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MILITARY STANDARD

DEFINITIONS OF TERMS FOR RELIABILITY AND MAINTAINABILITY



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DEPARTMENT OF DEFENSE
Washington, DC 20301

Definitions of Terms for Reliability and Maintainability

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1. This Military Standard is approved for use by all Departments and Agencies of the Department of Defense.
2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commanding Officer Engineering Specifications and Standards Department (Code 93), Naval Air Engineering Center, Lakehurst, NJ 08733, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

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FORWARD

1. This Standard defines words and terms most commonly used which are associated with Reliability and Maintainability (R & M). It is intended to be used as a common base for R & M definitions and to reduce the possibility of conflicts, duplications, and incorrect interpretations either expressed or implied elsewhere in documentation. The definitions address the intent and policy of DoD Directive 5000.40. Statistical and mathematical terms which have gained wide acceptance are not defined in this standard since they are included in other documents.

2. The following criteria were used for the inclusion of terms and definitions deemed pertinent to the scope of this standard:

a. Terms and their definitions are:

- (1) Important in acquisition of weapon systems for precise definition of reliability and maintainability criteria.
- (2) Unique in their definitions, allowing no other meaning.
- (3) Expressed clearly, preferably without mathematical symbols.

b. Terms that were avoided:

- (1) Those found in ordinary technical, statistical, or standard dictionary or text having a singularly acceptable meaning when used in the context.
- (2) Terms already existing in other Military Standards outside of the project scope.
- (3) Multiple word terms, unless needed for uniqueness.

c. The purpose of this Military Standard is to standardize on meanings of terms for the particular application, not to compile a handbook.

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1. SCOPE

1.1 Scope. The purpose of this standard is to define words and terms used most frequently in specifying Reliability and Maintainability (R & M) to give these terms a common meaning for the Department of Defense and defense contractors.

2. REFERENCED DOCUMENTS

2.1 Issues of Documents. The following documents of the issue in effect on the date of invitation for bid or request for proposal, are referenced in this standard for information and guidance.

STANDARDS

- MIL-STD-280 Definitions of Item Levels, Item Exchangeability, Models, and Related Terms.
- MIL-STD-882 System Safety Program Requirements.
- MIL-STD-45662 Calibration System Requirements.

(Copies of specifications, standards, drawings and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

3. DEFINITIONS

ACCESSIBILITY: A measure of the relative ease of admission to the various areas of an item for the purpose of operation or maintenance.

ACHIEVED: Obtained as the result of measurement.

ALIGNMENT: Performing the adjustments that are necessary to return an item to specified operation.

AVAILABILITY: A measure of the degree to which an item is in an operable and comitable state at the start of a mission when the mission is called for at an unknown (random) time. (Item state at start of a mission includes the combined effects of the readiness-related system R & M parameters, but excludes mission time; see DEPENDABILITY.

BURN-IN (PRE-CONDITIONING): The operation of an item under stress to stabilize its characteristics. Not to be confused with DE-BUGGING.

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CALIBRATION: A comparison of a measuring device with a known standard. Not to be confused with ALIGNMENT (see MIL-C-45662).

CHARGEABLE: Within the responsibility of a given organizational entity (applied to terms such as FAILURES, MAINTENANCE TIME etc.).

CHECKOUT: Tests or observations of an item to determine its condition or status.

CORRECTIVE ACTION: A documented design, process, procedure, or materials change implemented and validated to correct the cause of failure or design deficiency.

CRITICALITY: A relative measure of the consequence of a failure mode and its frequency of occurrences.

DE-BUGGING: A process to detect and remedy inadequacies. Not to be confused with terms such as BURN-IN, FAULT ISOLATION or SCREENING.

DEGRADATION: A gradual impairment in ability to perform.

DEMONSTRATED: That which has been measured by the use of objective evidence gathered under specified conditions.

DEPENDABILITY: A measure of the degree to which an item is operable and capable of performing its required function at any (random) time during a specified mission profile, given item availability at the start of the mission. (Item state during a mission includes the combined effects of the mission-related system R & M parameters but excludes non-mission time; see AVAILABILITY) see Figure 1.

