Asset Management Questions

Is the MTBF all I need to know to manage it well?

References:

A. International Electrotechnical Vocabulary (IEV)
B. US MIL-HDBK-338B, Electronic Reliability Design Handbook, 1998.
C. Navair 00-25-403 Guidelines for the Naval Aviation Reliability Centered Maintenance Process

Introduction

There is a view that when determining either the time to undertake preventive maintenance or its resourcing with spares and related logistics, all that is needed is the mean time between failure (MTBF) of a particular asset to do those calculations to manage an item and achieve its organisational intent.

This paper addresses the belief that the technical characteristic of MTBF is the primary value necessary to managing an asset over its whole of life. Additionally, there is an underlying implication that all I need to focus on is that technical MTBF value to "manage" an item to achieve business objectives. The underlying assumption is that other measures such as costs and human performance are not that relevant.

An application of the role of "MTBF" values in determining condition monitoring task frequency shall be assessed for the validity of this statement.

Implications

The view that "only one figure is required to work out maintenance task periods and resourcing effort" can also result in conservative maintenance programs where there may be adverse operational and financial outcomes from:

- Increased operational risk and costs from failures due to incorrect application of failure data
- Overproduction - Performing preventive maintenance and overhauls at intervals more often than what represents a desired balance between the performance required, the cost of that performance and the associated risk exposure;
- Inventory growth – Overstocking rotable/pools of repairable items and increasing consumable spares to resource expected increases in rate of activity both preventive and corrective periods;
- Increased overheads – each additional task brings with it unproductive staff time such as waiting for tools, parts documentation, transportation, or time spent travelling to the maintenance site;
- Increased defects/failures and risk – flowing from inappropriate intervention with ensuing likelihood of poor quality of corrective maintenance due to unnecessary time pressure and human error/violation.

Technical Facts

MTBF is a measure of the reliability of an item or its "*probability of operating to a defined standard for a defined time, in a defined environment*". This measure of failure related times (or durations) are defined in the IEV (with associated notes) as:

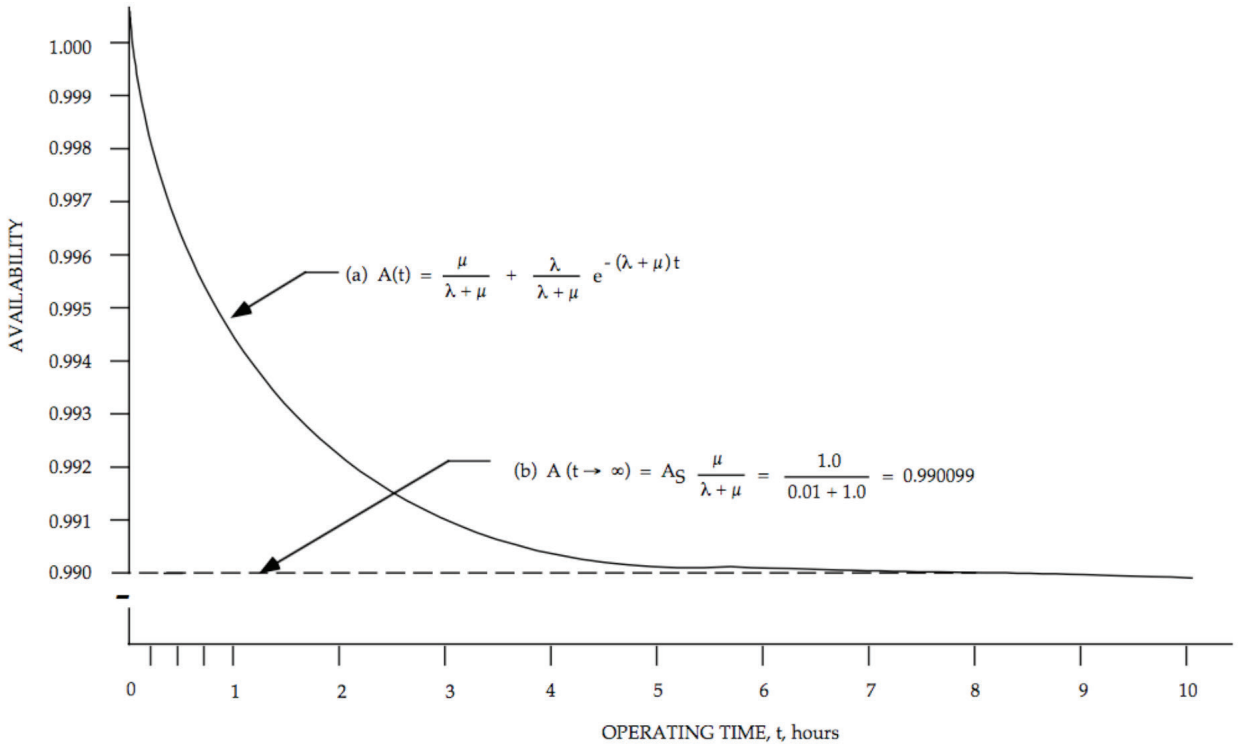
mean operating time to failure MTTF is the expectation of the operating time to failure.

