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Volume 5, Chapter 20

Control of Maintenance Activities Procedure



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1.0 PURPOSE

The control of Maintenance Activities is critical to any Assets and Facilities Management (A&FM) organization, from the owner of the assets through to the supply chain of the Facilities Management (FM) contractor. The adoption of Operations and Maintenance (O&M) standards, policies, procedures and plans is of limited value if the creation and implementation of these activities is not controlled in an effective manner.

This document defines Systems Engineering and explains how this is applied to effectively control the Maintenance Activities. It also includes the requirement to comply with various documents within the National Manual of Assets and Facilities Management (NMA&FM) and other international best practice publications, where applicable.

The purpose of this procedure is to guide Entities on the importance of Systems Engineering best practice and their application within their Maintenance Activities control processes.

2.0 SCOPE

This document is developed specifically for the Facilities Management of the built environment domain within the Kingdom of Saudi Arabia (KSA) government Entities. It describes the fundamental aspects of Maintenance Activities and how Systems Engineering is utilized to implement and control them.

Although references are made to typically adopted control processes that are applicable to Maintenance Activities within the maintenance management environment, each Entity should establish its own goals, objectives, and maintenance control processes according to its mission, vision, and strategic plan.

Furthermore, this procedure has been developed to enable Entities to utilize current Systems Engineering best practice methods, tools, and concepts, in order to successfully control their Maintenance Activities.

This Procedure has been written around the guidance and advice provided within the National Manual of Assets and Facilities Management, Volumes 5 Operations Management and Volume 6 Maintenance Management. Both volumes are applicable for the writing of procedures and plans used to define the maintenance activities.

3.0 DEFINITIONS

Term	Definition
Maintenance Activities	The technical and non-technical actions required for an asset to achieve its expected useful life
Maintenance Control	Using Maintenance Management and Work Control to ensure compliance, best practice, and customer satisfaction
Maintenance Management	Defining and documenting maintenance performance and requirements are defined and documented, from plans to selecting a maintenance type, post maintenance testing and maintenance history
Procedure	Documents which provide information about how to perform interdepartmental activities and processes consistently
Process	A collection of integrated procedures
Systems Engineering	A multidisciplinary approach that is intended to transform a set of stakeholder needs into a balanced system solution that meets those needs (Moore et al., 2012)
Work Control	A series of procedures including the steps through which maintenance, from requesting to work closeout, is carried out
Acronyms	
A&FM	Assets and Facilities Management
FM	Facilities Management
AMS	Asset Management Software
CAPEX	Capital Expenditure



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Term	Definition
EPMO	Enterprise Project Management Office
KPI	Key Performance Indicators
KSA	Kingdom of Saudi Arabia
MTBF	Mean Time Between Failure
NMA&FM	National Manual of Assets and Facilities Management
O&M	Operations and Maintenance
OPEX	Operational Expenditure
PM	Planned Maintenance
SLA	Service Level Agreement
WMC	Work Management Center

Table 1: Definitions & Acronyms

4.0 REFERENCES

- Building Services Research and Information Association (BSRIA) – Business Focused Maintenance
- Chartered Institution of Building Services Engineers (CIBSE) Guide M
- National Manual of Assets and Facilities Management, Volume 5, Operations Management
- National Manual of Assets and Facilities Management, Volume 6, Chapter 2, Formality of Maintenance Performance (EOM-ZM0-PR-000001)
- National Manual of Assets and Facilities Management, Volume 6, Chapter 3, Preventative and Predictive Maintenance Program Procedure (EOM-ZM0-PR-000003)
- National Manual of Assets and Facilities Management, Volume 7, Work Control
- Management and Engineering (Maintenance Control), Duffuaa et. al, 2009, Springer, London

5.0 RESPONSIBILITIES

Role	Description
Entity	Includes government Ministry, facilities maintenance, engineering management company, or any other agency authorized by the government Ministry to work on its behalf
Development Lead	Responsible for analyzing development need, proposing and implementing the improvement plan. Operationally a central member of staff, they may be the line manager of the Work Management Center (WMC) and other technical teams