DERATING: (a) Using an item in such a way that applied stresses are below rated values or
(b) The lowering of the rating of an item in one stress field to allow an increase in another stress field.

DIRECT MAINTENANCE MAN HOURS PER MAINTENANCE ACTION (DMMH/MA): A measure of the maintainability parameter related to item demand for maintenance manpower: The sum of direct maintenance man hours, divided by the total number of maintenance actions (preventative and corrective) during a stated period of time.

DIRECT MAINTENANCE MAN HOURS PER MAINTENANCE EVENT (DMMH/ME): A measure of the maintainability parameter related to item demand for maintenance manpower: The sum of direct maintenance man hours, divided by the total number of maintenance events (preventative and corrective) during a stated period of time.

DISASSEMBLE: Opening an item and removing a number of parts or subassemblies to make the item that is to be replaced accessible for removal. This does not include the actual removal of the item to be replaced.

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DORMANT: See NOT OPERATING.

DOWNING EVENT: The event which causes an item to become unavailable to initiate its mission (the transition from UP-TIME to DOWN-TIME).

DURABILITY: A measure of useful life (a special case of reliability).

ENVIRONMENT: The aggregate of all external and internal conditions (such as temperature, humidity, radiation, magnetic and electric fields, shock vibration, etc.) either natural or man made, or self-induced, that influences the form, performance, reliability or survival of an item.

ENVIRONMENTAL STRESS SCREENING (ESS): A series of tests conducted under environmental stresses to disclose weak parts and workmanship defects for correction.

FAILURE: The event, or inoperable state, in which any item or part of an item does not, or would not, perform as previously specified.

FAILURE ANALYSIS: Subsequent to a failure, the logical systematic examination of an item, its construction, application, and documentation to identify the failure made and determine the failure mechanism and its basic course.

FAILURE, CATASTROPHIC: A failure that can cause item loss. 1/

FAILURE, CRITICAL: A failure, or combination of failures, that prevents an item from performing a specified mission. 1/

FAILURE, DEPENDENT: Failure which is caused by the failure of an associated item(s). Not INDEPENDENT.

FAILURE EFFECT: The consequence(s) a failure mode has on the operation, function, or status of an item. Failure effects are classified as local effect, next higher level, and end effect.

FAILURE MODE AND EFFECTS ANALYSIS (FMEA): A procedure by which each potential failure mode in a system is analyzed to determine the results or effects thereof on the system and to classify each potential failure mode according to its severity.

FAILURE, INDEPENDENT: Failure which occurs without being caused by the failure of any other item. Not DEPENDENT.

1/ These terms are defined in a broader context for system safety purposes. See MIL-STD-882.

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FAILURE INTERMITTENT: Failure for a limited period of time, followed by the item's recovery of its ability to perform within specified limits without any remedial action.

FAILURE MECHANISM: The physical, chemical, electrical, thermal or other process which results in failure.

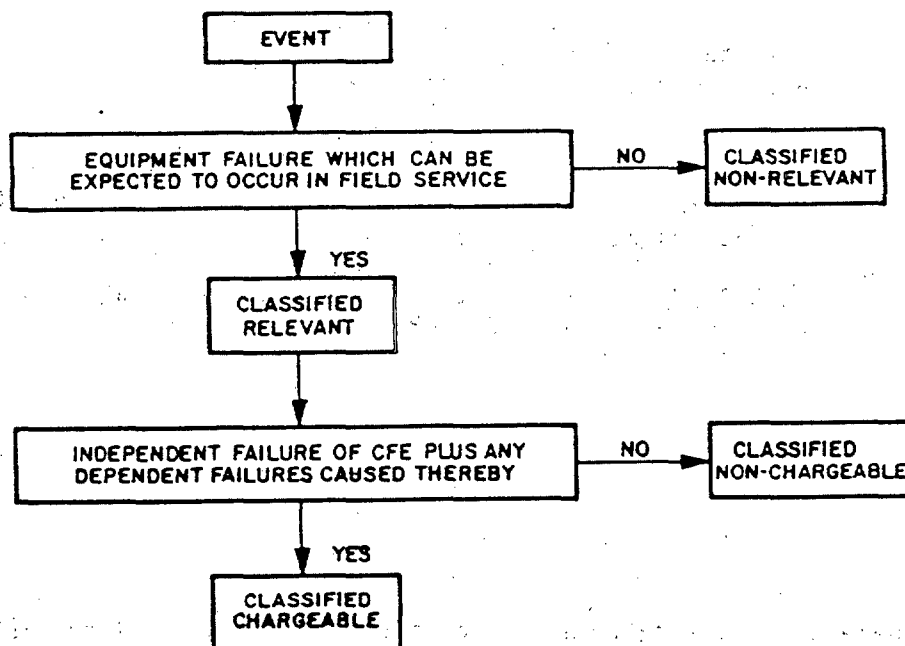
FAILURE MODE: The consequence of the mechanism through which the failure occurs, i.e., short, open, fracture, excessive wear.

