

Recommendation T/CS 10-13 (Innsbruck 1981, revised in Copenhagen 1987)**GENERAL MAINTENANCE CONCEPT AND TERMS**

Recommendation proposed by Working Group T/WG 11 "Signaling, Protocols and Switching" (SPS)

Text of the Recommendation adopted by the "Telecommunications" Commission:

"The European Conference of Postal and Telecommunications Administrations,

considering:

- that the provision of telecommunication services is dependent to a large degree on complex technical systems making up the network and the terminal equipment connected to it,
- that the service perceived by the user is thus the result of the functioning of a great many component parts,
- that degradation of and failures in the functioning of certain component parts may be expected, but that the collective influence of such improper functioning on the service can be controlled by adequate maintenance measures applied to the component parts,
- that Administrations have the responsibility for these maintenance measures during the whole time the equipment concerned is in service and have to take into account all the factors which contribute to the efforts the maintenance may require, including such factors as availability performance characteristics, design or choice of systems, standards, acquisition of documentation, training of personnel and the assurance of delivery of spare parts, etc.,
- that although in some cases the same personnel are in charge of maintenance and operation, it may be desirable to distinguish between operation and maintenance,

recommends:

the following general maintenance concept dealing with maintenance activities and the principal causes of them, the related overview classifications and the standardisation of terms and definitions to be used in telecommunication systems maintenance."

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0. **BASIC CONCEPTS**

0.1. **Item**

Any part, device, subsystem, functional unit, equipment or system that can be individually considered.
Note. An item may consist of hardware, software or both, and may also include people, e.g. operators in a telephone operator system.

0.2. **Repaired item**

A repairable item which is in fact repaired after a failure.

0.3. **Non-repaired item**

An item which is not repaired after a failure.
Note. A non-repaired item may be repairable or not.

0.4. **Service**

A set of functions offered to a user by an organization.

0.5. **Required function**

A function or a combination of functions of an item which is considered necessary for the provisioning of a given service.

0.6. **Instant of time**

A single point on a time scale.
Note. The time scale may be continuous as calendar time, or discrete e.g. number of use cycles.

0.7. **Period of time**

All instants of time between two given instants of time.

0.8. **Time interval**

The difference between the end points of a period of time.

0.9. **Accumulated time**

The sum of time intervals characterized by given conditions over a given period of time.

0.10. **Operation**

Combination of all technical and corresponding administrative actions intended so that an item can perform a required function recognizing necessary adaptation to changes in external conditions.
Note. By external conditions are understood for example service demand and environmental conditions.

0.11. **Expectation/mean of a random variable**

a) For a discrete random variable X taking the values x_i with the probabilities p_i
 $E(X) = \sum p_i x_i$
the sum being extended for all the values x_i which can be taken by X .

b) For a continuous random variable X having the density $f(x)$:
 $E(X) = \int x f(x) dx$
the integral being extended for all values of the interval of variation of X .

1. **RELATIONSHIP BETWEEN MAINTENANCE AND QUALITY ASPECTS OF PROVIDING TELECOMMUNICATION SERVICE**

CCITT Recommendation G.106 [1] provides a framework for availability and reliability studies and the terms and definitions given therein apply generally to this present Recommendation.

Figure 1 (T/CS 10-13) is derived from Recommendation G.106 and depicts the relationship between maintenance and performance aspects for providing telecommunications services.

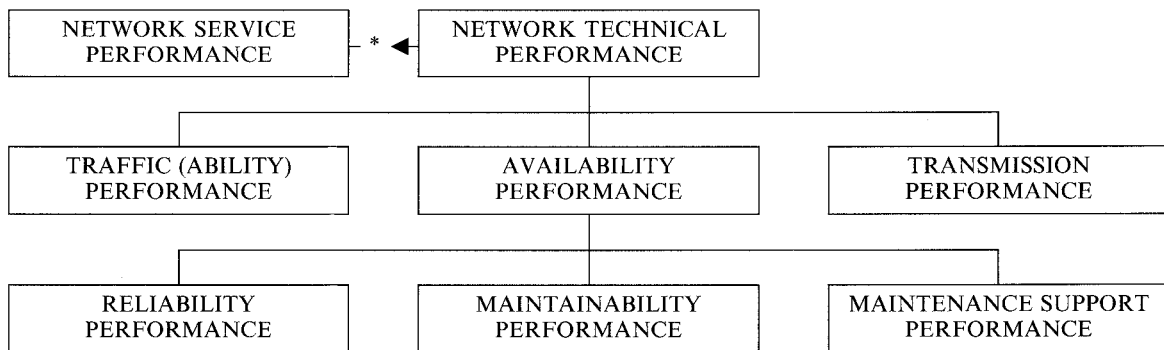
1.1. **Definitions**

The following definitions apply.

1.1.1. *Network technical performance*

The ability of a telecommunication network, under combined aspects of its traffic (ability), availability and transmission performances, to perform or to be in a state to perform a required service for a stated condition of time.

