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SERIES M: GENERAL MAINTENANCE PRINCIPLES

Maintenance of international transmission systems and telephone circuits – Introduction

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MAINTENANCE PHILOSOPHY FOR TELECOMMUNICATIONS NETWORKS

Reedition of CCITT Recommendation M.20 published in the Blue Book, Fascicle IV.1 (1988)

NOTES

1 CCITT Recommendation M.20 was published in Fascicle IV.1 of the *Blue Book*. This file is an extract from the *Blue Book*. While the presentation and layout of the text might be slightly different from the *Blue Book* version, the contents of the file are identical to the *Blue Book* version and copyright conditions remain unchanged (see below).

2 In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Recommendation M.20

MAINTENANCE PHILOSOPHY FOR TELECOMMUNICATIONS NETWORKS

(The principles described in Recommendation M.21 should also be taken into account.)

1 General

1.1 Maintenance involves the whole of operations required for setting up and maintaining, within prescribed limits, any element entering into the setting-up of a connection (see Recommendation M.60)[1]. In order to properly plan and program the maintenance operations required to establish and maintain an analogue, digital or mixed network, the following general strategy is recommended.

1.1.1 A maintenance organization should be established using the guiding principles set forth in Recommendations M.70 and M.710 for automatic circuits switched over analogue, digital and mixed networks. In addition, the concept of control and subcontrol stations found in Recommendations M.80 and M.90 for international circuits and transmission systems should be implemented.

1.1.2 The strategy should include the following maintenance operations considerations:

a) It should consider the evolution of the network from the present highly analogue environment to the future almost wholly digital environment. In doing this, it must consider the new services and functions offered by the networks (e.g. CCITT Signalling System No. 7 and ISDN) and the maintenance tools and capabilities becoming available (e.g. performance monitoring).

b) It should employ an overall maintenance philosophy that uses the maintenance entity concept, failure classification and network supervision process specified in § 3.

c) It should provide for the maintenance of the network systems, equipment and circuits during the following activities:

– installation and acceptance testing (§ 4);

– bringing into service (§ 4);

– keeping the network operational (§ 5).

It should support other maintenance activities (§ 6) associated with the administration of maintenance operations (e.g., data bases, spare parts, failure statistics, etc.) along with a detailed plan for preventive maintenance, where required, on the various telecommunication equipments.

d) It should have as a major aim to minimize both the occurrence and the impact of failures and to ensure that in cause of failure:

– the right personnel can be sent to

– the right place with

– the right equipment

– the right information at

– the right time to perform

– the right actions.

1.2 To apply this general strategy in a network, the following principles can be used:

Preventive maintenance

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

Corrective maintenance

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

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[1] It is recognized that for some Administrations, bringing into service is not considered to be part of maintenance.

Controlled maintenance

A method to sustain a desired quality of service by the systematic application of analysis techniques using centralized supervisory facilities and/or sampling to minimize preventive maintenance and to reduce corrective maintenance.

1.3 In general for all three types of network (analogue, digital and mixed), the use of controlled maintenance principles is recommended, i.e., the maintenance actions are determined on the basis of information generated in the maintained system or coming from auxiliary supervision systems.

1.4 The advantages of the controlled maintenance approach are that it directs future maintenance activity to those areas where a known improvement in service to the customer will be achieved. The monitoring techniques which are inherent in controlled maintenance provide data which simplify the identification of hidden faults by using statistical analysis.

1.5 The smaller the portion of the network which is affected by a failure, the more difficult and/or less economic it may be to detect it using controlled maintenance techniques. In these cases corrective and/or preventive maintenance techniques may have to be employed.

1.6 In analogue and mixed networks a mixture of the above-mentioned principles are used, depending on the existing equipment included in the network (see Recommendations M.710, M.715 to M.725).

1.7 The maintenance philosophy and fundamental principles are closely linked to:

– availability performance;

– network technical performance;

– network economics.

2 Maintenance objectives

2.1 *Purpose*

The main purpose of a general maintenance philosophy for analogue, digital and mixed networks is to accomplish the aims defined in § 1.1.

In addition the following objectives should be fulfilled:

– For a defined level of service the total cost should be kept to a minimum by the use of appropriate methods (e.g. centralized operation and maintenance).

– The same maintenance philosophy should be applied to exchanges, transmission equipment, data equipment, subscriber terminals, etc., wherever possible.

2.2 *Economics*

New technology provides new possibilities for low cost maintenance not only for individual exchanges, but for the whole network, e.g. using the same technology for both transmission and switching.

The operation and maintenance functions in a network should be planned in such a way that the life cost will be a minimum. For a defined level of service the total cost consists of:

– investment cost

– operations cost

– maintenance cost

– cost for loss of traffic.

2.3 *Transition from analogue to digital networks*

The basic philosophy, as described in this Recommendation, is valid in principle, for analogue, mixed and digital networks. However, many digital network parts are more suited to the implementation of controlled maintenance than are analogue network parts. Due to new technological developments maintenance functions can be incorporated within the digital equipment. Analogue equipment often requires additional external maintenance systems in order to permit controlled maintenance, e.g. ATME No. 2 (Recommendation O.22 [1]).

2.4 *Centralized maintenance operations*

The introduction of digital telecommunications equipment with enhanced maintenance operations functions, including the facility for remote reporting and control, provides new opportunities for centralization. Supplement No. 6.2 [2] provides a description of a centralized maintenance organization. There are many benefits that can be gained from centralization. These include the ability to:

– be more flexible in the organization of maintenance operations and administration;

– utilize highly skilled mechanical resources more efficiently;

– utilize more effectively data and data bases;

– improve maintenance effectiveness;

– decrease maintenance costs;

– increase the availability of transmission and switching systems;

– improve quality of service.

