair costs, test cost, No Fault Found Rates, Reliability and DMC.
In-Service DMC Benchmark	Operator specific information Maintenance Cost for specific A/C Types. (Total Costs for scheduled checks, in some cases split between material and labour costs)

The study aims at providing a methodology to ease the Troubleshooting Time assessment, to allow a better evaluation of the DMC on A/C.

Following the methodology explained in the report D1.6.2.3., the current estimation of the DMC is based on the following formulae:

$$DMC = \left(\frac{TS_Cost}{MTBUR} \right)_{On-AC} + \left(NFF \times \frac{Test\ cost_{Shop}}{MTBUR} + (1 - NFF) \times \frac{repair\ Cost_{Shop}}{MTBUR} + \frac{overhaul\ Cost}{Interval} \right)_{Off-AC}$$

Where the factor $\frac{TS_Cost}{MTBUR}$ is the DMC on A/C related to trouble-shooting.

$$TS_Cost = TS_Time \times Line_labor_Rate$$

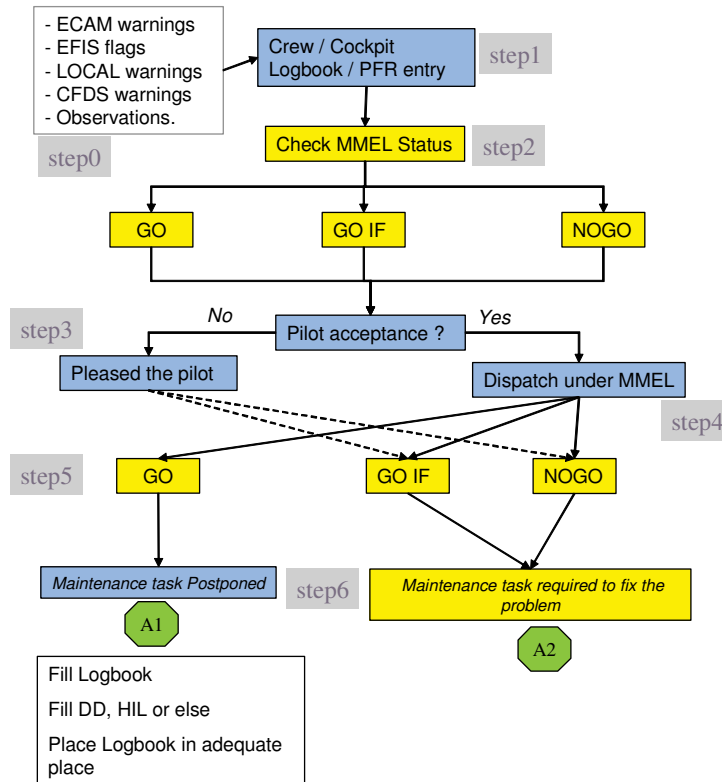
TS_cost is the trouble-shooting cost composed of

- TS_time (trouble shooting time)
- Line labour rate

MTBUR the mean time between unscheduled removals

All these parameters are mainly driven by design and maintenance philosophy.

Then the focus was to assess the troubleshooting time (TS_time). The methodology to assess the troubleshooting time has been built based on a common and agreed troubleshooting process and has been tested on representative uses-cases with in service.



Where the TS_time is computed as follow:

$$TS_Time = T_{\log\ book + PFR + MMELE} + T_{\text{confirmation}} + T_{\text{isolation}} + T_{RTST}$$

Tests were carry-on to estimate the different subtasks and summarized in the following table:

FIP ref	Designation	Fault Confirmation		Fault Isolation		Return To service Test		TOTAL TSM time
		nb of possible causes	FC time	F1 time better	F1 time worst	Number of test level (F-)	RTST time	
1	Loss of the Data from the RMP 2 to the FV							
2	Failure of the RMP 2 (RMP 2 Source)							
3	Loss of the Data from the RMP 1 to the FV							
4	Failure of the RMP 1 (RMP 2 Source)							
5	Loss of the Tuning Data for the HF1 System							
6	Loss of the RMP 1 Data on the Bus 2 (VHF1)							
7	Loss of the Tuning Data for the HF2 System							
8	Loss of the RMP 2 Data on the Bus 2 (VHF2)							
9	Loss of the Tuning Data for the HF3 System							
10	Loss of the RMP 2 Data on the Bus 1 (VHF2)							
11	Loss of the Tuning Data for the HF1 System							
12	Loss of the RMP 1 Data on the Bus 2 (HF1)							
13	Loss of the Tuning Data for the HF2 System							
14	Loss of the RMP 2 Data on the Bus 2 (HF2)							
15	Failure of One of the Two RMPs: The RMP 1							
16	Failure of One of the Two RMPs: The RMP 2							
17	Loss of the Data from the RMP 3 to the FV							
18	Loss of the Data from the RMP 1 to the FV							
19	Loss of the Data from the RMP 1 to the FV							
20	Loss of the Data from the RMP 2 to the FV							
21	Loss of the Data from the RMP 3 to the FV							
22	Failure of the RMP 1 (RMP 2 and RMP 3 Src)							
23	Failure of the RMP 2 (RMP 1 and RMP 3 Src)							
24	Loss of the RMP 1 Data on the Bus 1							
25	Loss of the RMP 2 Data on the Bus 1							
26	Loss of the RMP 3 Data on the Bus 3							
27	Failure of One of the Three RMPs: The RMP 1							
28	Failure of One of the Three RMPs: The RMP 2							
29	Failure of One of the Three RMPs: The RMP 3							
30	Loss of the RMP 2 Data by the RMP 1							
31	Loss of the RMP 1 Data by the RMP 2							
32	Action on Double Arrow Pushbutton: Suite							
33	Action on Double Arrow Pushbutton: Suite							
34	Action on Double Arrow Pushbutton: Suite							
35	Loss of the RMP 1 Data on the Bus 2 (CFDI)							
36	Loss of the BUS 1 Data from the CFDI to R							
37	Loss of the Reception of the FMOC OVN							
38	Loss of the Reception of the FMOC OVN							
39	Failure of the RMP 1							
40	Failure of the RMP 2							
41	Failure of the RMP 1							
42	Failure of the RMP 2							
43	Failure of the RMP 1							
44	Failure of the RMP 2							
45	average values							