FAILURE, NON-CHARGEABLE:

- (a) A non-relevant failure, or
- (b) A relevant failure caused by a condition previously specified as not within the responsibility of a given organizational entity. (All relevant failures are chargeable to one organizational entity or another.)

FAILURE, NON-RELEVANT:

- (a) A failure verified as having been caused by a condition not present in the operational environment, or
- (b) A failure verified as peculiar to an item design that will not enter the operational inventory.



Example of failure categories

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- FAILURE, RANDOM:** Failure whose occurrence is predictable only in a probabalistic or statistical sense. This applies to all distributions.
- FAILURE RATE:** The total number of failures within an item population, divided by the total number of life units expended by that population, during a particular measurement interval under stated conditions.
- FAULT:** Immediate cause of failure (e.g., maladjustment, misalignment, defect, etc.).
- FAULT ISOLATION:** The process of determining the location of a fault to the extent necessary to effect repair.
- FAULT LOCALIZATION:** The process of determining the approximate location of a fault.
- INHERENT R & M VALUE:** A measure of reliability or maintainability that includes only the effects of an item design and its application, and assumes an ideal operation and support environment.
- INTERCHANGE:** Removing the item that is to be replaced, and installing the replacement item.
- INVENTORY, ACTIVE:** The group of items assigned to an operational status.
- INVENTORY, INACTIVE:** The group of items being held in reserve for possible future assignments to an operational status.
- ISOLATION, FAULT:** See **FAULT ISOLATION**
- ITEM:** A non-specific term used to denote any product, including systems, material parts, subassemblies, sets, accessories, etc. (Source: MIL-STD-280).
- LIFE PROFILE:** A time-phased description of the events and environments an item experiences from manufacture to final expenditures or removal from the operational inventory, to include one or more mission profiles.
- LIFE UNITS:** A measure of use duration applicable to the item (e.g., operating hours, cycles, distance, rounds fired, attempts to operate, etc.).
- LOCALIZATION, FAULT:** See **FAULT LOCALIZATION**
- MAINTAINABILITY:** The measure of the ability of an item to be retained in or restored to specified condition when maintenance is performed by personnel having specified skill levels, using prescribed procedures and resources, at each prescribed level of maintenance and repair.
- MAINTAINABILITY, MISSION:** The measure of the ability of an item to be retained in or restored to specified condition when maintenance is performed during the course of a specified mission profile. (The mission-related system maintainability parameter.)

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MAINTENANCE: All actions necessary for retaining an item in or restoring it to a specified condition.

MAINTENANCE ACTION: An element of a maintenance event. One or more tasks (i.e., fault localization, fault isolation, servicing and inspection) necessary to retain an item in or restore it to a specified condition.

MAINTENANCE, CORRECTIVE: All actions performed as a result of failure, to restore an item to a specified condition. Corrective maintenance can include any or all of the following steps: Localization, Isolation, Disassembly, Interchange, Reassembly, Alignment and Checkout.

MAINTENANCE, EVENT: One or more maintenance actions required to effect corrective and preventative maintenance due to any type of failure or malfunction, false alarm or scheduled maintenance plan.

MAINTENANCE, MANNING LEVEL: Total authorized or assigned personnel, per system at specified levels of maintenance organization.

MAINTENANCE, PREVENTIVE: All actions performed in an attempt to retain an item in specified condition by providing systematic inspection, detection, and prevention of incipient failures.