Table 2: Roles and Responsibilities



6.0 PROCESS

6.1 Maintenance Activities

The fundamental aspects of maintenance activities include planned inspections, functional checks, monitoring, testing, measuring, servicing, repairing or replacing of necessary components, equipment, infrastructure, and supporting utilities so that assets perform their required functions in addition to achieving the intended service delivery objectives throughout the expected life of the asset. Also included are the non-technical activities that directly support the technical Maintenance Activities and are normally implemented by the adoption of standards, policies, procedures and plans as part of a coordinated process.

6.1.1 Work Control

The implementation of maintenance activities involves the management of resources (e.g., labor, materials, and time) in a planned yet responsive manner. This management task is commonly administered through an Asset Management System by a team responsible for Work Control. Work control team shall provide the direction of tasks to maintenance delivery teams. Work Control relies on the provision and management of data, information, instructions, resources, and activities applied to a prepared and agreed set of procedural steps.

Further information regarding work control refer to:

- The National Manual of Assets and Facilities Management, Volume 7, Work Control.

6.1.2 System Engineering

Systems Engineering is a multidisciplinary approach that is intended to transform a set of stakeholder needs into a balanced system solution that meets those needs. This approach can be applied to the widest range of stakeholder environments, from building a computer system to constructing a railway infrastructure. The Systems Engineering model recommended in this document is summarized here:

Requirements – Architecture – Design – Implementation – Deployment – Operations and Maintenance

Systems Engineering should be applied to the creation, development and management of all Maintenance Activities processes. It can also be applied to the analysis of work practices 'on the ground', while assessing performance and compliance.

Further guidance on the application of Systems Engineering and how it can be utilized to control Maintenance Activities can be found within the references of this document.

6.2 Purpose of Maintenance Activities Control

The purpose of maintenance activities control is to combine and facilitate the relationship between operations management and maintenance management. Applying work control to improve operational reliability, achieve optimal utilization of resources and ultimately achieve best practice Asset Management.

Maintenance control is a set of activities, tools, and methods that are used to allocate and manage maintenance resources to achieve the following objectives:

- Operational Continuity
- Work Control
- Quality Control
- Cost Control
- Operational Reporting
- Process Control
- Stakeholder Satisfaction



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Entities assets are wide ranging and some considered diverse. The following factors will determine the scope, extent and required level of maintenance activities:

- Types of assets owned
- Demands placed upon the assets
- Current assets conditions
- Local geography and situation

Some Entity asset examples include infrastructure or engineered assets. For example; roads, water causeway systems, sewer systems, buildings, geographical features such as coastlines.

6.3 Maintenance Activities Control Process

The basis of best practice maintenance management sits within well-designed procedures and plans. A well-established asset register, and effective operational procedures covering technical and non-technical responsibilities. The correct resource requirements and allocation to meet the demands of the procedures and plans are critical.

Furthermore, efficient arrangement of contract requirements, resources, processes, and active compliance provides the basis for assessment and continuous improvement.

A typical FM organization business operation process and control function flowchart is shown in Figure 1.

