Maintainability Modeling

Where there are specific maintainability requirements or goals, which must be obtained for a system, then there is a need to determine the system's quantitative maintainability characteristics. This could be represented in terms of a Mean-Time-To-Repair (MTTR). Other parameters to be considered are the maximum time repair and these could be determined for each of the various levels of maintenance.

The basic approach in deriving the MTTR for level one (or first line) maintenance action, would be to determine the maintenance task times for each corrective maintenance task and weight it with their occurrence. The elapse times for each corrective maintenance task could then be calculated. This would take into consideration the various steps required to implement this task and include the time to isolate the fault to the failed unit to be removed, removal time of that unit, its replace time and the time to complete system verification.

Critical to the remove and replace times is the accessibility to the failed unit required by the maintainer. This would include the ability to use the necessary hand tools and or test equipment and the actual physical removal of the unit.

Therefore, the design phase consideration must be given to the layout of the components and avoid the prospect of having to remove other components to access a failed unit. A good example of this would be the restricted engine compartment of an automobile. This could be seen where a mechanic will be faced with the prospect of having to remove a number of components from an engine to gain access to a particular item.

Another critical consideration when determining the overall MTTR calculation is the time it takes to isolate the fault. For some systems this could be relatively straight forward, while for others it could be a more complex affair. To ensure that the fault detection and isolation components and capabilities of a system are obtained, a careful testability analysis must be performed.

The following table provides an example for a given corrective maintenance task, on how it could be broken down into specific subtasks and their elapse time.

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Control Display Assembly			
Task Number	CM:107	**Task Type**	Corrective Maintenance
Sub Task	**Sub Task Details**	**Time**	**Required Support**
Fault Detection [01]			
CM:107:01:01	Run System BIT	2:00	
Removal [02]			
CM:107:02:01	Set the Control Switch on the Operator Station to "Off"	0:50	Located on Operator Station (OS)
CM:107:02:02	Isolate Power: Open OS CCT BRK main AC Power	2:00	OS electrical cct breaker panel
CM:107:02:03	Release the DZUS fasteners on the CDA	0:50	
CM:107:02:04	Pull/ Slide CDA from OS	0:50	
CM:107:02:05	Disconnect P1 and P2 and install protective caps	1:00	
Installation [03]			
CM:107:03:01	Verify Control Switch on the Operator Station to "Off"	0:50	
CM:107:03:02	Isolate Power: Verify OS CCT BRK main AC Power is "Open"	0:50	
CM:107:03:03	Remove Protective Caps from P1 and P2 sockets of CDA	0:50	
CM:107:03:04	Connect P1 and P2 to CDA	1:00	
CM:107:03:05	Slide CDA into Position	0:50	Care must be taken to ensure that the cables (P1 and P2) do not bind with the structure.
CM:107:03:06	Secure the DZUS fasteners on the CDA	0:50	
CM:107:03:07	Close OS CCT BRK main AC Power	1:00	
CM:107:03:08	Power up Operator Station (OS)	4:00	
Check Out/ Repair Verification [04]			
CM:107:04:01	Run System BIT	2:00	
	Total Elapse Time	**17:00**	**Minutes**

Table: LRU Corrective Maintenance Time (MCT)

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Example of a System MTTR Calculation

The MTTR for a system can be calculated by using a weight factor against each mean corrective maintenance time (mct), namely the unit's failure rate. The derived MTTR takes into consideration the elapse time (or mct) required to perform the corrective maintenance tasks for each of the LRUs, making up the system. In the given formula, the MTTR represents the mean of the number of times to repair, weighted by the probability of occurrences:

$$MTTR = \frac{\sum_{i=1}^{n}(\lambda_i . mct_i)}{\sum_{i=1}^{n}\lambda_i}$$

Where:

- λ_i = failure rate of the i^{th} unit
- mct_i = time to repair of the i^{th} unit
- n = Number of units

In deriving the MTTR, a given assumption is that the required logistics support is readily available. This includes the necessary manpower and spare parts. In other words the time for administration delay are not considered.

	MTBF	fpmh (λ)	mct	λ x mct
Video Unit	1,531	6.53E-04	22.6	1.48E-02
Display Unit	1,760	5.68E-04	34.0	1.93E-02
Power Unit	84,800	1.18E-05	16.0	1.89E-04
Disk Array	8,793	1.14E-04	27.0	3.07E-03
Synchronising Assembly	3,600	2.78E-04	34.5	9.58E-03
Sensor Unit	17,500	5.71E-05	24.5	1.40E-03
Relay Assembly	2,674	3.74E-04	18.5	6.92E-03
Control Display Assembly	3,000	3.33E-04	17.0	5.67E-03
Recorder	24,400	4.10E-05	12.4	5.08E-04
Hub Assembly	6,500	1.54E-04	19.5	3.00E-03
Totals	$\sum_{i=1}^{n}\lambda_i$	2.58E-03	$\sum_{i=1}^{n}(\lambda_i . mct_i)$	6.44E-02

Table: System MTTR

The System MTTR would yield a time of 24.93 Minutes

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