MAINTENANCE RATIO: A measure of the total maintenance manpower burden required to maintain an item. It is expressed as the cumulative number of manhours of maintenance expended in direct labor during a given period of the life units divided by the cumulative number of end item life units during the same period.

MAINTENANCE, SCHEDULED: Preventive maintenance performed at prescribed points in the item's life.

MAINTENANCE TIME: An element of down time which excludes modification and delay time.

MAINTENANCE, UNSCHEDULED: Corrective maintenance required by item conditions.

MALFUNCTION: See FAILURE.

MEAN-MAINTENANCE-TIME: The measure of item maintainability taking into account maintenance policy. The sum of preventive and corrective maintenance times, divided by the sum of scheduled and unscheduled maintenance events, during a stated period of time.

MEAN-TIME-BETWEEN-DEMANDS (MTBD): A measure of the system reliability parameter related to demand for logistic support: The total number of system life units divided by the total number of item demands on the supply system during a stated period of time. e.g. Shop Replaceable Unit (SRU), Weapon Replaceable Unit (WRU), Line Replacement Unit (LRU), and Shop Replaceable Assembly (SRA).

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- MEAN-TIME-BETWEEN-DOWNING-EVENTS (MTBDE):** A measure of the system reliability parameter related to availability and readiness. The total number of system life units, divided by the total number of events in which the system becomes unavailable to initiate its mission(s), during a stated period of time.
- MEAN-TIME-BETWEEN-FAILURE (MTBF):** A basic measure of reliability for repairable items: The mean number of life units during which all parts of the item perform within their specified limits, during a particular measurement interval under stated conditions.
- MEAN-TIME-BETWEEN-MAINTENANCE (MTBM):** A measure of the reliability taking into account maintenance policy. The total number of life units expended by a given time, divided by the total number of maintenance events (scheduled and unscheduled) due to that item.
- MEAN-TIME-BETWEEN-MAINTENANCE-ACTIONS (MTBMA):** A measure of the system reliability parameter related to demand for maintenance manpower: The total number of system life units, divided by the total number of maintenance actions (preventive and corrective) during a stated period of time.
- MEAN-TIME-BETWEEN-REMOVALS (MTBR):** A measure of the system reliability parameter related to demand for logistic support: The total number of system life units divided by the total number of items removed from that system during a stated period of time. This term is defined to exclude removals performed to facilitate other maintenance and removals for product improvement.
- MEAN-TIME-TO-FAILURE (MTTF):** A basic measure of reliability for non-repairable items: The total number of life units of an item divided by the total number of failures within that population, during a particular measurement interval under stated conditions.
- MEAN-TIME-TO-REPAIR (MTTR):** A basic measure of maintainability: The sum of corrective maintenance times at any specific level of repair, divided by the total number of failures within an item repaired at that level, during a particular interval under stated conditions.
- MEAN-TIME-TO-RESTORE-SYSTEM (MTTRS):** A measure of the system maintainability parameter related to availability and readiness: The total corrective maintenance time, associated with downing events, divided by the total number of downing events, during a stated period of time. (Excludes time for off-system maintenance and repair of detached components.)
- MEAN-TIME-TO-SERVICE (MTTS):** A measure of an on-system maintainability characteristic related to servicing that is calculated by dividing the total scheduled crew/operator/driver servicing time by the number of times the item was serviced.
- MISSION PROFILE:** A time-phased description of the events and environments an item experiences from initiation to completion of a specified mission, to include the criteria of mission success or critical failures.

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MISSION-TIME-BETWEEN-CRITICAL-FAILURES (MTBCF): A measure of MISSION RELIABILITY: The total amount of mission time, divided by the total number of critical failures during a stated series of missions.

MISSION-TIME-TO-RESTORE-FUNCTIONS (MTTRF): A measure of MISSION MAINTAINABILITY: The total corrective critical failure maintenance time, divided by the total number of critical failures, during the course of a specified mission profile.

NOT OPERATING (DORMANT): The state wherein an item is able to function but is not required to function. Not to be confused with DOWN-TIME.

OPERABLE: The state of being able to perform the intended function.

