International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

M.3040

(04/2019)

SERIES M: TELECOMMUNICATION MANAGEMENT, INCLUDING TMN AND NETWORK MAINTENANCE

Telecommunications management network

Principles for on-site telecommunication smart maintenance

Recommendation ITU-T M.3040

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Recommendation ITU-T M.3040

Principles for on-site telecommunication smart maintenance

Summary

Recommendation ITU-T M.3040 introduces principles for on-site telecommunication smart maintenance (TSM). This Recommendation provides the background and basic concepts of on-site telecommunication smart maintenance. This Recommendation also provides details of various TSM architectures, including TSM functional architecture, TSM physical architecture, TSM information architecture, and maintenance processes.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T M.3040	2019-04-13	2	11.1002/1000/13877

Keywords

Smart maintenance assistant toolkit, telecommunication smart maintenance, TSM.

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

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In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

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Recommendation ITU-T M.3040

Principles for on-site telecommunication smart maintenance

1 Scope

The telecommunication management network (TMN) architecture has been used as a guide, for the rapid development of telecommunication management technology products and applications, and the establishment of a complete industrial chain. From the standpoint of fault, configuration, accounting, performance and security (FCAPS), the effective management architecture for the management of telecommunication networks has been proposed in [ITU-T M.3010], and a series of related technical standards have been compiled.

However, due to insufficient development of technologies such as the Internet of things (IoT) and augmented reality (AR), on-site maintenance work relating to the non-intelligent parts (such as racks, boards, pipes, optical fibers, lines and other dummy resources) that constitute the telecommunication network have required the participation of a large amount of manpower for a long period of time. As the intelligence degree of maintenance is in a low level, it is difficult to ensure the consistency and completeness of dummy resource information, which seriously affects the quality of the network management.

With the development of IoT and AR technology, wearable device has been widely used in the field of on-site telecommunication smart maintenance. It is urgent to build the appropriate technical reference architecture, based on which the specific technical standards, including maintenance management functions, interfaces, information models, can be established.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T E.800] Recommendation ITU-T E.800 (2008), *Definitions of terms related to quality of service.*

[ITU-T M.20] Recommendation ITU-T M.20 (1992), *Maintenance philosophy for telecommunication networks.*

[ITU-T M.60] Recommendation ITU-T M.60 (1993), *Maintenance terminology and definitions.*

[ITU-T M.3010] Recommendation ITU-T M.3010 (2000), *Principles for a telecommunications management network.*

[ITU-T M.3347] Recommendation ITU-T M.3347 (2012), *Requirements for the NGN service activation across the interface between the network management system and the element management system.*

[ITU-T Q.3903] Recommendation ITU-T Q.3903 (2008), *Formalized presentation of testing results.*

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 architecture (functional) [ITU-T M.60]: A description of appropriate distribution of functionality, that allows for a creation of functional blocks from which a TMN of any complexity can be implemented. These function blocks are separated by reference points and lead to the requirements for the TMN-recommended interface specifications.

3.1.2 architecture (information) [ITU-T M.60]: The information architecture based on an object-oriented approach gives the rationale for the application of OSI systems management principles to the TMN principles. The OSI systems management principles are mapped onto the TMN principles and are expanded to fit the TMN environment where necessary.

3.1.3 architecture (physical) [ITU-T M.60]: A description of realizable interfaces and examples of physical components (hardware and software) that make up the TMN.

3.1.4 corrective maintenance [ITU-T M.20]: The maintenance carried out after fault recognition and intended to restore an item to a state in which it can perform a required function.

3.1.5 F interface [ITU-T M.3010]: An interface applied at f reference points.

3.1.6 f reference points [ITU-T M.3010]: A reference point that is located between the workstation function block (WSF) and the operations systems function block (OSF).

3.1.7 function block [ITU-T M.3010]: The smallest (deployable) unit of TMN management functionality that is subject to standardization.