Note – By the use of remote terminals, an Administration can choose how they allocate their technical staff between local and centralized locations.

Because of these benefits, it is recommended that centralized maintenance and other operations capabilities be considered when specifying new telecommunications systems and equipments. The general principles for setting-up, operating and maintaining a Telecommunication Management Network (TMN) to support centralized maintenance and other operations are given in Recommendation M.30.

3 Overall maintenance philosophy

3.1 *Maintenance entity concepts*

In order to facilitate efficient maintenance, the telecommunication network (analogue and digital) is divided into parts, called Maintenance Entities (MEs), Maintenance Entity Assemblies (MEAs) and Maintenance Sub-Entities (MSEs). Examples of MEs, MEAs and MSEs are given in Figures 1, 2 and 3/M.20.

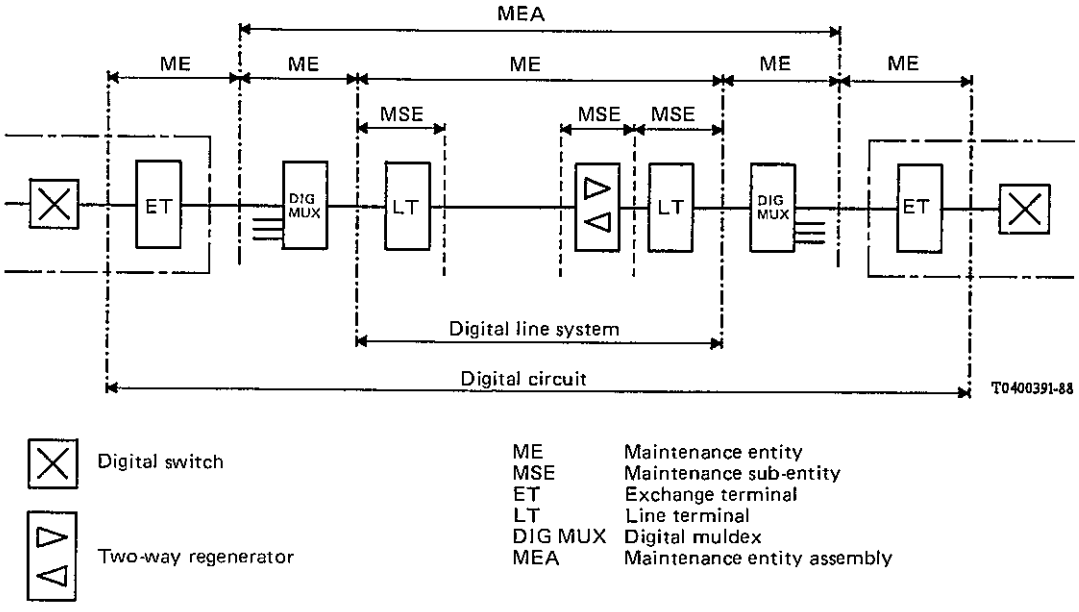
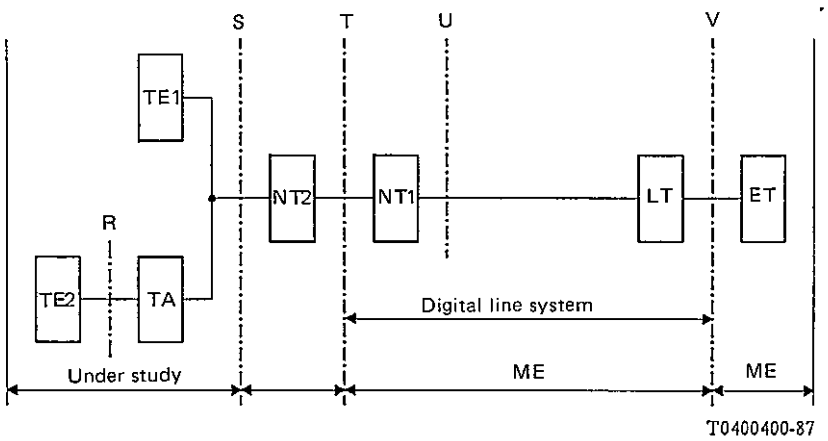
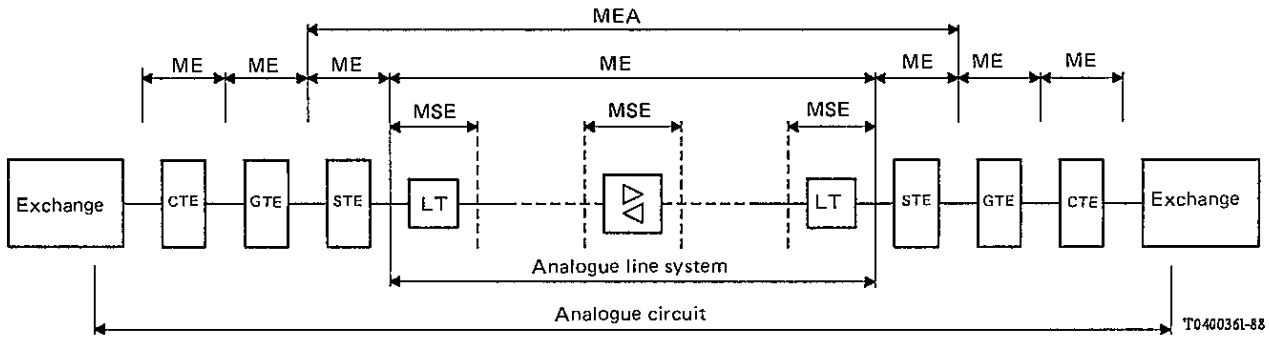