OPERATIONAL READINESS: The ability of a military unit to respond to its operation plan(s) upon receipt of an operations order. (A function of assigned strength, item availability, status, or supply, training, etc.).

OPERATIONAL R & M VALUE: A measure of reliability or maintainability that includes the combined effect of item design, installation, quality, environment, operation, maintenance and repair.

RECONDITIONING: See BURN-IN.

PREDICTED: That which is expected at some future time, postulated on analysis of past experience and tests.

REASSEMBLY: Assembling the items that were removed during disassembly and closing the reassembled items.

REDUNDANCY: The existence of more than one means for accomplishing a given function. Each means of accomplishing the function need not necessarily be identical.

REDUNDANCY, ACTIVE: That redundancy wherein all redundant items are operating simultaneously.

REDUNDANCY, STANDBY: That redundancy wherein the alternative means of performing the function is not operating until it is activated upon failure of the primary means of performing the function.

RELEVANT: That which can occur or recur during the operational life of an item inventory.

RELIABILITY:

- (1) The duration or probability of failure-free performance under stated conditions.
- (2) The probability that an item can perform its intended function for a specified interval under stated conditions. (For non-redundant items this is equivalent to definition (1). For redundant items this is equivalent to definition of mission reliability.)

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RELIABILITY GROWTH: The improvement in a reliability parameter caused by the successful correction of deficiencies in item design or manufacture.

RELIABILITY MISSION: The ability of an item to perform its required functions for the duration of a specified "mission profile."

R & M ACCOUNTING: That set of mathematical tasks which establish and allocate quantitative R & M requirements, and predict and measure quantitative R & M requirements.

R & M ENGINEERING: That set of design, development and manufacturing tasks by which reliability and maintainability are achieved.

REPAIR: See MAINTENANCE, CORRECTIVE.

REPAIRABLE ITEM: An item which can be restored to perform all of its required functions by corrective maintenance.

SCREENING: A process for inspecting items to remove those that are unsatisfactory or those likely to exhibit early failure. Inspection includes visual examination, physical dimension measurement and functional performance measurement under specified environmental conditions.

SERVICING: The performance of any act needed to keep an item in operating condition, (i.e. lubricating, fueling, oiling, cleaning, etc.), but not including preventative maintenance of parts or corrective maintenance tasks.

SHELF-LIFE: See STORAGE LIFE.

SINGLE POINT FAILURE: The failure of an item which would result in failure of the system and is not compensated for by redundancy or alternative operational procedure.

SNEAK CIRCUIT ANALYSIS: A procedure conducted to identify latent paths which cause occurrence of unwanted functions or inhibit desired functions assuming all components are functioning properly.

STORAGE LIFE: The length of time an item can be stored under specified conditions and still meet specified requirements.

SUBSYSTEM: A combination of sets, groups, etc. which performs an operational function within a system and is a major subdivision of the system. (Example: Data processing subsystem, guidance subsystem). Source MIL-STD-280.

SYSTEM: General - A composite of equipment and skills, and techniques capable of performing or supporting an operational role, or both. A complete system includes all equipment, related facilities, material, software, services, and personnel required for its operation and support to the degree that it can be considered self-sufficient in its intended operational environment.