Note. A stated condition of time refers to a stated instant of time or to a stated interval of time.



* Implies that the relation is not hierarchical but characterises the subscriber's experiences.

Figure 1 (T/CS 10-13). Concept of service quality from a maintenance point of view.

1.1.2. *Network service performance* (provisional term)

The ability of a telecommunication network, under combined aspects of its traffic (ability), availability and transmission performances as seen by the subscriber, to perform or to be in a state to perform a required service for a stated condition of time.

1.1.3. *Availability performance*

The ability of an item, under combined aspects of its reliability performance, maintainability performance and of the maintenance support performance, to perform or to be in a state to perform a required function for a stated condition of time.

1.1.4. *Reliability performance*

The ability of an item to perform a required function, under stated conditions, for a stated period of time.
Note. The term reliability is used as a measure of the functional reliability performance.

1.1.5. *Maintainability performance*

The ability of an item, under stated conditions of use, to be retained in, or restored to a state in which it can perform a required function, when maintenance is performed under stated conditions and using stated procedures and resources.

Note. The maintainability is used as a measure of the functional maintainability performance, denoting the probability that the active maintenance is carried out within a given period of time.

1.1.6. *Maintenance support performance*

The ability of a maintenance organisation, under stated conditions, to provide upon demand the resources required to maintain an item.

Note 1. Maintenance organisation includes physical resources expected to act under a given maintenance policy.

Note 2. The stated conditions are related to the item itself and to the conditions under which the item is used and maintained.

- 1.1.7. *Traffic(ability) performance*¹⁾
The ability of a telecommunication system to handle the offered traffic under specified conditions.
¹⁾ The term traffic performance is preferred by CCITT Study Group II.
Note. Specified conditions refer to any combination of failed and not-failed parts of the system.

- 1.1.8. *Transmission performance*
The ability of an item to have the relevant transmission characteristics in the allowable range.

1.2. **Call approach and failure approach**

There exists a direct relationship between the network technical performance and the use of the telecommunication system. The imperfect behavior of the system can be considered in two ways as shown in Figure 2 (T/CS 10-13): the call approach and the failure approach.

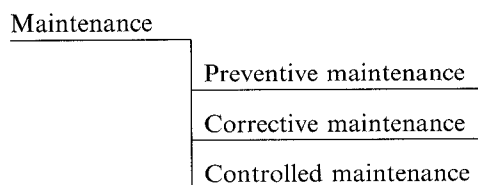
2. **MAINTENANCE CONCEPTS**

2.1. **Definitions**

- 2.1.1. *Maintenance*
The combination of all technical and corresponding administrative actions intended to retain an item in, or restore it to, a state in which it can perform its required function.
- 2.1.2. *Maintenance philosophy*
A system of underlying principles for the organization and execution of the maintenance (T/CS 50-01).
- 2.1.3. *Maintenance policy*
A description of the interrelationship between the indenture level, line of maintenance and the levels of maintenance to be applied for the maintenance of an item.
- 2.1.4. *Level of maintenance*
The maintenance action to be carried out at a specified indenture level.
Note. Examples are replacing a component, a printed circuit board, a subsystem, etc.
- 2.1.5. *Line of maintenance*
The position in an organization where specified levels of maintenance are to be carried out on an item.
Note 1. Examples of maintenance echelons are: field, repair shop, manufacturer.
Note 2. The maintenance echelon is characterized by the skill of the personnel, the facilities available, the location, etc.
- 2.1.6. *Indenture level*
A level of subdivision of an item from the point of view of a maintenance action.
Note 1. Examples of indenture levels could be a subsystem, a circuit board, a component.
Note 2. The indenture level depends on the complexity of the item's construction, the accessibility to subitems, skill level of maintenance personnel, test equipment facilities, safety considerations, etc.
- 2.1.7. *Maintenance phases*
The activities carried out for a given purpose.
Note. Examples are failure detection, failure localization, failure correction or combinations thereof.

