Maintenance Costs

1 Basic Equations

$$TMC = DMC + IMC$$

TMC	Total Maintenance Costs
DMC	Direct Maintenance Costs (costs caused by the aircraft)
IMC	Indirect Maintenance Costs (costs caused by the maintenance environment)

Only DMC are needed to calculate Direct Operating Costs, DOC.

$$DMC = \left(MMH_{on} + MMH_{off}\right) \cdot LR + MC$$

MC	Material Costs		
LR	Labor rate	without "overhead":	unburdened labor rate ≈ 23 $/FH
	Labor rate	with "overhead":	burdened labor rate ≈ 69 $/FH

FH Flight Hour

MMH	Maintenance Man Hour
MMH_{on}	Line Maintenance (on aircraft)
MMH_{off}	Shop Maintenance (in the workshop)

All costs should be based initially on one yeas. As such also DMC are calculated per aircraft and per year. In this case also MMH_{on}, MMH_{off} und MC are calculated per year. Often it is known:

MMH_{on}/FH, MMH_{off}/FH und MC/FH

2 Calculation of Maintenance Hours for one Maintenance Event

$$MTBUR = FTRR \cdot MTBF$$

MTBF = Mean Time Between Failures

$MTBF = \frac{1}{\lambda}$ with λ, failure rate (from reliability calculations)

FTRR = Failure To Removal Ratio from Table 1

MTBUR = Mean Time Between Unscheduled Removals

Table 1 Failure To Removal Ratio (FTRR)

System	FTRR
Elektronic	0,3…0,4
Elektric	0,6…0,7
Hydraulic	0,8…0,9
Mechanic	1,0

The number of maintenance events per year are calculated with

$$n_M = \frac{FT \cdot NFY}{MTBUR}$$

FT Flight Time

NFY Number of Flights per Year

$$MMH_{on} = RT_{on} \cdot n_M$$

RT Repair Time

$$MMH_{off} = RT_{off} \cdot n_M$$

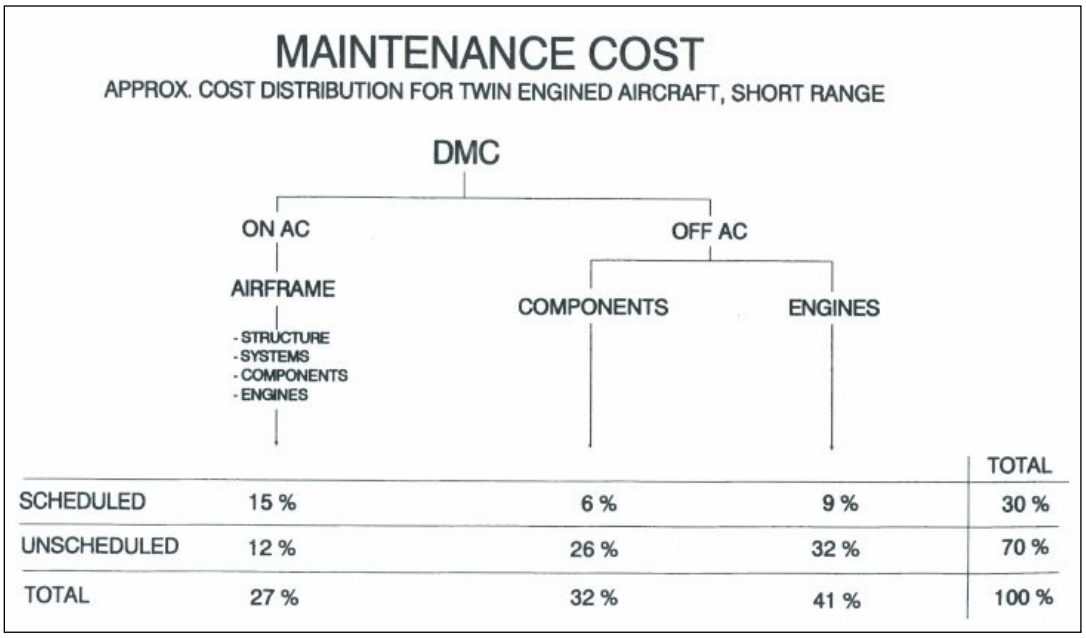
Table 2 gives values from experience about Labor Costs and Material Costs for maintenance of a long range aircraft. Assumed is a labor rate with overheads of 69 US$/MMH.