3.1.8 g reference points [ITU-T M.3010]: A reference point located outside the TMN between the human users and the workstation function block (WSF). It is not considered to be part of the TMN even though it conveys TMN information.

3.1.9 knowledge base [ITU-T Q.3903]: Intelligence media ensuring user query processing and information analysing with subsequent brief or detailed query processing result.

3.1.10 interface [ITU-T M.3010]: An architectural concept that enables interoperable interconnection at reference points between physical blocks by realizing the reference points.

3.1.11 management function [ITU-T M.3010]: The smallest part of a business process (or management service) as perceived by the user of the process (or service).

3.1.12 management function set (MFS) [ITU-T M.3010]: A grouping of management functions that contextually belong together.

3.1.13 on-site maintenance [ITU-T E.800]: Maintenance performed at the premises where the item is used.

3.1.14 preventive maintenance [ITU-T M.20]: 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.

3.1.15 Q interface [ITU-T M.3010]: An interface applied at q reference points.

3.1.16 q reference points [ITU-T M.3010]: A reference point located between NEF and OSF, between QAF and OSF, and between OSF and OSF.

3.1.17 reference point [ITU-T M.3010]: An architectural concept which delineates and exposes an external view of management functionality of a function block; it defines all or part of that function block's service boundary.

3.1.18 service activation [ITU-T M.3347]: The procedure of making a service ready for use, which processes information related to the telecommunications management for the purpose of configuration and activation of the resources reserved for supporting a specific service instance.

3.1.19 X interface [ITU-T M.3010]: An interface applied at x reference points.

3.1.20 x reference points [ITU-T M.3010]**:** A reference point located between OSF function blocks in different TMNs.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 telecommunication smart maintenance: The maintenance carried out with advanced technology-based (IoT, AR, wearable technology, etc.) toolkit and system, which can provide strong human-computer interaction capabilities and online guidance to personnels, to achieve higher efficiency and precision of actions.

3.2.2 on-site overhaul: A kind of on-demand preventive maintenance performed at facility site in the condition of natural disasters or major events.

3.2.3 on-site patrol: A kind of routine preventive maintenance periodically performed at a facility site.

3.2.4 on-site troubleshooting: A kind of corrective maintenance performed at a facility site when the quality of equipment degrades.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AR	Augmented Reality
FCAPS	Fault, Configuration, Accounting, Performance and Security
GPS	Global Positioning System
IOT	Internet of things
MO	Managed Object
NE	Network Element
NEF	Network Element Function
OS	Operations Systems
OSF	Operations Systems Function
OSI	Open Systems Interconnection
RFID	Radio Frequency Identification
SMAT	Smart Maintenance Assistant Toolkit
SMATF	Smart Maintenance Assistant Toolkit Function
TMN	Telecommunications Management Network
TSM	Telecommunication Smart Maintenance
TSMS	Telecommunication Smart Maintenance System
TSMSF	Telecommunication Smart Maintenance System Function

5 Convention

None.

6 Overview

This Recommendation presents the general architectural requirements for on-site telecommunication smart maintenance (TSM), which is to support telecommunication Operators to perform on-site maintenance actions with the aid of IOT, AR, smart wearable device and other technologies.

Within the context of the TSM, a telecommunication smart maintenance system (TSMS) and smart maintenance assistant toolkit (SMAT) provide a set of capabilities to assist on-site pesonnel in conducting their maintenance service efficiently and precisely.

With reference to description method of principles in [ITU-T M.3010], this Recommendation proposes principles for telecommunication smart maintenance.

The Recommendation also defines TSM architectures, including TSM functional architecture, TSM physical architecture, TSM information architecture and maintenance processes.

7 Scenarios for on-site telecommunication smart maintenance

Clauses 7.1 to 7.4 give some typical scenarios related to on-site telecommunication smart maintenance, including on-site patrol scenario, on-site overhaul scenario, on-site troubleshooting scenario and activate new service scenario.