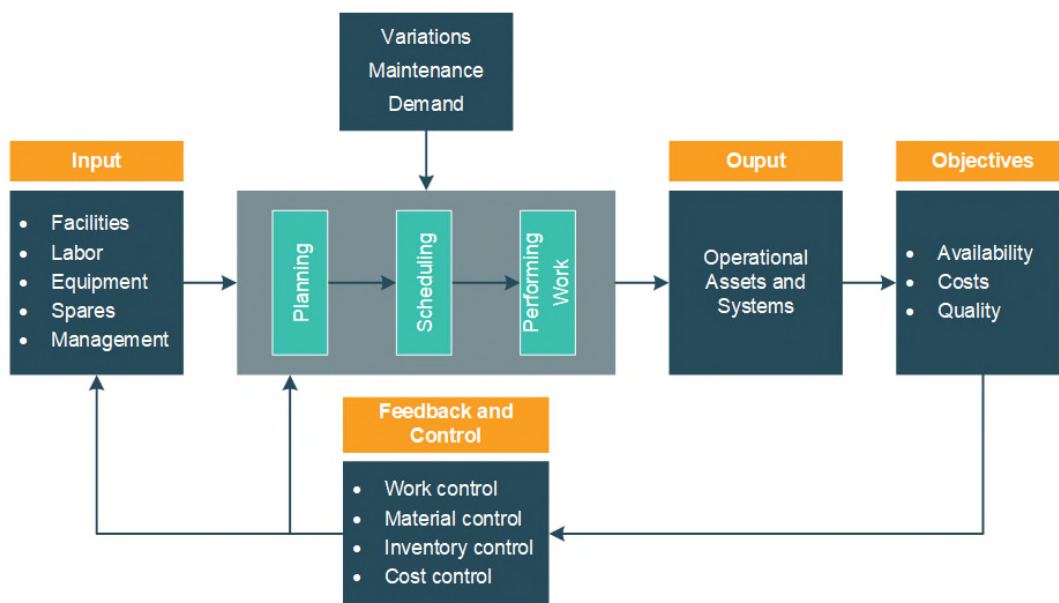


Figure 1: Maintenance System and Process Control



6.4 Control of Maintenance Activities Applied

Maintenance Control is applied by means of adopting approved procedures, including those designed to monitor for compliance. This control is normally applied through an Asset Management System and Work Orders which are processed and controlled by the Work Control Centre.

6.4.1 Asset Management Systems

Asset Management Systems, a computerized maintenance management system, is a suite of software programs Management System that are used for planning, scheduling, and tracking maintenance work orders, as well as for managing assets. For this reason, the Asset Management System is a key tool in controlling the maintenance activities, however, the success is also dependent on the entry of reliable data.

The functionality of an Asset Management System varies, although a typical application provides the following features:

- Scheduling of maintenance tasks (preventative, corrective)
- Tracking of work orders
- Stores information about assets and maintenance resources
- Collates and tracks spare parts
- Reporting

Asset Management Systems can track every step of the asset management and maintenance process and gives instant access to the stored data – allowing maintenance technicians to undertake the task, identify spare parts required, conduct maintenance, and estimate duration.

As the data management tool, the Asset Management System is also responsible for computing any reports or statements on the status of individual or groups of work orders. Groups of work orders often form the basis of Key Performance Indicator (KPI) reports. Other informational outputs from the Asset Management System are able to inform the decision maker on subjects such as the effectiveness of maintenance or the efficiencies of the various parts of the operation. For example, the Asset Management System will be able to provide the data related to any unplanned maintenance of an asset, which may be used when deciding whether the planned maintenance is adequate. This example relies on compliance with the advice provided within the NMA&FM Maintenance History and Work Closeout Procedures. These Procedures highlight and define the collection of data that will inform the recording of system performance, and in the situation of operational failure, the data required to compute Mean Time Between failure (MTBF) and related metrics.

From drafting and reviewing documents, including the creation and integration of flowcharts, the principles of Systems Engineering should be adopted to ensure the desired outcome is achieved.

6.4.2 Work Order

An essential part of the maintenance control is the work order system that is used for planning, scheduling, performing work and work closeout.

Figure 3 below is an example of the typical software output page provided by an Asset Management System, configuration and instructions provided by the system is usually designed to meet each individual customer's needs. This example is for recalibration of an optical laser used to measure the thickness of steel. It includes the location of the asset, engineers name, time allocation, the tasks needed to complete the maintenance as well as other information related to the task deemed beneficial to the work control team and engineer.



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Figure 3: Asset Management Software Maintenance Order Window

6.4.3 Work Control Centre

A secondary layer within controlling maintenance activities and work control is estimating work, troubleshooting, plans and procedures development, post maintenance testing, and maintenance history. The Work Control Center has the responsibilities for the creation, management, and administration of maintenance operations through this work order system.