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- SYSTEM R & M PARAMETER:** A measure of reliability or maintainability in which the units of measurement are directly related to operational readiness, mission success, maintenance manpower cost, or logistic support cost.
- TEST, ACCEPTANCE:** A test conducted under specified conditions by, or on behalf of, the government, using delivered or deliverable items, in order to determine the item's compliance with specified requirements. (Includes acceptance of first production units.)
- TEST ANALYZE AND FIX:** See TESTING, DEVELOPMENT (GROWTH).
- TEST MEASUREMENT AND DIAGNOSTIC EQUIPMENT (TMDE):** Any system or device used to evaluate the condition of an item to identify or isolate any actual or potential failures.
- TEST QUALIFICATION (DESIGN APPROVAL):** A test conducted under specified conditions, by, or on behalf of the government, using items representative of the production configuration, in order to determine compliance with item design requirements as a basis for production approval. (also known as a "Demonstration.")
- TESTING DEVELOPMENT (GROWTH):** A series of tests conducted to disclose deficiencies and to verify that corrective actions will prevent recurrence in the operational inventory. Note: Repair of test items does not constitute correction of deficiencies. (Also known as "Test-Analyze-And-Fix (TAAF)" testing.)
- TIME:** The universal measure of duration. The general word "time" will be modified by an additional term when used in reference to operating time, mission time, test time, etc. In general expressions such as "Mean-Time-Between-Failure (MTBF)," time stands for "life units" which must be more specifically defined whenever the general term refers to a particular item.
- TIME, ACTIVE:** That time during which an item is in an operational inventory.
- TIME, ADMINISTRATIVE:** That element of delay time, not included in the supply delay time.
- TIME, ALERT:** That element of up time during which an item is assumed to be in specified operating condition and is awaiting a command to perform its intended mission.
- TIME, CHECKOUT:** That element of MAINTENANCE TIME during which performance of an item is verified to be a specified condition.
- TIME, DELAY:** That element of down time during which no maintenance is being accomplished on the item because of either supply or administrative delay.
- TIME, DOWN (DOWNTIME):** That element of active time during which an item is not in condition to perform its required function. (Reduces AVAILABILITY and DEPENDABILITY.)

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TIME, INACTIVE: That time during which an item is in reserve. (In the INACTIVE INVENTORY).

TIME, MISSION: That element of up time required to perform a stated mission profile.

TIME, MODIFICATION: The time necessary to introduce any specific change(s) to an item to improve its characteristics or to add new ones.

TIME, NOT OPERATING: That element of uptime during which the item is not required to operate.

TIME, REACTION: That element of uptime needed to initiate a mission, measured from the time command is received.

TIME, SUPPLY DELAY: That element of DELAY TIME during which a needed replacement item is being obtained.

TIME, TURN AROUND: That element of MAINTENANCE TIME needed to replenish consumables and check out an item for recommitment.

TIME, UP (UPTIME): That element of ACTIVE TIME during which an item is in condition to perform its required functions. (Increases AVAILABILITY and DEPENDABILITY).

UPTIME RATIO: A composite measure of operational availability and dependability that includes the combined effects of item design, installation, quality, environment, operation, maintenance, repair and logistic support: The quotient of uptime divided by uptime plus downtime.)

USEFUL LIFE: The number of life units from manufacture to when the item has an unrepairable failure or unacceptable failure rate.

UTILIZATION RATE: The planned or actual number of life units expended, or missions attempted during a stated interval of calendar time.

WEAROUT: The process which results in an increase of the failure rate or probability of failure with increasing number of life units.

4. GENERAL REQUIREMENTS

Not applicable.

5. DETAIL REQUIREMENTS

Not applicable.

Custodians:

Army - CR
Navy - AS
Air Force - 17

Preparing Activity

Navy - AS
(Project No. RELI-0024)

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Figure 1

EXAMPLES OF
SYSTEM R&M PARAMETERS

PARAMETERS RELATED TO:

* READINESS (OR AVAILABILITY)

RELIABILITY
MEAN TIME BETWEEN DOWNING EVENTS (MTBDE)

MAINTAINABILITY
MEAN TIME TO RESTORE SYSTEM (MTTRS)

* MISSION SUCCESS (OR DEPENDABILITY)

RELIABILITY
MISSION TIME BETWEEN CRITICAL FAILURES (MTBCF)

MAINTAINABILITY
MISSION TIME TO RESTORE FUNCTIONS (MTTRF)

* MAINTENANCE MANPOWER COST

RELIABILITY
MEAN TIME BETWEEN MAINTENANCE (MTBM)

MAINTAINABILITY
DIRECT MANHOURS PER MAINTENANCE ACTION (DMH/MA)

* LOGISTIC SUPPORT COST

RELIABILITY
MEAN TIME BETWEEN DEMANDS (MTBD)