FIGURE 1/M.20
Maintenance entity concept for digital transmission networks



ET Exchange terminal
LT Line terminal
ME Maintenance entity
NT Network terminal
TA Terminal adaptor
TE Terminal equipment

FIGURE 2/M.20
Maintenance entity concept for the ISDN subscriber networks



CTE Channel translation equipment
GTE Group translation equipment
STE Supergroup translation equipment
MEA Maintenance entity assembly
MSE Maintenance sub entity

FIGURE 3/M.20
Maintenance entity concept for analogue networks

3.1.1 *Definition of Maintenance Entity*

Maintenance entities are defined by the following principles:

– The different equipments of a telecommunications network constituting the MEs are interconnected at consecutive and easily identifiable interface points at which points the interface conditions defined for these equipments apply and which possess the means of detecting maintenance events and failures.[2]

– If the telecommunication equipment supports bidirectional transmission, it normally consists of telecommunications equipment transmitting in both directions and then both directions are considered part of the same ME.

– When a failure occurs within a network, it is desirable that the maintenance alarm indication appears at the failed maintenance entity. When this is not practical, the indication should appear at the closest possible entity.

[2] If an easily identifiable interface point is not available, the interface point may be replaced by a point permitting sectionalization with functions such as, e.g., looping-back or performance monitoring.

– Maintenance alarm information indications in an entity should not cause related alarm information indications at other entities. In the event that such indications are permitted to occur, they should clearly indicate that the failure has occurred upstream, and not in the other entities displaying the information.

Meeting these four principles ensures that the responsible maintenance personnel are called into action, and that usually no unnecessary maintenance activity is initiated elsewhere.

In an integrated digital network, for example, easily identifiable points may be provided by digital distribution frames. Even in a location where no digital distribution frame is provided, an equivalent point, where defined interface conditions apply, will normally be identifiable. The interface between the exchange terminals and the digital switch may be accessed on a virtual basis.

3.1.2 An ME has to perform a determined function between transmission interfaces (see Figure 4/M.20). The performance is checked by internal failure detection and conveyed to the maintenance interface either automatically after a failure occurrence, or after a request for maintenance information.

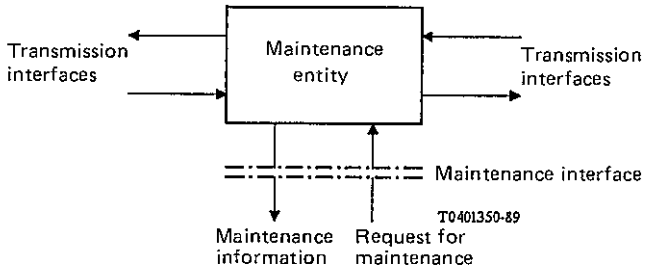


FIGURE 4/M.20
Maintenance entity interface

In addition, other operations and administrative functions may be carried out by the maintenance interface. Several types of maintenance interfaces are described in Recommendation M.30 which covers the TMN.

3.1.3 *Definition of Maintenance Entity Assembly*

A maintenance entity assembly (MEA) is defined by the following principles:

– An MEA contains a group of MEs assembled for additional maintenance purposes.

– Principles that apply for MEs apply also for MEAs.

– An MEA may detect failures and maintenance event information which can not be detected by MEs.

– An MEA may provide end-to-end maintenance alarm information which can not be provided by MEs.

End-to-end information may be collected by using additional supervision means.

3.1.4 *Defintion of Maintenance Sub-Entity (MSE)*

A maintenance sub-entity is defined by the following principles:

– The different parts of an MSE constituting the MEs are interconnected at consecutive and easily identifiable interface points.

– When a failure occurs within an MSE, it is desirable that the maintenance alarm information indication appears at the failed maintenance entity containing the MSE.

– An failed MSE should be identified as failed by the fault location process, but should lead only to the identification of the failed ME by the supervision process.

– An MSE generally corresponds to the item which is replaceable during routine operations in the event of a failure.

3.1.5 The choice of ME, MEA and MSE should be compatible with the maintenance organization of an Administration (Recommendations M.710, M.715 to M.725).

3.1.6 *Relationship between Maintenance Entities and Network Elements*

The relationship between maintenance entities and network elements is defined in Recommendation M.30.

3.2 *Failure concepts*

The following definitions and classifications are used in developing the concept of a failure.

3.2.1 *Anomalies*

An anomaly is a discrepancy between the actual and desired characteristics of an item.

The desired characteristic may be expressed in the form of a specification.

An anomaly may or may not affect the ability of an item to perform a required function.

As an example, for a multiplexer one type of elementary information that can be detected is an error in the frame alignment word. This elementary information is an anomaly. More examples of anomalies are given in Recommendation M.550.

3.2.2 *Defects*

A defect is a limited interruption in the ability of an item to perform a required function. It may or may not lead to maintenance action depending on the results of additional analysis.

Successive anomalies causing a decrease in the ability of an item to perform a required function are considered as a defect.

As an example, the G.700 [3] series recommends that three consecutive errored frame alignment words will give a loss of frame alignment. This loss of frame alignment is a defect. More examples of defects are given in Recommendation M.550.

The process of using anomalies and defects is explained in § 3.3.

3.2.3 *Failures*

A failure is the termination of the ability of an item to perform a required function.

Analysis of successive anomalies or defects affecting the same item can lead to the item being considered as "failed".

3.2.3.1 *Classification of failures*

The severity of the failure depends on the failure effect. This effect can be related to:

– the network service performance requirements as experienced by the subscribers;

– the probability that multiple failures will occur, thus resulting in a deteriorating performance as seen by the customer;

– the probable loss of revenue to the Administration.