For more information and tools on the work control process refer to:

- National Manual of Assets and Facilities Management, Volume 7, Work Control.

Other essential parts of the maintenance control is the adoption of Operational Management and Maintenance Management requirements and advice.

For more information and advice on the requirements and delivery of maintenance activities refer to:

- National Manual of Assets and Facilities Management, Volume 5 – Operations Management
- National Manual of Assets and Facilities Management, Volume 6 – Maintenance Management

6.5 Systems Engineering Model Applied to Maintenance Activities

System Engineer Models are dependent on the data which is provided, the greater the detail the more effective the asset management system can become in managing the maintenance activities. The two list provided below present the methods in which Systems Engineering can be applied, to the two aspects of a maintenance organization, namely the creation of a procedure and the design of a data provision system.

6.5.1 Information Management Maintenance History

- **Requirements:** Understanding the purpose of the document in the context of others
- **Architecture:** Identifying stakeholders and their roles and responsibilities
- **Design:** Agreeing with stakeholders on a high level draft
- **Implementation:** Document is drafted and checked by stakeholders at various stages
- **Deployment:** Document is signed off and awareness training carried out



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- **Operations and Maintenance:** Enablement phase in which the document is delivered and supported by a team of Subject Matter Experts (SME), including the requirement to review effectiveness

6.5.2 Resource Tracking Function from within an Asset Management System

- **Requirements:** Understand the need for and format of data
- **Architecture:** Establish how and when the data will be gathered
- **Design:** Present requirements to an Asset Management System specialist
- **Implementation:** Test the Asset Management system data management solution, including integration
- **Deployment:** Upload tracking tool function into the active Asset Management System
- **Operations and Maintenance:** Support, monitor, and review effectiveness

A Development Lead would normally be identified and assigned to lead any 'project' that required the application of a Systems Engineering model to an aspect of an asset management and/or maintenance organization.

6.6 Maintenance Activities Control Tools

6.6.1 Asset Management System Data Input/Output

An Asset Management System is the key tool that complements and assists the technical workforce in the delivery of the O&M objectives. As such, it is vital that the system is provided with the right information of the right quality in the right format. Failure to understand and respect this requirement results in the delivery team being hampered from achieving success.

Both Asset Management System and maintenance management and work control processes can be viewed as having input/output relationships. The key information inputs to an Asset Management System include:

- Human, Material, and Time Resources
- Asset and System Data and Requirements
- Policies and Rules
- Plans and Procedures

The desired output is the correct combination, computation, and allocation of the inputs such that the assets and systems are managed by well configured O&M activities with the objective of meeting the ultimate business goals.

The functionality of Asset Management Systems varies, however, the typical features include, but not limited to the following:

- Requirements Management
- Resource Planning and Scheduling
- Resource Tracking
- Information Management
- Resource Statuses
- Reporting Capabilities
- Communications/Data Sharing

An Asset Management System should allow tracking of each step of the Work Control procedures and give access to the required data, thereby allowing maintenance operation to undertake the tasks with identified resources, within the predicted timeframe and a conduct of maintenance compliant framework.

The control is required in reference to the objectives of the Entity and the maintenance contract, and will likely include equipment availability, optimized costs, compliance, transparency, accuracy and availability of data, and quality.



6.7 Maintenance Activities Failures

Maintenance Activities are prone to failure. The failures can be identified and recorded in multiple ways such as, but not limited to:

- Failure to meet pre-set KPIs e.g., timely closure of unplanned and planned work orders against criteria, usually defined in a Service Level Agreement (SLA)
- Maintenance organization operating out with its set financial budget

Failings in both of these aspects of maintenance operation may be persistent or intermittent. Audits and Analysis can find that the reasons for failure changes. There are many examples such as; one month the cause may be shortage of labor; the next month may be several key assets expiring their service life.

When the evidence points towards procedural failings, it is recommended that the plans and procedures are analyzed. It may be that the requirements were not exactly correct, or the design was not implemented correctly. The skills of Root Cause Analysis should be applied to identify the source of the failings, bearing in mind that a small flaw may have consequential impacts that are not readily visible.