MAINTAINABILITY
TOTAL PARTS COST PER REMOVAL, AT ALL LEVELS OF REPAIR

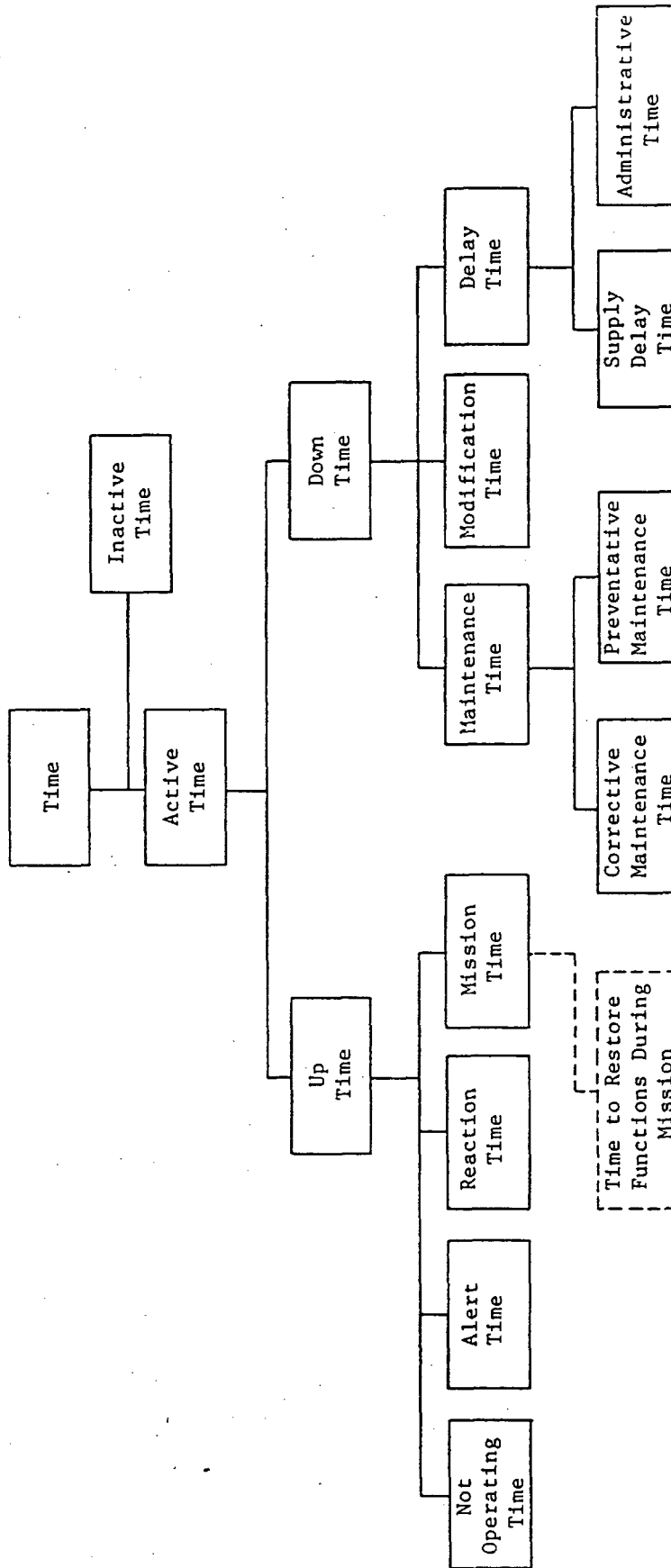


FIGURE 2. Time relationships.

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions - Reverse Side)

1. DOCUMENT NUMBER

2. DOCUMENT TITLE

3a. NAME OF SUBMITTING ORGANIZATION

4. TYPE OF ORGANIZATION (Mark one)

 VENDOR USER MANUFACTURER OTHER (Specify): _____

b. ADDRESS (Street, City, State, ZIP Code)

5. PROBLEM AREAS

a. Paragraph Number and Wording:

b. Recommended Wording:

c. Reason/Rationale for Recommendation:

6. REMARKS

7a. NAME OF SUBMITTER (Last, First, MI) - Optional

b. WORK TELEPHONE NUMBER (Include Area Code) - Optional

c. MAILING ADDRESS (Street, City, State, ZIP Code) - Optional

8. DATE OF SUBMISSION (YYMMDD)

(TO DETACH THIS FOR CUT ALONG THIS LINE.)