7.1 On-site patrol scenario

The on-site maintenance personnel gets and confirms the routine patrol work task by smart maintenance assistant toolkit (SMAT), SMAT then generates patrol routes by using global positioning system (GPS) navigation technology and displays them on the virtual operation panel of SMAT.

When personnel arrives at the site, SMAT intelligently recognizes the equipment with technologies such as radio frequency identification (RFID) or two-dimensional code, and then superposes the virtual operation panel on the actual equipment by AR, and displays information including the content of the work task, the real-time guidance information, etc.

By using SMAT, operational status of network equipment can be recorded and uploaded automatically and timely during the process of patrol.

7.2 On-site overhaul scenario

In the event of natural disasters and major event, on-site maintenance personnel will perform on-demand maintenance know as on-site overhaul. During the procedure of on-site overhaul, SMAT provides real-time operation guidance in AR glasses through various forms such as video, voice and text. The SMAT can help maintenance personnel to implement the overhaul process in an efficient way.

7.3 On-site troubleshooting scenario

During the on-site troubleshooting procedure, SMAT analyzes the trouble based on information such as location, time of occurence, service type, content of trouble, etc.

The SMAT uses the maintenance knowledge base to automatically idientify the trouble, and filters out the corresponding knowledge.

Subsequently, the solution for the trouble can be provided in the AR operation panel, and the processing flow or operation instruction video related to the trouble can also be provided.

For more complex troubles, the SMAT provides video conferencing channels between SMAT and experts, so that experts can remotely view the resource objects to be maintained and provide guidance through video or voice. By so doing, telecommunication smart maintenance system (TSMS) can also accumulate accurate operational experience and form a maintenance knowledge base.

7.4 Activate new service scenario

Maintenance personnel can activate a new service with the help of SMAT, such as installation and configuration of home gateway. SMAT can provide timely guidance, and automatically take photos according to the progress of the work. SMAT can upload the scene photos to TSMS to provide feedback on the implementation of the work task.

8 Functional architecture of on-site telecommunication smart maintenance

The telecommunication smart maintenance management function can be divided into two functional blocks. Different function blocks are delimited by reference points. The reference points between function blocks constitute the functional architecture of on-site telecommunication smart maintenance, as shown in Figure 1.

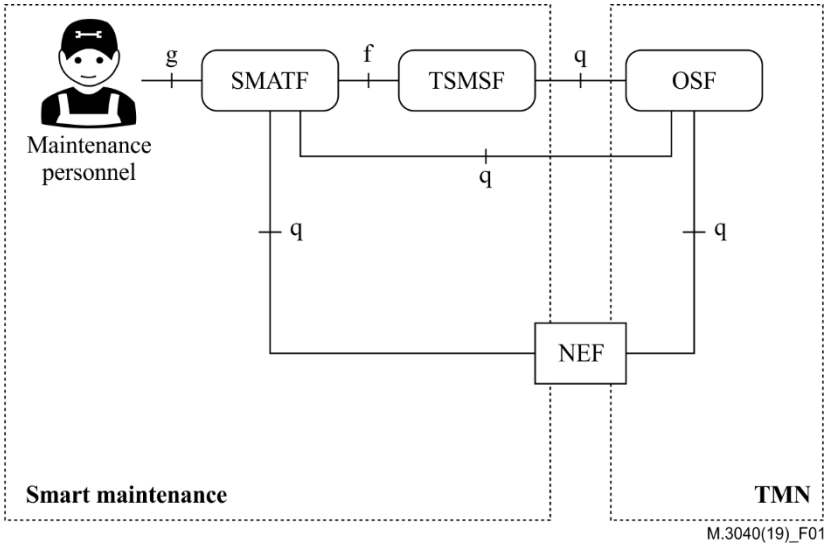

Figure 1 – Functional architecture of on-site telecommunication smart maintenance

The on-site maintenance personnel interact with the smart maintenance assistant toolkit function (SMATF) block through reference point g. SMATF basically presents the smart maintenance information to the on-site maintenance personnel in a visible way.