2.2. **Classifications**

- 2.2.1. *Classification of maintenance in relation to its intention*



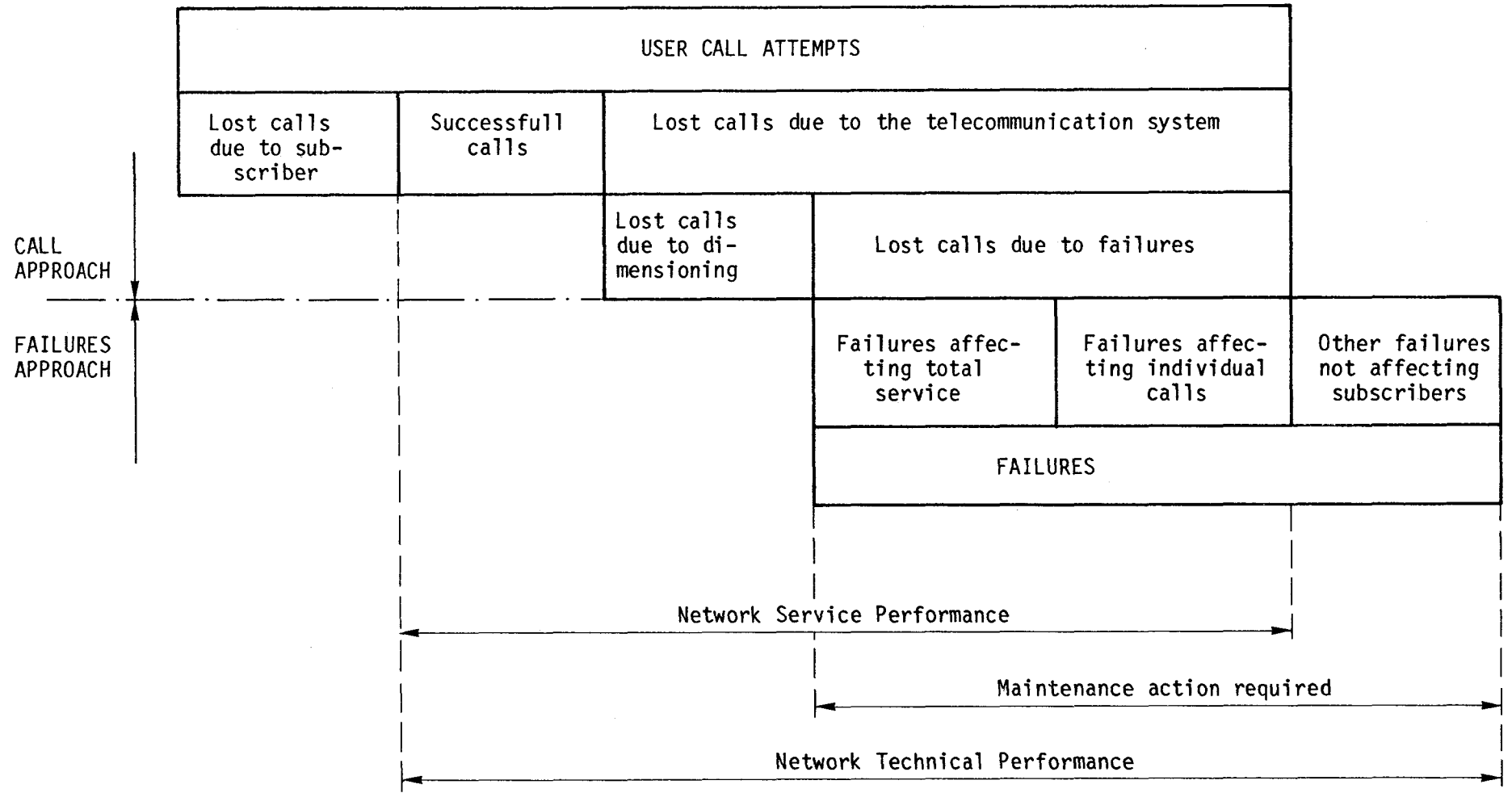


Figure 2 (T/CS 10-13). Classification of lost calls and equipment failures.

2.2.1.1. Preventive maintenance

The maintenance carried out at predetermined intervals or corresponding to prescribed criteria and intended to reduce the probability of failure or the performance degradation of an item.

2.2.1.2. Corrective maintenance (repair)

The maintenance carried out after failure recognition and intended to restore an item to a state in which it can perform its required function.

2.2.1.3. Controlled maintenance

A method of sustaining a desired network technical performance by the systematic application of analysis techniques using centralised supervisory facilities and sampling to minimize preventive maintenance and to reduce corrective maintenance.

2.2.2. *Classification of maintenance in relation to the urgency of the maintenance action*MaintenancePrompt maintenanceDeferred maintenanceScheduled maintenanceUnscheduled maintenance

2.2.2.1. Prompt maintenance

Such corrective maintenance which is immediately initiated after a failure recognition in accordance with given maintenance rules.

2.2.2.2. Deferred maintenance

Such corrective maintenance which is not immediately initiated after a failure recognition but is delayed in accordance with given maintenance rules.

2.2.2.3. Scheduled maintenance

The maintenance carried out in accordance with an established time schedule.

2.2.2.4. Unscheduled maintenance

The maintenance carried out, not in accordance with an established time schedule, but e.g. after reception of an indication regarding the state of an item.

2.2.3. *Classification of maintenance in relation to its impact on item function*MaintenanceFunction permitting maintenanceFunction affecting maintenanceFunction degrading maintenanceFunction preventing maintenance

2.2.3.4. Function degrading maintenance

Maintenance such that affects one or more of the required functions of a maintained item, but not to such an extent as to cause complete loss of all the functions.

2.2.4. *Classification of maintenance in relation to where it is performed*

Maintenance

On-site maintenance

Off-site maintenance

2.2.4.1. On-site maintenance

Maintenance performed on a item at the location where the item is intended to be used.

