4.3.3 Maintainability

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About

Maintainability is the *characteristic that represents the degree of effectiveness and efficiency with which a product or system can be modified to improve it, correct it or adapt it to changes in its environment and requirements. This characteristic is composed of the following sub-characteristics:*[1)]

- ***Modularity*** *- Degree to which a system or computer program is composed of discrete components such that a change to one component has minimal impact on other components.*
- ***Reusability*** *- Degree to which an asset can be used in more than one system, or in building other assets.*
- ***Analysability*** *- Degree of effectiveness and efficiency with which it is possible to assess the impact on a product or system of an intended change to one or more of its parts, or to diagnose a product for deficiencies or causes of failures, or to identify parts to be modified.*
- ***Modifiability*** *- Degree to which a product or system can be effectively and efficiently modified without introducing defects or degrading existing product quality.*
- ***Testability*** *- Degree of effectiveness and efficiency with which test criteria can be established for a system, product or component and tests can be performed to determine whether those criteria have been met.*

Maintainability is a characteristic of a system that is able to resume full operation after a failure in a component of the system. Components that are mission critical for the system can include equipment, machine, power, air conditioning, software, etc. Maintainability is expressed as the probability of recovery based on a specified time frame, usually done in terms of Five Nines (i.e., 99%, 99.9%, 99.99%, and 99.999%). For example, a 99.999% maintainability would be for 5 minutes, 15 seconds or less of downtime in a year. The downtime must include all the steps required to recover with full operational capabilities, so the time must include removal, diagnostics, assembly of resources required to perform the maintenance (i.e., parts, bays, tools, personnel, etc.) and the re-installation of the failed component.[2)] [3)]

Two main aspects of Maintainability need to be addressed for all systems or components:

- Servicability - the ease of conducting scheduled inspections and servicing
- Repairability - the ease of restoring service after a failure

Maintainability is a projection of the downtime of a system. Given that it is, by its very nature, a projection, it should not viewed as a guarantee that a system will only be down for the projected amount of time. Maintainability must therefore rely on models to calculate the probability of failures for components based on actual failure rates for components in the past or test results of the components.

> *There are a wide range of models that estimate and predict reliability (Meeker and Escobar 1998).*

Simple models, such as exponential distribution, can be useful for "back of the envelope" calculations.

System models are used to:

(1) combine probabilities or their surrogates, failure rates and restoration times, at the component level to find a system level probability or
(2) to evaluate a system for maintainability, single points of failure, and failure propagation. The three most common are reliability block diagrams, fault trees, and failure modes and effects analyses.

There are more sophisticated probability models used for life data analysis. These are best characterized by their failure rate behavior, which is defined as the probability that a unit fails in the next small interval of time, given it has lived until the beginning of the interval, and divided by the length of the interval. See: Upkeep's discussion of models in Maintainability Definition & Calculation [4)]

All these models are abstractions of reality; therefore, at best they are only approximations of reality. To the extent they provide useful insights, they are still very valuable. The more complicated the model, the more data necessary to develop precise estimations. The greater the extrapolation required for a prediction, the greater the imprecision. Also, obtaining all the data required as input to the models is difficult, time consuming, and may not even be very accurate.

Measuring the Mean Time To Repair (MTTR), is also used as part of Availability (see 4.3.2.2 Availability).

The MTTR, identifies the average time to restore a system or component after experiencing a failure or breakdown in the expected (i.e., specified) operating conditions. The formula for MTTR is:

$$MTTR = \frac{Total\ downtime\ (hours)}{Number\ of\ failure\ events}$$

A lower MTTR value corresponds to a higher level of maintainability and which means that maintainable systems take less time to repair.

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All systems, regardless of their level of complexity, require maintenance. To reduce the impact of performing maintenance, using physical (hardware) modules (components) that require the fewest number of repairs in a given time frame and choosing hardware and designs that require the least amount of downtime is one way to reduce the impact of maintenance. Another way to reduce the impact of maintenance is to design a system that anticipates maintenance and provides redundancy to handle the downtime required for maintenance. Nevertheless, managing redundancy is not a trivial task and adds complexity to the overall system. The more components that require redundancy, the more complex the system becomes unless the Middleware can manage the transition seamlessly, easily and transparently.

There are a few major forms of redundancy DDS can help with:

Hardware redundancy	Means that there are multiple modules (components) that provide the same functionality available in the system at the same time. For many systems, a simple dual modular redundancy is sufficient to accomplish the job (i.e., two components). However, for life critical systems, some systems rely on a triple modular redundancy. These systems should have zero to minimum loss from downtime.
Information redundancy	Occurs when there are multiple information sources available, so that modules can use whichever source is active if there is an interruption in information. In a system that has only one network available to it, the information redundancy is of little use if the network needs maintenance.

1)

ISO/IEC 25010, Maintainability, Accessed 27 July 2020, https://iso25000.com/index.php/en/iso-25000-standards/iso-25010/64-maintainability

2)

Maintainability Definition & Calculations, Upkeep, answered 4 June 2019, Accessed 13 July 2020, https://www.onupkeep.com/answers/preventive-maintenance/maintainability-definitions-calculations/

3)

Note: Maintainability is part of Reliability, Maintainability, and Availability (RAM)

4)

Maintainability Definition & Calculations, Upkeep, answered 4 June 2019, Accessed 13 July 2020, https://www.sebokwiki.org/wiki/Reliability,_Availability,_and_Maintainability#Models

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