The telecommunication smart maintenance system function (TSMSF) block mainly implements the functions related to managing maintenance tasks, maintaining data collection, online support of maintainance process, etc. The detailed componets and function requirements for TSMSF will be provided in a future ITU-T Recommendation focusing on the function requirements of the telecommunication smart maintenance system.

The SMATF block and TSMSF block support the application scenarios described in clause 7.

The smart maintenance assistant toolkit function block is connected to the network element function (NEF) block module abstracted by the maintained network resource through reference point q, and is connected to the TSMSF block through reference point f.

The TSMSF block and the SMATF block are connected to other operation system function (OSF) blocks through the q reference point as defined in [ITU-T M.3010].

9 Physical architecture of on-site telecommunication smart maintenance

The physical architecture of on-site telecommunication smart maintenance is described by the interface between physical entities, as shown in Figure 2.

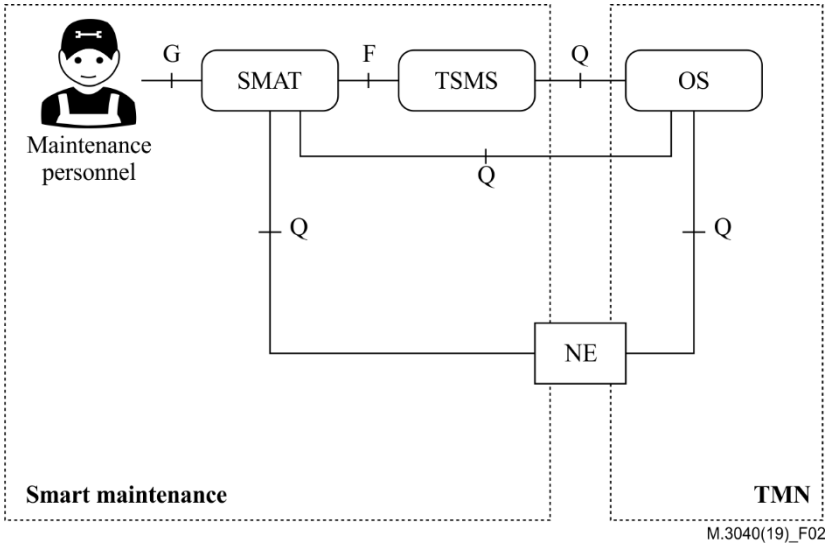

Figure 2 – Physical architecture of on-site telecommunication smart maintenance

The characteristic functional block of the SMAT is related to the SMATF block, and its entities may include AR glass and a controller installed with application software connected to the AR glass.

The SMAT performs intelligent upgrades of existing maintenance toolkits such as smart phones through IOT and AR technologies. SMAT is currently mainly based on AR glass, which can later be extended to other types of terminal.

The characteristic function block of the TSMS is related to the TSMSF block.

TSMSF can be implemented in a variety of physical configurations. The relationship of the functional blocks to the physical equipment is shown in Table 1. The table names the telecommunication smart maintenance physical blocks in accordance to the set of function blocks that each is allowed to contain. For each physical block there is a characteristical function block which is mandatory for it to contain. There are also other existing functions which are optional for the physical blocks to contain. Table 1 does not imply any restriction of possible implementations, but defines those identified within this Recommendation.

Table 1 – Relationship of TSM physical block names to functional blocks (Notes 1, 2)

	SMATF	**TSMSF**
SMAT	M	O (Note 3)
TSMS		M

M Mandatory
O Optional

NOTE 1 – Within this table, where more than one name is possible, the choice of the physical block name is determined by the predominant usage of the block.

NOTE 2 – Physical blocks may contain additional functionality which allows them to be managed.