2.2.4.2. Off-site maintenance

Maintenance performed at a place different from where the item is used.

Note. An example is the repair of a sub-item at a maintenance centre.

3. **FAILURE CONCEPT**

3.1. **Definitions**

3.1.1. *Event concept*

3.1.1.1. Failure

Fault (deprecated).

The termination of the ability of an item to perform a required function.

Note. After failure the item has a fault.

3.1.1.2. Failure occurrence

The event when an item loses its ability to perform a required function.

3.1.1.3. Failure recognition

The event when it is recognized that an item has lost its ability to perform a required function.

3.1.1.4. Failure cause

The circumstances during design, manufacture or use which have led to failure.

3.1.1.5. Failure effect

The effect of the failure of the item in terms of the loss of one or more required function(s) of the complex item.

3.1.2. *State concept*

3.1.2.1. Failure state

A state of an item characterised by its lack of ability to perform a required function.

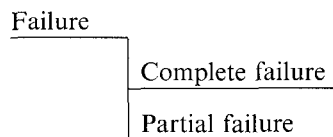
3.1.2.2. Failure mode

One of the possible states of an item, defined as a failure state.

- 3.1.2.7. Standby state
A non-operating up state during the required time.
- 3.1.2.8. Free state, idle state
A non-operating up state during non-required time.
- 3.1.2.9. Busy state
The state of an item in which it performs a required function for a user and for that reason is not accessible by other users.

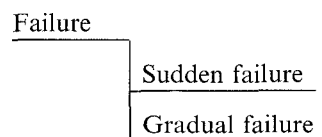
3.2. **Classifications of failures**

3.2.1. *Classification of failures as to degree*



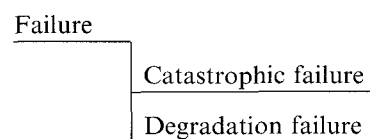
- 3.2.1.1. Complete failure
Failure resulting from deviations in characteristic(s) beyond specified limits such as to cause a complete lack of the required function.
Note. The limits referred to in this category are special limits specified for this purpose.
- 3.2.1.2. Partial failure
Failure resulting from deviations in characteristic(s) beyond specified limits, but not such as to cause a complete lack of the required function.
Note. The limits referred to in this category are special limits specified for this purpose.

3.2.2. *Classification of failures as to suddenness*



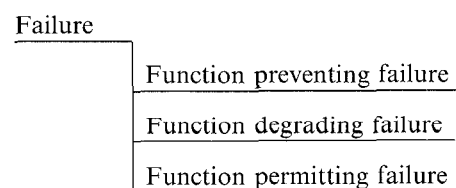
- 3.2.2.1. Sudden failure
Failure that could not be anticipated by prior examination or monitoring.
- 3.2.2.2. Gradual failure
Failure that could be anticipated by prior examination or monitoring.

3.2.3. *Classification of failures as to suddenness and degree*



- 3.2.3.1. Catastrophic failure
Failure which is both sudden and complete.
- 3.2.3.2. Degradation failure
Failure which is both gradual and partial.
Note. In time such a failure may develop into a complete failure.

3.2.4. *Classification of failures as to their effect on item functions*

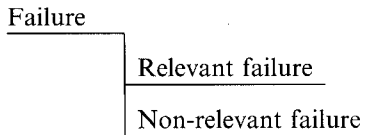


3.2.4.1. Function preventing failure
Failure of a sub-item such as to cause a complete lack of all of the required functions.

3.2.4.2. Function degrading failure
Failure of a sub-item such as to cause a lack of a part of the required functions.

3.2.4.3. Function permitting failure
Failure of a sub-item such as not to cause a lack of the required functions.

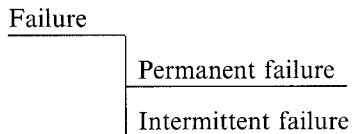
3.2.5. *Classification of failures as to relevance*



3.2.5.1. Relevant failure
Failure to be included when interpreting test or operational results or when calculating the value of a reliability performance measure.
Note. The criteria for the inclusion should be stated.

3.2.5.2. Non-relevant failure
Failure to be excluded in interpreting test or operational results or in calculating the value of a reliability performance measure.
Note. The criteria for the exclusion should be stated.

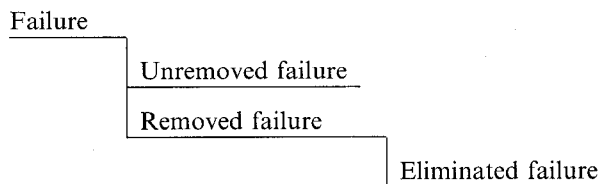
3.2.6. *Classification of failures in relation to their permanence*



3.2.6.1. Permanent failure
Failure of an item that persists until corrective maintenance (repair) actions are undertaken.

3.2.6.2. Intermittent failure
Failure of an item for a limited period of time following which the item recovers a required function without being subjected to any external corrective action.
Note. Such a failure is often recurrent.