TS_time is based on 3 sources of data:

- Engineering data coming from the troubleshooting process such as: logbook, PFR and MMEL,
- Engineering experience coming from A/C diagnosis:
 - o Possible TSM procedures based on the same ECAM /FDE message
 - o Several failures causes in the same TSM procedure
- Design data at system level such as :
 - o Time of confirmation
 - o Time of RTST
 - o MTTR
 - o Data loading time

The main contributor to the TS time is the **isolation time**. This time is mainly dependent of the system architecture (connexion, test capabilities, etc.), the MMEL status and to maintenance philosophy. The isolation procedure is applied only for GOIF /NOGO items. This means that a design with GO item will reduce the TS time and thus the DMC on A/C cost.

At first estimation, we have chosen to select the average value for the TS time computation but a further improvement will be to evaluate the probability of occurrence of the possible TSM procedures.

Then to consider a global isolation time and ON A/C Trouble-Shooting DMC figure, it is needed to complete the study by assessing:

- the occurrences of the T/S procedure which is based mainly on system/equipment MMEL Status and on the equipment reliability (e.g. MTBF)
- and the equipment replacement reasons such as operators behaviours (mechanics experience). Because in-service fault indication occurs more frequent than equipment removals.

5. REFERENCES

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[2] : VIVACE 1.6/2/AIG/T/04010-1.0 : D1622_MEM_ISDC_report

[3] : VIVACE 1.6/2/EADS-CRC-F/T/05019-2.0 : D1623_MEM_Model_report

[4] : VIVACE 1.6/2/EADS-CRC-F/T/06026-1.0: D1624_MEM_tests_report

[5] : ATA Common Support Data Dictionary (CSDD)

This document is classified as VIVACE Confidential**6. APPENDIX A: GLOSSARY AND ABBREVIATIONS**

Abbreviation	Signification	Reference
A/C	Aircraft	AECMA
AECMA	Aircraft European Contractors Manufacturers Association	AECMA
ATA	Air Transport Association of America	AECMA
CAFDE	Computer Aided Field Data Engineering	
CAME	Computer Aided Maintenance Engineering	
CARE	Computer Aided Reliability Engineering	
CFDS	Centralized Fault Display System	AP2080
COTS	Commercial Off The Shelf (procurement)	AECMA
DMC	Direct Maintenance Cost	AECMA
DOC	Direct Operating Cost	AECMA
ECAM	Electronic Centralized Aircraft Monitoring	AECMA
FC	Flight Cycle	AECMA
FH	Flight Hour	AECMA
FIP	Fault Isolation Procedure	
FORDS	Fleet Operational & Reliability Data System	ABD0200.1.3
GO	refer to MEL status	
GO IF	refer to MEL status	
IMC	Indirect Maintenance Cost	
LCC	Life Cycle Costs	AECMA
LRU	Line Replaceable Unit	AECMA
MEL	Minimum Equipment List	AECMA
MEM	Maintenance Economic Model	
MMEL	Master Minimum Equipment List	AECMA
MSN	Manufacturer Serial Number	AECMA
MSG-3	Maintenance Steering Group issue3	AECMA
MTBF	Mean Time Between Failures	AECMA
MTBUR	Mean Time Between Unscheduled Removals	AECMA
MTTR	Mean Time To Repair	AECMA
MTTRS	Mean Time To Restore the System	MIL-STD-721
MTTRF	Mean Time To Restore the Function	AECMA
NFF	No Fault Found	AECMA
OI	Operational Interruption	AP2080

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Abbreviation	Signification	Reference
OR	Operational Reliability (refer to WP1.6.4)	AECMA
ORA	Operational Reliability Analyser	
PN	Part Number	AECMA
PFR	Post Flight Report	AECMA
RAS	Repair Approval Sheet	AECMA
RTST	Return-To-Service-Test	AECMA
SB	Service Bulletin	AECMA
SDMS	Structure Damage Management System	
SIMFIA	SIMulation de FIAbilité software	
SIMLOG	SIMulation LOGistique software	
SRM	Structural Repair Manual	AECMA
SRU	Shop Replaceable Unit	AECMA
SSI	Safety Significant Item	AECMA
SW	Software Loading	
THAV	Thales-Avionics	
TSM	Trouble-Shooting Manual	AECMA
WATOG	World Airlines Technical Operations Glossary	AECMA