The failures can be classified according to their importance and consequences to the quality of service provided to the subscribers and to the network technical performance:

– failures which result in complete interruption of service(s) for one or several subscribers;

– failures which result in partial interruption of service(s) (e.g. degradation of transmission quality) to one or several subscribers;

– failures which decrease the availability performance of the equipment and/or the network but do not affect the subscribers.

– A failure can be either a permanent or intermittent condition and this may alter its effect on the network.

– The severity of a failure can be determined by measuring the down time, up time and failure rate of the ME. These items are defined in Supplement No. 6 to Fascicle II.3 [4].

3.2.4 *Fault*

A fault is the inability of an item to perform a required function, excluding that inability due to preventive maintenance, lack of external resources or planned actions.

Note – A fault is often the result of a failure of the item itself, but may exist without prior failure.

3.3 *Network supervision*

Network supervision is a process in which the anomalies and defects detected by the maintenance entities ME or MEA are analyzed and checked. This analysis may be internal or external to the entity. In the external case it can be accomplished either locally or on a centralized basis.

For maintenance, this supervision process has to include the following actions:

a) Locating “failed” equipment, or the equipment in which a fault is suspected or a failure is believed to be imminent. It is generally carried out by analytical or statistical identification processes. The supervision process consists of three continuously running concurrent processes:

   – the supervisory process for anomalies (short period),

   – the defect supervisory process (medium period), and

   – the malfunction supervisory process (long period).

   Each process is interfaced by the characteristic data, e.g. accumulated anomaly data and accumulated defect data. The supervisory processes for anomalies and defects respectively, indicate that the anomaly or defect states have been reached. The malfunction supervisory process evaluates the performance level of the maintenance entity and judges it to be normal, degraded or unacceptable. These levels are determined from the anomalies and defects received and analyzed over a given time. The thresholds limiting degraded or unacceptable performance limits and the process period are defined for each defect and confirmed fault or group of anomalies and defects and also for each type of entity. Indications of degraded and unacceptable performance levels are generated each time the corresponding threshold is exceeded. This process is shown in Figure 5/M.20.

b) Reporting of failures to maintenance personnel.

c) Transmission of data to the maintenance personnel, relating to specific functional features of the network (traffic, state of equipment, particular malfunctions, etc.). This information can be transmitted systematically or on demand.

d) Protecting the system by transmitting to all concerned network equipment the necessary information for automatic initialization of internal or external protection mechanisms, e.g., reconfiguration, traffic rerouting, etc.

e) Modify the supervision process due to:

   – the type of service being offered over a given portion of the network;

   – the time of day.

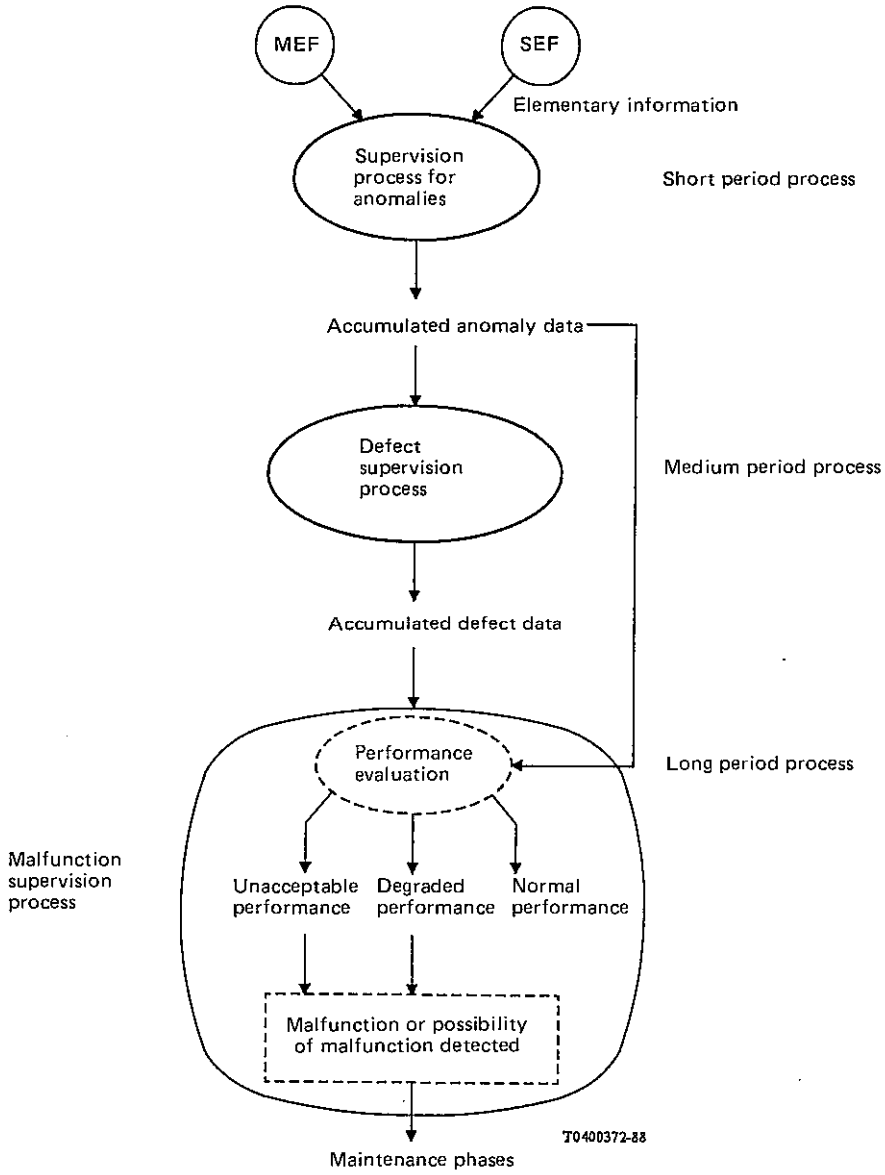


FIGURE 5/M.20
Supervision process for a maintenance entity

4 Bringing new international transmission systems and circuits into service

4.1 *Installation and acceptance testing*[3]

For new systems, this work may include the necessary installation of new equipment. Once the new equipment is working, the Administration should make the necessary tests to ensure the new system meets required specifications. Acceptance testing of the new system or equipments should be based on policies established by the Administration. However, Administrations may wish to use the performances monitoring techniques found in Recommendation M.24 to aid in their acceptance testing of new transmission systems.