3.2.7. *Classification of failures in relation to the result of maintenance*



3.2.7.1. Removed failure
Failure of an item which has been removed by a repair action.

3.2.7.2. Unremoved failure
Failure of an item which has not been removed by a repair action.

3.2.7.3. Eliminated failure
Failure of an item, of which further occurrence has been prevented by a preventive action.
Note. The preventive action referred to could be a design change.

4. INTERRUPTION CONCEPT

4.1. Interruption

Temporary inability of a service to be provided persisting for more than a given time interval. Characterized by a change beyond given limits in at least one parameter essential for the service.

Note 1. An interruption of a service may be caused by disabled states of the items used for the service or by external reasons such as high service demand.

Note 2. An interruption of a service is generally an interruption of the transmission, which may be characterized by an abnormal value of power level, noise level, signal distortion, error rate, etc.

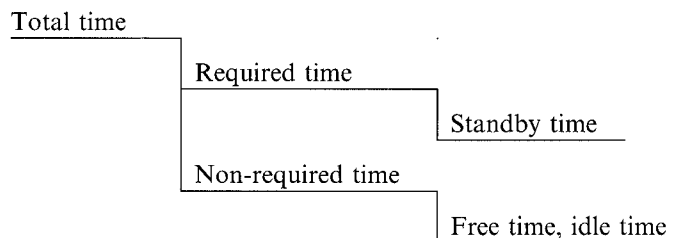
5. TIME CONCEPT

The concept of time used is to be interpreted in a very wide sense. It may thus, where appropriate, be replaced by distance, cycles, operations or other quantities.

The time concepts below represent random variables. To each time can be associated a distribution function, and thus the usual probabilistic and statistical modelling techniques can be applied to it.

Measurements are either to be made from a functional point of view or are single-valued. The time concepts are then used singly (e.g. p-fractile active repair time), in combination (e.g. asymptotic availability) or as accumulated times (e.g. mean accumulated down time per year).

5.1. Times in relation to whether the item is required or not



5.1.1. *Required time*

The period of time during which the user requires the item to be in a condition to perform a required function.

5.1.2. *Non-required time*

The period of time during which the user does not require the item to be in a condition to perform a required function.

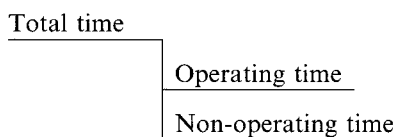
5.1.3. *Free time, idle time*

That part of the non-required time during which an item is in a condition to perform a required function.

5.1.4. *Standby time*

The time interval during which an item is in a stand-by state.

5.2. Times in relation to whether the item is operating or not



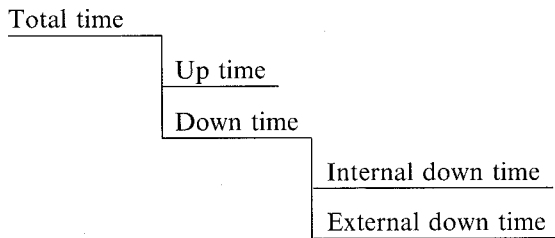
5.2.1. *Operating time*

The period of time during which an item is in an operating state.

5.2.2. *Non-operating time*

The period of time during which an item is in a non-operating state.

5.3. **Times in relation to the state of the item**



5.3.1. *Up time*
The period of time during which an item is in an up state.

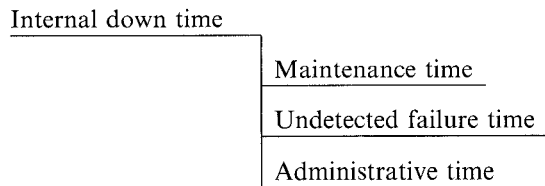
5.3.2. *Down time*
The period of time during which an item is in a down state.
Note. Unless otherwise stated, down time will include any additional time necessary to reach the same stage in the working programme of the item as at the time of occurrence of the failure.

5.3.3. *Internal down time*
That part of down time which is caused by internal failure states of the item.

5.3.4. *External down time*
That part of down time which is not caused by failure states of the item.
Note. This may be due to lack of external resources such as power, fuel etc.

5.3.5. *Accumulated down time*
The sum of the duration of down times of an item over a given period of time.