NOTE 3 – When the TSMSF function block is implemented in the SMAT, the TSMSF will not be implemented in the TSMS at the same time.

In the physical architecture, reference points between different functional blocks are implemented as physical interfaces, including:

– Interface G: This is the interface between on-site maintenance personnel and SMAT. It is mainly composed of the human-machine interface, voice recognition, AR operation panel, etc.

– Interface F: This is the interface between SMAT and TSMS. It is mainly composed of resource identification interaction steps, trouble identification, information collection, etc.

– Interface Q: This is the interface between the SMAT and the maintained network element (NE). It facilitates the exchange of information related to the interaction of the maintained resources. The interface between TSMS and the operations systems (OS) [ITU-T M.3010] or the interface between SMAT and OS mainly interact with resource data, work task, maintenance record, user information, etc.

10 Information architecture of on-site telecommunication smart maintenance

The information architecture of on-site telecommunication smart maintenance includes an information interaction model and a management information model. The information interaction model complies with the requirements of the TMN information interaction model in [ITU-T M.3010]. This Recommendation mainly describes the scope of the telecommunication smart maintenance management information model.

The information model of TSM is an abstraction of smart maintenance resources and related management activities. That is, the maintained physical or logical resources are abstracted as managed objects (MOs) as describes in [ITU-T M.3010].

The definition of information objects in this Recommendation are mainly based on the following principles. The definition of network resource information models refers to existing ITU-T Recommendations. In this clause, the scope of the information object that is not included in the existing standard is explained. The details of the information model will be described in the other ITU-T Recommendations about specific information models of this series of Recommendations.

The categories of information model for telecommunication smart maintenance include:

– Resource management information model: The information model about specific network resources refers to relevant existing standards.

– On-site patrol information model: The on-site patrol information model is an abstraction of the information involved in patrol work tasks, patrol procedures and results.

– On-site overhaul information model: The on-site overhaul information model is an abstraction of the information involved in work task information and overhaul record information.

– On-site troubleshooting information model: The on-site troubleshooting information model is an abstraction of the information involved in troubleshooting processing and results.

– Service activation information model: The service activation information model is an abstraction of the information involved in service information and results.

– Maintenance work evaluation information model: The maintenance work evaluation information model is an abstraction of the information involved in the on-site recording and maintenance work evaluation.

– Maintenance knowledge base information model: The maintenance knowledge base information model is an abstraction of knowledge and information related to maintenance.

– Smart maintenance assistant toolkit information model: The smart maintenance assistant toolkit information model is an abstraction of information involved in smart assistant toolkit and applications.

11 Processes of on-site telecommunication smart maintenance

This clause outlines the processes of on-site telecommunication smart maintenance, and the manner in which TSMS or SMAT supports maintenance personnel to perform maintenance work in a more efficient way. The clause provides an overview of the interaction between TSMS and SMAT, and also the interaction between SMAT and the maintenance personnel.

The processes of on-site telecommunication smart maintenance can be divided into two categories based on the triggering factors of the process. One is order-driven maintenance processes, and the other is active support maintenance processes.

– Order-driven maintenance processes

  Order-driven maintenance processes are based on orders related to specific tasks, such as on-site patrol work task, on-site overhaul work task or on-site troubleshooting work task. TSMS initiates maintenance requirements and assigns work tasks to maintenance personnel. Maintenance personnel then performs the maintenance job with SMAT according to the assigned tasks. A general flow chart for order-driven maintenance processes is shown in Figure 3.

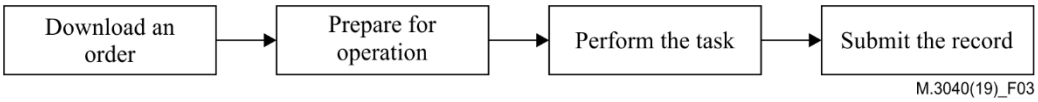

Figure 3 – A general flow chart for order-driven maintenance processes

– Active support maintenance processes

  Active support maintenance processes are mainly initiated by the TSMS, which are proactive and help to improve the quality of the maintenance work. In this case, TSMS can combine data mining, machine learning and other big data processing technologies to analyze and evaluate the records of the maintenance work, and form useful maintenance knowledge. It is used in the follow-up maintenance work, such as smart matching of maintenance guidance video, smart pushing of intelligent maintenance task, and it is helpful to improve the efficiency and intelligence of maintenance work.