- *Note 1 to entry: In the case of non-repairable items with an exponential distribution of times to failure (i.e. a constant failure rate) the MTTF is numerically equal to the reciprocal of the failure rate. This is also true for repairable items if after restoration they can be considered to be "as-good-as-new".*
- *Note 2 to entry: See also operating time to failure (192-05-01).*

mean operating time between failures [MTBF or MOTBF] is the expectation of the duration of the operating time between failures.

- *Note 1 to entry: Mean operating time between failures should only be applied to repairable items. For non- repairable items, see mean operating time to failure.*

MTBF is closely related to, and a component of, equipment or item "availability" which defines the probability that an item shall be available when required. There are many forms of availability assessment. The difficulty faced by the use of availability as a measure is demonstrated at Figure 1 from MIL-HDBK-338B, which shows the degradation curve of operational availability over time from 100% at new to the long run average after often a considerable period of time in long lived equipment.



(a) INSTANTANEOUS OR POINT AVAILABILITY
(b) STEADY STATE AVAILABILITY OR INHERENT UPTIME RATIO, $\lambda = 0.01$ fr/hr; $\mu = 1.0$ rp/hr.

For repairable equipment, operational availability is often of more importance than pure reliability as it provides a measure of the impact of maintainability on the assurance of overall performance.

Thus more than just reliability is needed to assess a system's likely availability and hence usefulness. Low reliability systems that recover very quickly may have greater utility than a highly reliable system that is very difficult to recover. More than just MTBF is important to the management of assets to achieve their desired balance of performance cost and risk. Mean time to repair (MTTR) also becomes of equal significance and may be traded against MTBF to achieve a desired balance of performance, cost and risk, a required outcome of asset management.

Role of MTBF in Decision Making

MTBF, as a measure of reliability, is used for a number of purposes across the life cycle of a system or physical asset.

In the initial stages of architecting a system concept for delivering a function, the future potential costs of a system concept can be explored through application of failure mode and effects analysis combined with reliability, maintainability and supportability assessments where:

- FMEA determines what failure effect function;
- Reliability assessment (MTBF) determines how often those failure might occur;
- Maintainability assessment (Mean time to repair MTTR) determines what maintenance tasks are necessary, their frequency and duration;
- Supportability determines what resources are necessary to undertake those maintenance tasks and how long they might take to source and apply (Mean time to support MTTS).

During the ownership stage these initial predictions and allocations can be confirmed and the actual operational capability of the built system can be assessed. While MTBF data is important, decisions will reflect the need to achieve a balance of performance, cost, and risk that requires more than just the simplistic value of how often something is likely to fail in the future. Knowledge of maintainability and supportability performance is equally necessary.

General Applications

During the design stage of a system, item MTBF will provide us with some knowledge of the individual failures associated with firstly a failure mode in an item, which represents the way in which the item fails. Secondly, these individual failure modes can be aggregated by summation, to the performance of the equipment.

Finally, the construction of a reliability block diagram can then allow the system performance to be determined by summating the individual equipment impacts depending on their series or parallel relationship. Readers should note that in repairable systems there are two types of failures being:

- functional failures and
- conditional failures.

MTBF represents the summation of these two failure outcomes where:

- Functional failures are those where the items specified function, described by a measurable value and its allowed variance, has been exceeded
- Conditional failure is where the items assessed condition has reached a measure where the future potential for functional failure of the item is no longer acceptable.

Thus MTBF by itself is a poor measure of the cost of failures, as the two scenarios of functional failure and conditional failure will have significantly different costs to the business.

Specific Application of MTBF

In the preventive maintenance domain a number of calculations that relate to equipment maintenance actions use MTBF as a variable. One of those task types, and the most common, is condition monitoring. However, more than MTBF is necessary to identify a task period that represents the desired (best) balance of performance, cost and risk.