5.4. **Breakdown of internal down time**

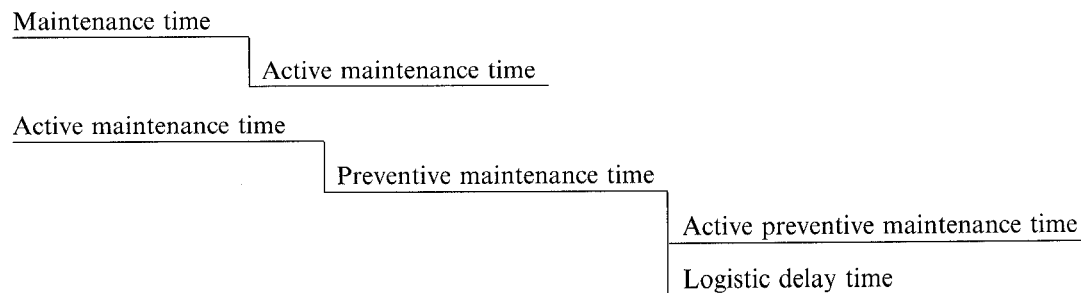


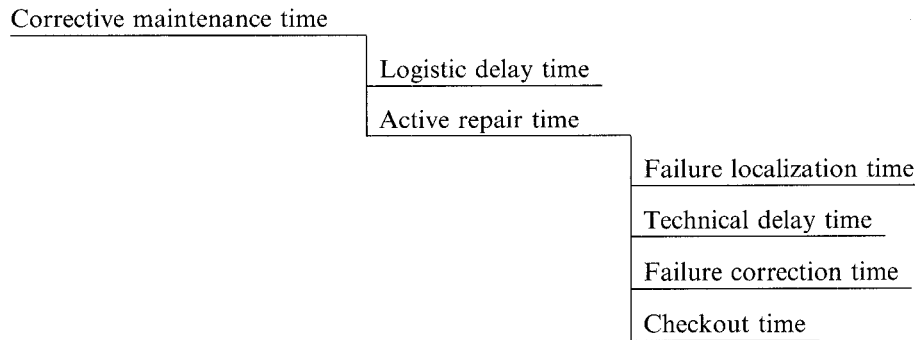
5.4.1. *Maintenance time*
The period of time during which maintenance actions, including delays inherent in the maintenance operations, are performed on an item either manually or automatically.
Note 1. The inherent delays include those due to design or to prescribed maintenance procedures.
Note 2. Maintenance may be carried out while the item is still performing a required function.

5.4.2. *Undetected failure time*
The period of time between the instant of failure and its recognition.

5.4.3. *Administrative time*
The total time during which an item has failed and during which corrective maintenance actions are pending or prepared but not yet initiated.

5.5. **Breakdown of maintenance time**





- 5.5.1. *Active maintenance time*
That part of the maintenance time during which a maintenance action is performed on an item, either automatically or manually, excluding logistic delays.
Note. Active maintenance may be carried out while the item is performing a required function.
- 5.5.2. *Preventive maintenance time*
That part of the maintenance time during which preventive maintenance is performed on an item, including the time due to logistic delays inherent in the preventive maintenance operations.
Note 1. The inherent delays include those due to design or to prescribed maintenance procedures.
Note 2. Preventive maintenance time does not include any time taken to maintain an item which has been replaced.
- 5.5.3. *Corrective maintenance time (Repair time)*
The part of the maintenance time, including that due to logistic delays, during which corrective maintenance is performed on an item.
- 5.5.4. *Active preventive maintenance time*
That part of the preventive maintenance time, including technical delays inherent in the actions, during which preventive maintenance actions are performed on an item either manually or automatically.
- 5.5.5. *Logistic delay time*
That total time during which no maintenance actions are performed due to delays.
Note. Delays can be due to travelling to unattended exchanges or awaiting the arrival of spare parts, specialists and test equipment.
- 5.5.6. *Active corrective maintenance time (Active repair time)*
That part of the active maintenance time in which corrective maintenance actions are performed on an item either automatically or manually, including the time due to delays inherent in the repair operations.
Note 1. The inherent delays could, for example, include those due to design or to prescribed maintenance procedures.
Note 2. Active corrective maintenance time does not include any time taken to repair an item which has been replaced as part of the corrective maintenance action under consideration.
- 5.5.7. *Failure localization time*
That part of active repair time during which failure localization is performed.
- 5.5.8. *Technical delay time*
The accumulated total time necessary to perform auxiliary technical actions associated with the maintenance action itself.
- 5.5.9. *Failure correction time*
That part of active corrective maintenance time during which the ability of a failed item to perform its functions is restored.
Note 1. That restoring action may be a replacement of a sub-item of the item.
- 5.5.10. *Check out time*
That part of active corrective maintenance time during which function check out is performed.

5.6. **Reliability performance related measures**

5.6.1. *Time to first failure*

The total operating time of an item, from the instant it is first put in an up state until it fails.

5.6.2. *Time to failure*

The total operating time of an item, from the instant it goes from a down state to an up state, after a corrective maintenance action, until next failure.

5.6.3. *Time between failures*

The interval of time between two consecutive failures of a repaired item.

Note 1. Those parts of *non-operating time* which are included must be identified.

Note 2. In some applications only the *up time* is considered.

5.6.4. *Useful life*

Under given conditions, the period of item beginning at a given instant of time, (e.g. from the time of installation or power on) and ending when the failure intensity becomes unacceptable or when the item is considered unrepairable as a result of a failure.