Based on the TSM architecture and categories of maintenance processes described above, six intelligent maintenance processes are described in clauses 11.1 to 11.6. Among them, the processes of on-site patrol, on-site overhaul, on-site troubleshooting and service activation belong to the order-driven maintenance processes category. Processes of maintenance work evaluation and the management process of maintenance knowledge base belong to the active support maintenance processes category.

This Recommendation gives a brief description of the above processes.

11.1 Process of on-site patrol

The process of on-site patrol is as follows:

1) Download an order related to patrol work task: On-site maintenance personnel use SMAT to download an order related to patrol work task from the TSMS.

2) Prepare for operation: TSMS generates patrol routes intelligently by using GPS positioning and GPS navigation technology. SMAT visually displays patrol routes, directions, and patrol points in the AR glasses in a graphic manner. Some identification object information packages (i.e, a virtual resource view and an operation panel map that can present the maintained resource in the AR glasses) are generated and downloaded in advance into SMAT.

3) Carry out patrol: SMAT is used by on-site maintenance personnel responsible for the daily patrol work of network resources, such as viewing the appearance, running status, connection status and signage of the equipment, and recording them in the form of text, picture, video, etc. SMAT provide AR image recognition tracking and voice command recognition input methods, as well as 3D dual display and headphone audio output methods to help maintenance personnel with the patrol.

4) Submit the patrol record: After completing each patrol task, SMAT will submit the patrol records to TSMS.

11.2 Process of on-site overhaul

The process of on-site overhaul is as follows:

1) Download an order related to overhaul work task: On-site maintenance personnel uses SMAT to download an order related to the overhaul work task from the TSMS.

2) Prepare for operation: TSMS obtains maintenance data and procedure information related to the work task according to the actual implementation status of maintenance personnel on site, and pushs them to the SMAT.

3) Carry out an overhaul: On-site maintenance personnel scan and identify the two-dimensional code on the rack through the SMAT, obtain the corresponding rack information, and compare the information in the work task to determine the correctness of the operation object. They then overhaul the resources that were maintained according to the standardized operations provided by TSMS.

4) Submit the overhaul record: After completing maintenance tasks, on-site maintenance personnel upload the overhaul record to TSMS. SMAT can automatically take photos according to the progress of the work, and uploads them to the TSMS. It can overcome manual inertia and lack of information, accumulate experience, and form a maintenance knowledge base.

11.3 Process of on-site troubleshooting

The process of on-site troubleshooting is as follows:

1) Download an order related to troubleshooting work task: TSMS receives the trouble report, creates the order related to the troubleshooting work task, and dispatches it to the corresponding on-site maintenance personnel.

2) Match the trouble automatically: SMAT analyses the trouble according to the resource object, location, time, service, type and content of the trouble. The TSMS uses the maintenance knowledge base to automatically matche the possible causes of troubles and provides troubleshooting solutions to push them to SMAT.

3) Recovery: On-site maintenance personnel follow the instructions of SMAT to restore the equipment back to normal operation. During this process, experts can be identified according to the type of trouble. On-site maintenance personnel can use the form of dial-up video conferencing with the remote experts to communicate through text, pictures and video, and return the on-site information to remote experts in the form of text, pictures, video, etc. A number of experts can be accessed at the same time for trouble consultation.

4) Submit the troubleshooting record: The on-site maintenance personnel are responsible for uploading the relevant information of the trouble to the TSMS. After the troubleshooting is completed, on-site maintenance personnel will submit the troubleshooting record to TSMS. TSMS checks the troubleshooting records and stores them in the maintenance knowledge base.