[3] Installation and acceptance testing is not generally considered part of maintenance.

4.2 *Setting-up and lining-up*

As soon as Administrations have decided to bring a new international transmission system and/or circuit into service, the necessary contacts are made between their technical service for the exchange of information. Those services jointly select the control and sub-control stations for the new system or circuit (see Recommendations M.80 and M.90).

The technical service of each Administration is responsible for the setting-up and lining-up of the line or circuit sections in its territory, and for arranging that the adjustments and tests required are made by the station staff concerned.

4.3 *Detailed considerations*

To set-up a line section or circuit which crosses a frontier, Administrations should arrive at bilateral agreements on the basis of CCITT Recommendations and, for radio-relay sections, the Recommendations of the CCIR. Administrations should refer to the following Recommendations for detailed considerations associated with bringing into service the following entities:

4.3.1 *New transmission systems*

CCITT Volume IV, § 2.3, Recommendations M.450 through M.480 and M.24.

4.3.2 *Telephone circuits*

CCITT Volume IV, § 3.1, Recommendations M.570 through M.590.

4.3.3 *Common channel signalling systems*

CCITT Volume IV, § 4, Recommendations M.761 and M.782.

4.4 *Bringing into service*

After the control station has determined from reports provided by the subcontrol station that appropriate tests and adjustments have been performed, the control station conducts overall tests of the system or circuit. The overall tests results are recorded, operations systems data bases are updated and synchronized between Administrations, and the system and/or circuits are placed in service. At this time the system and/or circuits are transferred to a performance measuring state (see § 5.1) to track and insure their continuing proper operation.

5 Maintenance phases under normal and fault conditions

Under normal conditions in the network, performance information should be gathered from MEs on a continuous or periodic basis. This data can be used to detect acute fault conditions which generate alarm reports. Further analysis may reveal subtle degradations which generate maintenance information reports.

After the occurrence of a failure in the network, a number of maintenance phases are required to correct the fault and to protect, when possible, the traffic affected by the fault if it has been interrupted.

As an example, Figure 6/M.20 lists the maintenance phases which are involved before and after a failure occurrence in a maintenance entity (ME). The parameters determining the different phases are indicated in the figure. It is intended to characterize different maintenance strategies with the aid of the maintenance phases. The mechanics used to implement the various maintenance processes should be defined in connection with each specific application in the relevant Recommendations. The maintenance phases are described below in more detail.