Table 2 Labor costs and material costs for maintenance of a long range aircraft in 1997-US $

ATA Chapter	Labor Costs [$/FH]		Material Costs [$/FH]
	on A/C	off A/C	
21	3,3	8,2	3,7
22	0,8	1,5	0,7
23	3,2	4,9	2,0
24	2,2	4,1	4,8
25	15,0	30,4	21,6
26	1,3	0,9	0,6
27	7,4	6,0	2,5
28	7,2	3,0	2,1
29	3,8	2,0	3,7
30	1,2	0,4	0,7
31	1,0	1,2	8,7
32	2,4	11,9	40,8
33	6,9	0,4	2,9
34	2,2	8,8	4,5
35	1,8	1,8	0,6
36	2,9	4,4	2,5
38	1,6	3,6	1,0
49	0,2	1,4	1,5

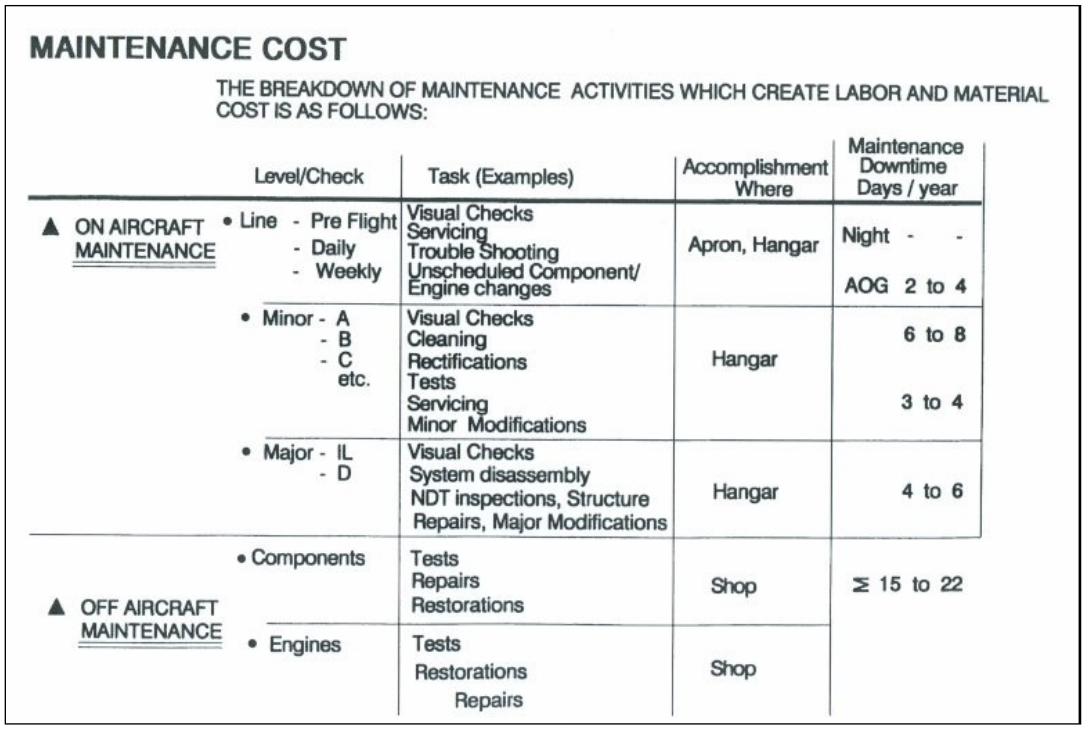
With the help of the Airbus Industry Comparison Method (AICM) - also described in the VDI article " Wartungsaufwandsanalyse auf Systemebene" (Maintenance Effort Analysis at System Level) - data from existing aircraft (as in Table 2) can be used to infer the corresponding data of projected systems.

3 Division of Maintenance Costs



				TOTAL
SCHEDULED	15 %	6 %	9 %	30 %
UNSCHEDULED	12 %	26 %	32 %	70 %
TOTAL	27 %	32 %	41 %	100 %

Figure 1 Division of Direct Maintenance Costs (DMC)



MAINTENANCE COST

THE BREAKDOWN OF MAINTENANCE ACTIVITIES WHICH CREATE LABOR AND MATERIAL COST IS AS FOLLOWS:

	Level/Check	Task (Examples)	Accomplishment Where	Maintenance Downtime Days / year
▲ ON AIRCRAFT MAINTENANCE	• Line - Pre Flight - Daily - Weekly	Visual Checks Servicing Trouble Shooting Unscheduled Component/ Engine changes	Apron, Hangar	Night - - AOG 2 to 4
	• Minor - A - B - C etc.	Visual Checks Cleaning Rectifications Tests Servicing Minor Modifications	Hangar	6 to 8 3 to 4
	• Major - IL - D	Visual Checks System disassembly NDT inspections, Structure Repairs, Major Modifications	Hangar	4 to 6
▲ OFF AIRCRAFT MAINTENANCE	• Components	Tests Repairs Restorations	Shop	≥ 15 to 22
	• Engines	Tests Restorations Repairs	Shop	

Figure 2 Development of maintenance costs for different maintenance events