5.7. **Time period with respect to failure occurrence of a maintained item**

5.7.1. *Failure rate; $\lambda(t)$ (symbol)*

The limit, if this exists, of the ratio of the conditional probability that the time to failure, T , of an item falls within a given period of time $(t, t + \Delta t)$, and the length of this period, Δt , when Δt tends to zero, given that the item is in a state to perform a required function at the beginning of the period of time.

Note. The failure rate is expressed by formula as:

$$\lambda(t) = \lim_{\Delta t \rightarrow 0} \frac{\text{Pr}(t < T < t + \Delta t \mid T > t)}{\Delta t}$$

where T is the time to failure and Pr the abbreviation of probability.

The formula is also applicable if T denotes the instant of time of failure.

5.7.2. *Failure intensity; $Z(t)$ (symbol)*

The limit, if this exists, of the ratio of the mean number of failures of a repaired item in a period of time $(t, t + \Delta t)$, and the length of this period, Δt , when the length of the period of time tends to zero.

Note. The failure intensity is expressed by formula as:

$$Z(t) = \lim_{\Delta t \rightarrow 0} \frac{E[N(t + \Delta t) - N(t)]}{\Delta t}$$

where $N(t)$ is the number of failures in the period of time $(0, t)$ and E the abbreviation of expectation.

5.7.3. *Early failure period*

That possible early period in the life of an item, beginning at a given instant of time (e.g. from the time of installation or power on) and during which the failure intensity for a repaired item or the failure rate for a non-repaired item decreases rapidly.

Note. In any particular case, it is necessary to explain what is meant by "decreases rapidly".

5.7.4. *Constant failure intensity period*

That possible period in the life of a repaired item during which the failure intensity is approximately constant.

Note. In any particular case it is necessary to explain what is meant by "approximately constant".

5.7.5. *Constant failure rate period*

That possible period in the life of a non-repaired item during which the failure rate is approximately constant.

Note. In any particular case it is necessary to explain what is meant by "approximately constant".

5.7.6. *Wear-out failure period*

That possible later period in the life of a repaired item during which the failure intensity for a repaired item or the failure rate for a non-repaired item increases rapidly.

Note. In any particular case it is necessary to explain what is meant by "increases rapidly".

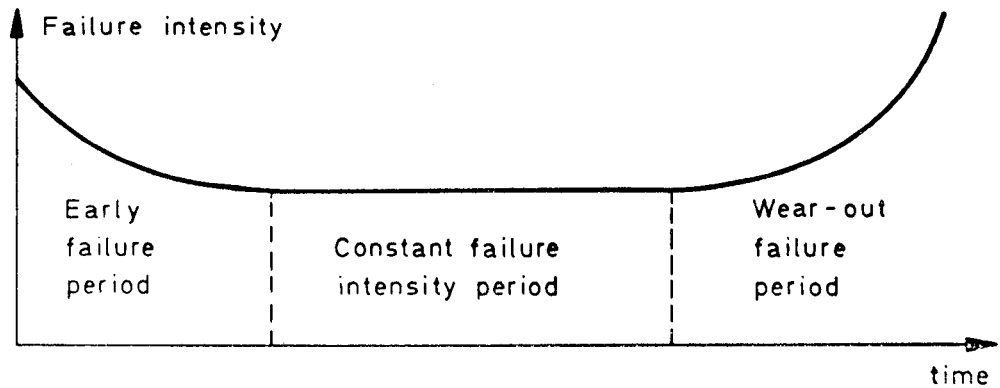


Figure 3 (T/CS 10-13). Time periods with respect to failure occurrence during the lifetime of a repaired item.

- 5.7.7. *Mean time to first failure; MTTF (abbreviation)*
The expectation of the time to first failure.
- 5.7.8. *Mean time to failure; MTF (abbreviation)*
The expectation of the time to failure.
- 5.7.9. *Mean time between failures; MTBF (abbreviation)*
The expectation of the time between failures.
- 5.7.10. *Mean up time; MUT (abbreviation)*
The expectation of the up time.
- 5.7.11. *Mean down time; MDT (abbreviation)*
The expectation of the down time.
- 5.7.12. *Mean accumulated down time; MADT (abbreviation)*
The expectation of the accumulated down time.
- 5.7.13. *Mean time to repair; MTTR (abbreviation)*
The expectation of the time to repair.

5.8. **Time diagram**

The subdivision of total time can be made from different points of view. A diagram showing all these parts at the same time is thus difficult or impossible to draw. The following time diagram in Figure 4 (T/CS 10-13) is an example and shows the relationship between the various phases in the total time of a maintained item and some of the elements which make up these phases.

No significance is to be given to the lengths of the boxes containing the time phase names, the space being determined by the space needed.

The diagram incorporates the facility to show overlapping times.

The diagram represents the case of a typical piece of equipment in order to show the general relationship which means that some simplifications have been adopted, e.g. to avoid repetitions. In specific cases of equipment and conditions, the drawing of a more complex or a more simplified diagram may be appropriate or necessary. This may also be needed when times are to be shown in strict time order.

It is advisable in practical applications to draw a separate diagram which includes those time concepts relevant to that study.