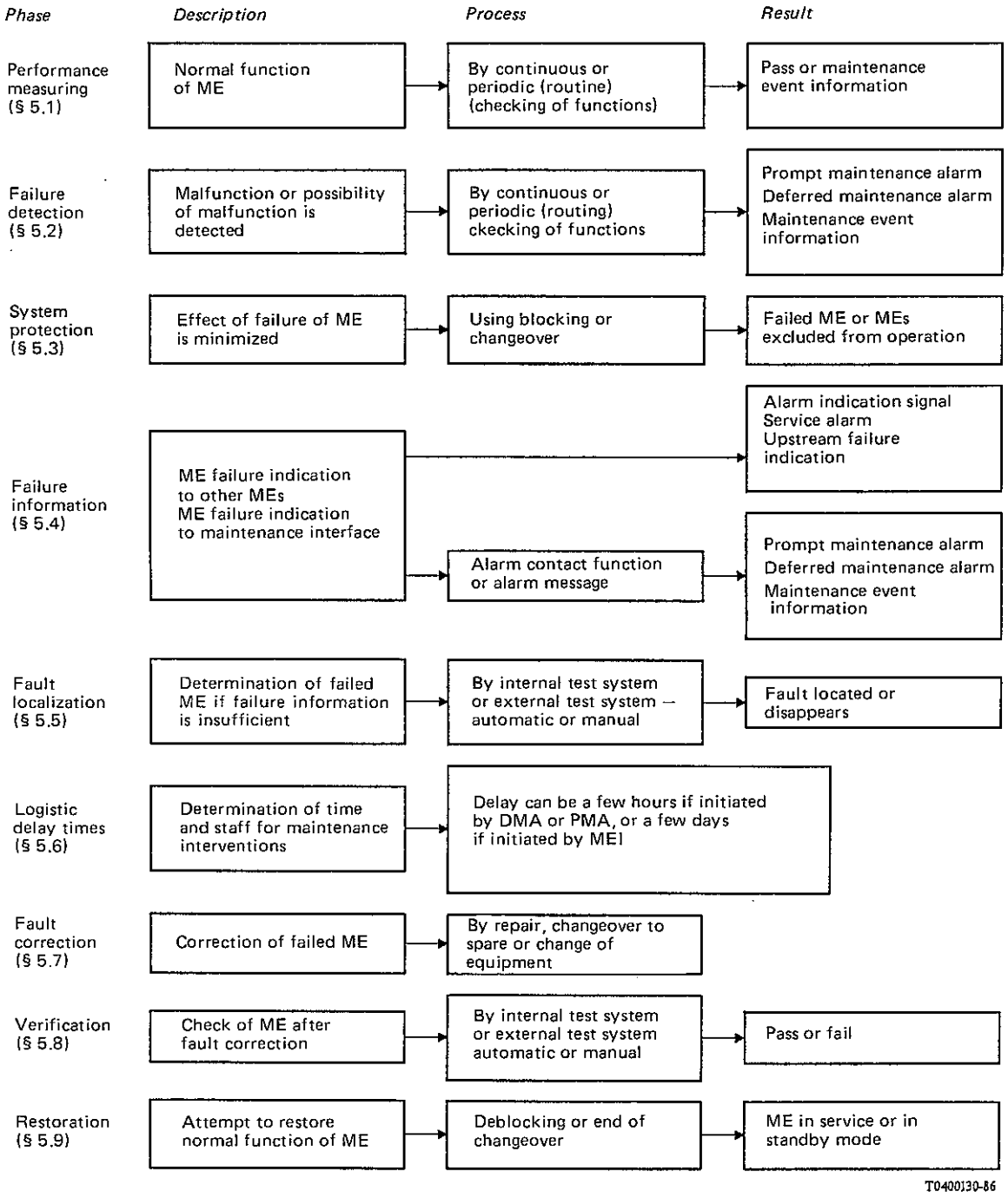


FIGURE 6/M.20
Maintenance phases under normal and failure conditions

5.1 *Performance measuring*

Different types of performance measuring mechanisms can be used:

a) continuous checking,

b) routine or periodic testing,

c) checking of behavior in live traffic,

d) checking of behavior in the absence of live traffic.

The rules governing the measurement mechanisms are defined when conceiving the systems; no intervention of the maintenance personnel is necessary. Under some conditions, however, the personnel can control some operations which may prove necessary for periodic or casual checking, such as:

– modifying the priority level of a checking process;

– modifying the nominal period in the case of periodical checking;

– carrying out some partial or recurrent checks (e.g. test on demand).

The choice of a measurement mechanism depends on the requirements for the "quality of service" as seen by the subscribers, and on the technical network performance and the nature of the equipment. In addition, several mechanisms may be operated in the same item of equipment.

Typical measurement mechanisms are listed below.

5.1.1 *Continuous checking*

All the time an item is active, it is being checked for good performance. If the item does not fulfill the test requirements, it is considered to have failed.

5.1.2 *Routine or periodic testing*

Items are tested periodically, initiated either by the system or by the maintenance staff.

The frequency of the test depends on the importance of the item, the failure rate and the number of items of that type present in the element.

5.1.3 *Checking in live traffic*

Checking behavior in live traffic can be done directly or statistically.

This checking exists if the ME itself indicates a failed performance or the continuous detection of anomalies or defects.

All of the elementary information from the different detectors is either retransmitted by each entity to a processing unit or processed locally.

Performance parameters are derived from this information.

5.1.3.1 *Processing of performance parameters*

Some performance parameters in use are Errored Seconds (ES), Severely Errored Seconds (SES) and Degraded Minutes (DM). These particular parameters are defined in Recommendation G.821 [5].

Each of the performance parameters (e.g., ES, SES, DM) is to be processed separately in order to evaluate the performance level of the entity's operation.

5.1.3.2 *Evaluation of unacceptable performance*

Unacceptable performance is characterized by a significant and long-lasting degradation in quality. It can be associated with the failed state.

It is ascertained by statistical analysis of each of the performance parameters individually, throughout a given time T1.

As soon as the result of statistical analysis reaches a N1 threshold (defined for each entity individually), the entity is declared to be at an unacceptable level of performance.

Elsewhere, for each defect corresponding to an interruption, lasting *x* consecutive seconds, the entity is considered as having reached an unacceptable level.

5.1.3.3 *Evaluation of degraded performance*

Each of the performance parameters is analyzed statistically over a time T2 which can be a relatively long period.

As soon as the result of statistical analysis reaches a N2 threshold (to be defined), the entity can be considered to be at degraded performance. The time T2 will depend on the entity in question.

This checking leads to maintenance decisions on statistical grounds:

– the number of times in which the item performs its function "normally" is compared with the number of times the performance of the item does not fulfill the requirements;

– the average time of functioning is compared with standard values;

– the number of times an item performs its function during a certain period is compared to normal values.

If the degraded performance level is characterized by a gradual degradation in quality, the maintenance personnel should be informed before this decrease in performance becomes unacceptable to the user.

5.1.4 *Checking in the absence of live traffic (traffic is zero)*

Checking of system internal functions is done once a process is over, or when a process has been initiated several times. Examples are operational checks which start when a customer initiates an action to use the network.

5.2 *Failure detection*

Failures should be discovered by the Administration independently of, and preferably before, the subscriber, i.e., the majority of failures are both detected and remedied without the subscriber having been aware of them.

Failures are classified depending on their nature (see § 3.2) and may be categorized depending on their severity. Corresponding maintenance alarm information is then passed on to the appropriate entities.

5.3 *System protection*

When a failure has occurred or performance has degraded, the following functions must be performed:

– as a result of the medium and longer period supervision process a signal must be transmitted to all the concerned network equipment of any necessary information for automatic (preferred) initialization of internal or external protection mechanisms, e.g., reconfiguration, traffic rerouting, etc.;

– decision on any necessary actions, e.g. putting an item “out of service” or “in testing condition”, changing to a configuration with minimal or degraded service.