Condition monitoring goes under many names and is applied in many ways from real time monitoring to periodic sampling. It is the most common process in maintenance as it:

- Is applied to the vast majority of operating items being those that possess random failure characteristics, and
- provides a protective function to give confidence that the item is of a condition that can be expect to continue service until its conditionally assessed when next due.

Sampling condition monitoring tasks that require the regular assessment of condition against some form of qualitative or quantitative measure requires six variables as follows to allow their optimal task period to be determined:

- Frequency of failure of MTBF;
- Expected consistent time from a defined condition to a functional failure;
- Costs of business being, cost of each task, cost of functional failure, and cost of discovered conditional failure;
- Task effectiveness as a derivative of the task, its description and its delivery.

The algorithm, contained in Reference C, applied to identify the optimum condition monitoring task period is relatively insensitive to MTBF variation. Other variances such as task effectiveness and warning period have significantly greater influence. These impacts on the "Percent Change to Optimal Task Period (Days)" are shown as the ordinate value at Figure 2 (overleaf).

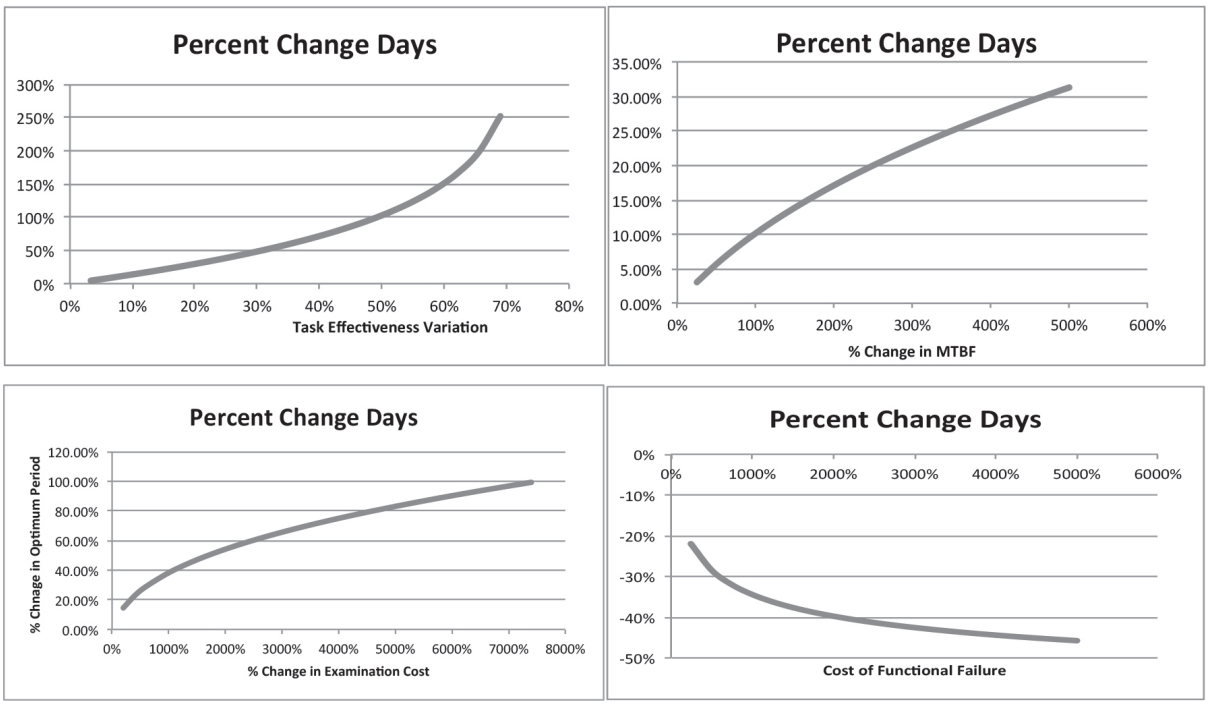


Figure 2: Impact of a Change to Optimisation Variables

Thus it is more important to manage the human variation than the equipment variation when it comes to determining preventive maintenance program content.

Conclusion

MTBF is only one of a number of item and organisational characteristics necessary to manage an asset. While technical knowledge such as MTBF is valuable information as to cost of ownership, the management function requires a variety of other information. This information relate to financial and human performance to be able to manage an asset over it's life and achieve an organisation's desired balance of performance cost and risk.

Hence the belief that "All I need to know is the MTBF to manage it well!" is confirmed as mostly a myth.

ASSET MANAGEMENT COUNCIL

Acknowledgment and thanks to AMCouncil AMBoK Team in writing of this article and giving permission for the Asset Management Council to publish.