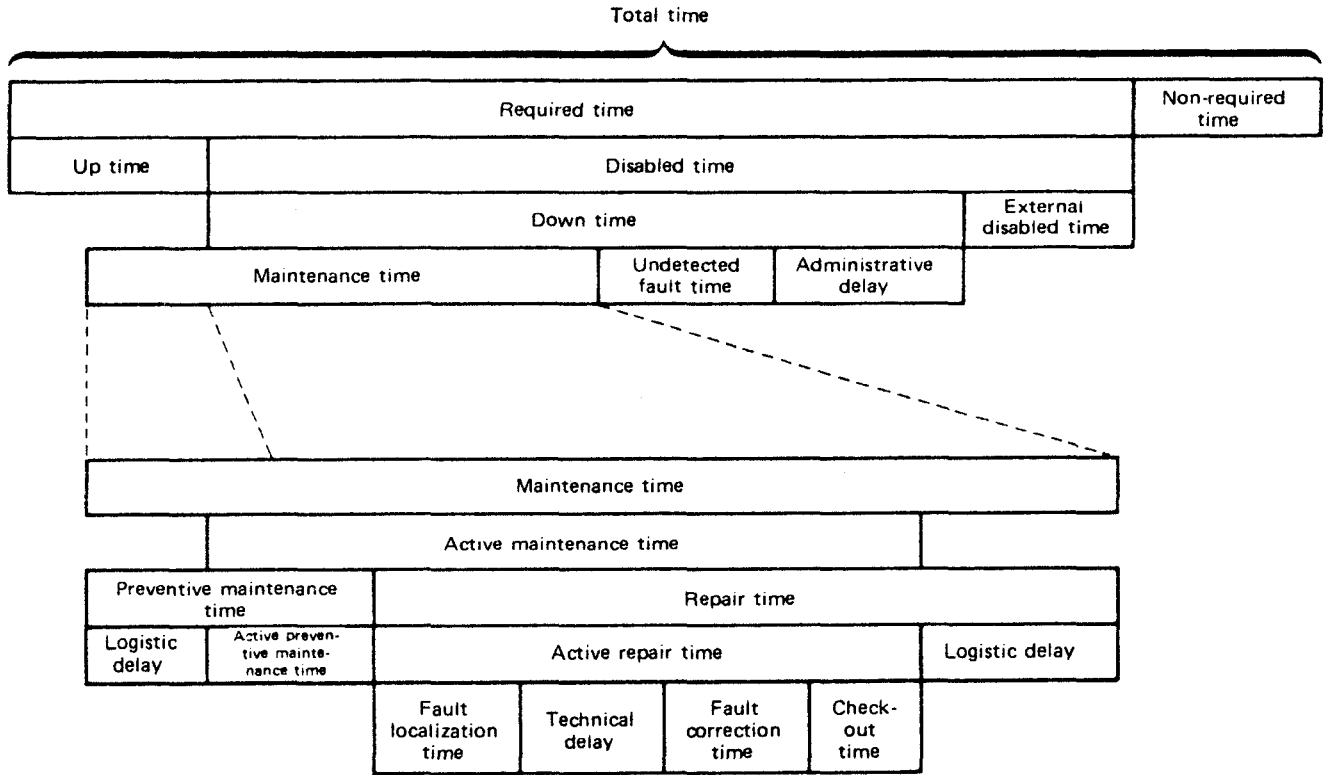


Figure 4 (T/CS 10-13). Time diagram.

6. DESIGN CONCEPTS

6.1. Redundancy

In an item, the existence of more than one means for performing a required function.

6.2. Active redundancy

That redundancy wherein all means for performing a required function are operating simultaneously.

6.3. Standby redundancy

That redundancy wherein the alternative means for performing a required function are inoperative until needed.

6.4. Fail safe

A designed property of an item which prevents its failures from being critical failures.

7. EXPLANATORY TEXT

7.1. Arrangement principles

The selection and arrangement of the terms has been made according to a number of principles, of which the following are the most important:

1. The performance (ability) concepts are chosen to subdivide the subject area into logical sub-areas.
2. Each sub-area (performance) is allocated a set of basic measures (parameters) by which the properties of that sub-area are described and to which logical additions can be made, when needed.
3. The terms are logically grouped under a common heading.
4. Each term has only one meaning (except in a few cases).

7.2. Failure terms

The word failure denotes either the termination of the ability of an item to perform a required function or, in combination with the term state, the state or condition of an item which has failed. For some of the failure terms included in the list, an abbreviation has been used and the term state has been excluded, where it was appropriate to do so. In practical applications, it may be necessary to add the term state to avoid misunderstanding. A failure term applies only to the item under consideration. Thus a complete failure of a particular sub-item may imply only a partial failure of the item in which it is used.

REFERENCE

- [1] CCITT Recommendation G.106. *Terms and definitions related to quality of service, availability and reliability*. Red Book, ITU, Malaga-Torremolinos 1984.