A specific protection method is recommended for transmission systems using manual or automatic restoration on a maintenance entity basis:

a) If a failure occurs either in maintenance entities without automatic changeover capabilities or with automatic changeover capabilities but no standby available, the following actions should be executed:

   1) initiate maintenance alarm information identifying the maintenance entity containing the failed equipment;

   2) transmit an alarm indication signal (AIS) in the direction affected (downstream direction) or give an upstream failure indication (UFI) at equipment which has not failed;

   3) initiate a service alarm indication at the appropriate entities, e.g. primary PCM multiplex or digital switch interfaces. (As a consequence the circuits may be removed from service.)

b) If a failure occurs in a maintenance entity having automatic changeover capability with a standby available, the following actions should be automatically executed:

   1) changeover to the standby;

      Note – Whether or not connections are released as a result of automatic changeover depends on the service performance objectives assigned to each maintenance entity.

   2) initiate maintenance alarm information indicating the maintenance entity containing the failed equipment.

5.4 *Failure or performance information*

Information on failure, unacceptable performance or degraded performance will normally be transmitted to the maintenance staff and other parts of the network notified when appropriate.

Information for the use of personnel is available either in the entity, when the processing of anomalies or defects is internal, or via a unit which provides processing, when external to the entity.

5.4.1 *Alarm information categories*

The following maintenance alarm information may be associated with the information of failure or unacceptable or degraded performance:

a) *Prompt maintenance alarm (PMA)*

   A prompt maintenance alarm is generated in order to initiate maintenance activities (normally immediately) by maintenance personnel to remove from service a defective equipment for the purpose of restoring good service and effecting repair of the failed equipment.

b) *Deferred maintenance alarm (DMA)*

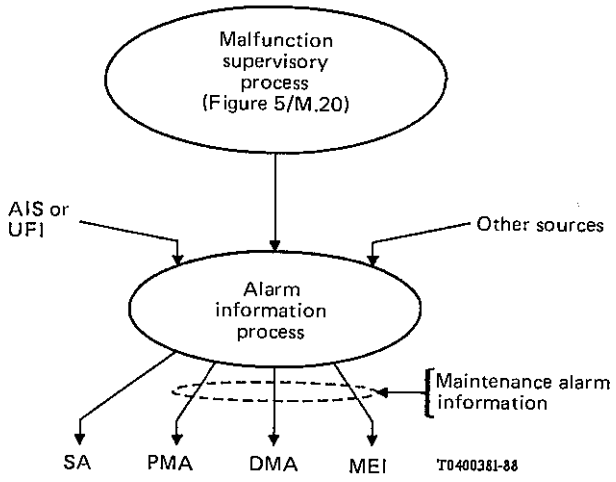
A deferred maintenance alarm is generated when immediate action is not required by maintenance personnel, e.g. when performance falls below standard but the effect does not warrant removal from service, or generally if automatic changeover to standby equipment has been used to restore service.

c) *Maintenance event information (MEI)*

This information has to be generated as a consequence of events when no immediate actions by the maintenance staff are required because the total performance is not endangered. The maintenance actions can be performed on a scheduled basis or after the accumulation of maintenance event information indications.

Starting with the malfunction supervisory process from Figure 5/M.20, Figure 7/M.20 shows the alarm informtion process for an ME. The actual PMA, DMA or MEI may or may not be generated in the ME. When generated outside the ME, the alarm information process may combine information from other sources (e.g., other MEs, time of day, traffic load, etc.) with the output from the malfunction supervisory process to decide if a PMA, DMA or MEI should be generated. When an AIS or UFI is received, an ME may be required to generate an SA.

Both the malfunction supervisory process and the alarm information process, including the use of PMAs, DMAs and MEIs, can also be applied to other non-telecommunications equipment.



AIS Alarm indication signal
UFI Upstream failure indication
SA Service alarm
PMA Prompt maintenance alarm
DMA Deferred maintenance alarm
MEI Maintenance event information

FIGURE 7/M.20
Alarm information process

5.4.2 *Other fault and service indications*

In order to avoid unnecessary maintenance actions and to signal the unavailability of the service, the following fault indications are used:

– Alarm indication signal (AIS)

An alarm indication signal (AIS) is a signal associated with a defective maintenance entity and is, when possible, transmitted in the direction affected (downstream direction) as a substitute for the normal signal, indicating to other nondefective entities that a failure has been identified and that other maintenance alarms consequent to this failure should be inhibited. The binary equivalent of the AIS corresponds to an all 1s signal.

Note 1 – The AIS is different from the "alarm information to the remote end"; see § 5.4.4.

Note 2 – The AIS capability does not impose any restrictions on the binary content of signals which may be transmitted over the digital hierarchy at the primary multiplex and higher levels. The implications at the 64-kbit/s level and at lower bit rates are under study, since ambiguity arises between AIS and an all 1s information signal.

Note 3 – For a maintenance entity with multidestination ends (e.g. in networks with TDMA/DSI satellite systems) alarm indication signals on a circuit basis may useful. This subject is under study.

Note 4 – In the particular case of the 44 736 kbit/s hierarchical level, the AIS is defined as a signal:

i) with a valid frame alignment signal, parity and justification control bits as defined in Table 2/G.752 [6];

ii) with the tributary bits being set to a 1010 . . . sequence, starting with a binary one ("1") after each frame alignment, multiframe alignment and justification control bit;

iii) and with all justification control bits being set to binary zero ("0").

Demultiplexers of the 44 736 kbit/s hierarchical level must produce the all 1s AIS at their tributary outputs when they receive the 44 736 kbit/s AIS at their high speed inputs.

– Service alarm (SA)

A service alarm is generated at maintenance entities at which the service originates and/or terminates to indicate that the particular service is no longer available (e.g. when a primary block is no longer available for setting up connections, the PCM muldex will extend a service alarm indication to the exchange equipment).