11.4 Process of service activation

The process of service activation is as follows:

1) Download an order related to service activation work task: TSMS genarates the order that is related to service activation work task based on the service requirements and distributes it to the on-site maintenance personnel. The on-site maintenance personnel obtains the service activation work task from the TSMS and downloads the service activation work task into SMAT based on their duties.
2) Service activation: On-site maintenance personnel use SMAT to perform service activation work tasks and take photos automatically according to the work schedule.
3) Submit the service activation record: During and after the execution of the work task, on-site maintenance personnel upload the scene photos, labels, etc., to the TSMS through the SMAT to provide record on the implementation of the work task.

11.5 Process of maintenance work evaluation

The process of maintenance work evaluation is as follows:

1) Collect data: TSMS supports the use of SMAT for intelligent acquisition of on-site maintenance operation data for telecommunication.
2) Establish evaluation criteria: TSMS collects maintenance data over a period of time and conducts a comprehensive evaluation of the data. Based on the evaluation results, TSMS establishes a dynamic assessment baseline for the intelligent maintenance work quality of telecommunication.
3) Evaluate the quality of maintenance work: TSMS evaluates the quality of telecommunication smart maintenance work according to the evaluation criteria. The evaluation includes star rating and explanation information.
4) Upload evaluation report: TSMS generates evaluation reports based on the quality evaluation results of the maintenance work. TSMS uploads the evaluation report to other OSs.

   The process of maintenance work evaluation is shown in Figure 4.

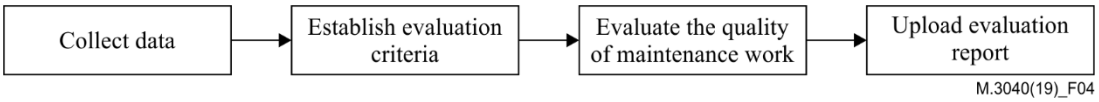

Figure 4 – Process of maintenance work evaluation

11.6 Management process of maintenance knowledge base

The maintenance knowledge base records maintenance experience and can help personnel involved in the process to quickly troubleshoot and locate troubles, as well as provide a standardized approach to handling troubles or activate services. By establishing a maintenance knowledge base, the intelligent operation and maintenance decision-making can be realized.

The management process of maintenance knowledge base is as follows:

1) Collect maintenance records: On completion of the telecommunication smart maintenance process, SMAT submits the maintenance records to TSMS. The maintenance record is about the operation steps, time, results, exceptions and other information related to the equipment when on-site maintenance personnel perform the maintenance job.
2) Evaluate and generate maintenance knowledge: TSMS uses data mining and other data management technologies to evaluate maintenance records and generate maintenance knowledge.

3) Apply maintenance knowledge: TSMS can automatically select the appropriate knowledge based on certain reasoning principles. During the task execution process, if on-site training function is performed, TSMS automatically performs knowledge search and query pre-processing and provides the applicable knowledge for training.

4) Knowledge maintenance: TSMS performs routine maintenance on maintaining knowledge records in the knowledge base, and assesses maintenance knowledge by counting usage. TSMS updates the knowledge in the knowledge base according to evaluation results.

The management process of maintenance knowledge base is shown in Figure 5.

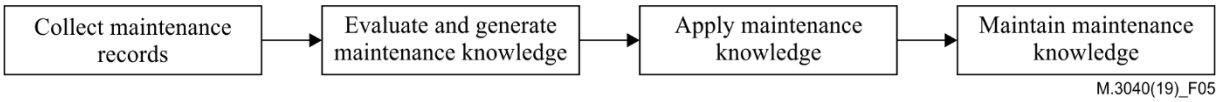

Figure 5 – Management process of maintenance knowledge base

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Printed in Switzerland
Geneva, 2019