The service alarm should be generated when performance falls below a level specified for a particular service. This level may coincide with that for initiating also a prompt maintenance alarm.

– Upstream failure indication (UFI)

The upstream failure indication given by a maintenance entity indicates that the signal arriving at that maintenance entity is defective. The UFI indicates that the failure has occurred upstream of this point, and no unnecessary maintenance activities are initiated.

The appearance of an alarm indicates either a fault in the equipment generating the alarm or a failure of the incoming signal (an upstream failure). To distinguish between these two possibilities it is necessary to provide an independent test, either of the input signal, or of the equipment generating the alarm. The input signal can be checked for proper parity, for example, by a monitor included in the protection switching equipment. A defective input signal indicates an upstream failure. Alternatively, the equipment generating the alarm can be tested independently, by looping, for example, and if the equipment operates correctly, an upstream failure is indicated.

Note – For a multiple destination maintenance entity (e.g. in networks with TDMA/DSI satellite systems) alarm indication signals on a circuit basis may be useful. This subject is under study.

5.4.3 *Transmission and presentation of alarm information*

The failure information at the alarm interface is used to determine the faulty ME or part of ME. The information can be presented either locally, or remotely via an alarm collection system.

The alarms may be presented as:

– an indication at an alarm interface (e.g. contact function, d.c. signal)

– an alarm message on the man-machine interface.

5.4.4 *Alarm information to the remote end*

Equipment which is a source of digital multiple signals (i.e. multiple equipment or exchanges) may, in case of a fault condition, transmit alarm information within a specified bit or specified bits of the pulse frame. This information is intended for evaluation at the remote terminal (at the end of the digital link). Examples: see Recommendation G.704, § 2.3.2 [7], Recommendation G.732, § 4.2.3 [8] and Recommendation G.733, § 4.2.4 [9].

5.5 *Fault localication*

Where the initial failure information is insufficient for fault localization within a failing ME, it has to be augmented with information obtained by additional fault localization routines. The routines can employ ME internal or external test systems, initiated manually or automatically, at the local and/or remote end.

A test system, serving one or more MEs could have the following functions:

– alarm collection, e.g. by sampling of alarm interfaces and assembling of alarm messages;

– request for failure information, e.g. by addressing different MEs;

– test programs, e.g. for selection of essential alarms, editing, etc.;

– control of special devices, e.g. for looping measurement of electrical characteristics;

– display of results, e.g. for all MEs within a network region.

It should be particularly noted that:

– the corrective maintenance action time and the activity of repair centres (these repair centres may receive unfailed items or sub-items) are strongly conditioned by the localization efficiency (not yet defined);

– if an ME can be subdivided into MSEs, the faulty MSE should be identified as failed in the fault localization process;

– for interchangeable items, the failed item must be identified uniquely.

5.6 *Logistic delay*

5.6.1 The logistic delay is the period of time between the fault localization and arrival of the maintenance staff of site. In the case of an ISDN, the logistic delay will depend on the type of failures and how they are reported, i.e. by PMA, DMA or MEI.

5.6.2 Following a PMA or DMA alarm, fault correction will be performed normally in the course of a specific trip of the maintenance staff. The logistic delay may vary from a few hours in the case of PMA alarms, to a few days in the case of DMA alarms.

5.6.3 Following an MEI, which indicates that no immediate actions are necessary, the maintenance action can be postponed until the next scheduled maintenance visit unless an accumulation of MEIs demands earlier action.

5.7 *Fault correction*

Fault correction normally requires change or repair of an ME, MSE or a part thereof. One or more fault corrections can be performed in the course of a maintenance visit. It is desirable that strategies be developed to accomplish fault correction satisfying overall maintenance objectives with a minimum number of visits, using the concept of logistic delay.

Failed interchangeable items will be sent to a specialized repair centre, where appropriate test equipment is available (the system itself should not act as a test machine).

Normally, cooperation between maintenance elements in different Administrations will result in the satisfactory identification and correction of faults. There may be circumstances, however, where the fault escalation procedure defined in Recommendation M.711 may be required.

5.8 *Verification*

After the fault has been corrected, checks must be made to assure the ME is working properly. The verification can be made locally or remotely.

5.9 *Restoration*

The corrected part of the ME or MSE is restored to service. Blocked MEs are deblocked and changeover to spare may be terminated.

6 Additional maintenance activities

Besides the above-mentioned phases, the following activities may be required.

6.1 *Maintenance support*

Maintenance support covers the functions identified below:

– management of information of network equipment in operation,

– management of operating data (routing data mainly),

– correction instruction for hardware and software,

– repairing of removable items,

– management of maintenance stocks,

– network and equipment documentation.

The quantity of spare parts held depends on:

– organization of maintenance entities,

– failure rate of an item,

– turn around time (actual repair time, transport),

– number of items in operation,

– risk that no spare part is available.

6.2 *Failure statistics*

If all failures are recorded, this information, after processing, can serve the following organizational fields:

a) management, e.g. evaluating system performance,

b) organization of maintenance, e.g. use of test equipment, subscriber complaints versus test results, amount of spare parts,

c) maintenance activities, e.g. identifying weak components where preventive maintenance actions are necessary.

6.3 *Preventive maintenance actions*

Mechanical parts (such as magnetic equipment heads) have to be cared for periodically.

After analyzing failure statistics, decisions can be made to interchange items even before failures have occurred, if they seem to be weak items.

7 Other maintenance considerations

7.1 *Reference test frequency considerations*

(Under study.)

7.2 *Use of maintenance test lines and loop-backs*

(Under study.)

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