6.8 Planned and Unplanned Maintenance Activities

Expense on maintenance is called Operational Expenditure (OPEX). Inadequate planned maintenance typically leads to underperforming assets that cause increased business risks, potential engineering systems service disruptions, and premature asset failure. The net result is a higher lifecycle cost of delivering the expected level of service or a decreased level of service.

Several studies of facilities management maintenance in KSA have concluded that a sizeable majority of the Maintenance Activities is unplanned rather than planned or predictive, and that a high percentage of maintenance time is spent on repairing assets about to fail, or that have failed. Premature asset failure as a result of unplanned maintenance is illustrated in Figure 2 below.

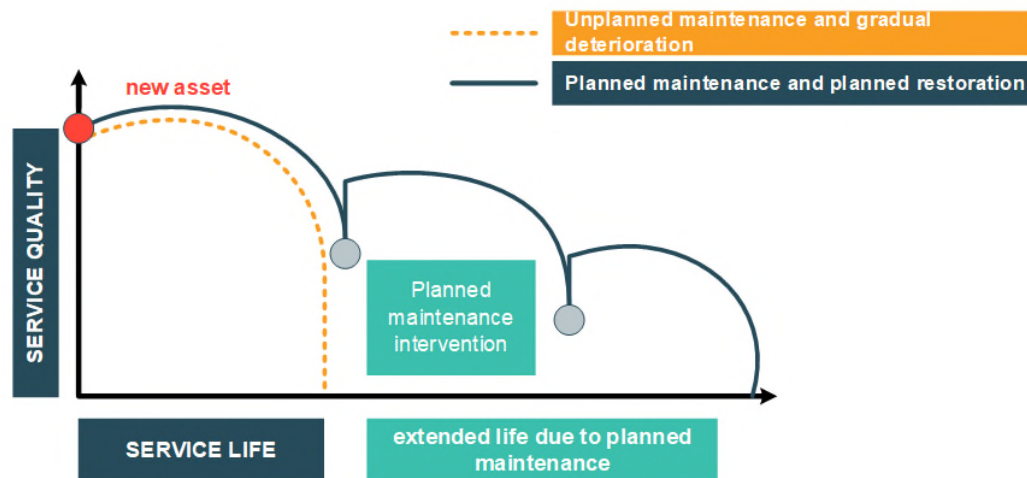


Figure 2: Unplanned/Planned Maintenance Comparison

An effective approach to defer capital replacement, and reinvestment expenditures, is to improve maintenance. Moving from an unplanned to intelligent maintenance concept by utilizing the assets behavior history, please refer the NMA&FM, Volume 6, Chapter 3, Types of Maintenance for more details. This mode can extend the service life of the asset, improve service reliability and performance, and reduce costs. Achieving contract success is made more difficult when implementing change control but as is illustrated by Figure 2, the benefits are comprehensive.



6.9 Financial Management

Many organizations financial budgets combine O&M costs into a one line within their accounts. Making decisions about optimizing maintenance and the timing of asset renewal, replacement or decommissioning requires an increased level of tracking and analysis of the maintenance information and costs, separately from other operations information.

Tools and systems for tracking costs separately are typically only used by larger organizations, however, scalable tools and techniques are available and suitable for use in smaller organizations.

Failure to control Maintenance Activities can result in OPEX targets being missed. Whether zero-based or traditional/incremental, budget predictions will be based on certain assumptions, some of which will be voided if control and practices are different from the assumed. Hence, there is a significant need to have a good degree of certainty on how maintenance will be controlled, and the effectiveness of it.

6.10 Engagement

6.10.1 Stakeholder Engagement

Increased collaboration among internal organizational departments can also improve outcomes. For the Facilities Management operation, this means close connections between construction/manufacture, operations, user groups, Capital Expenditure (CAPEX) projects, and the finance stakeholders.

The importance of O&M team's involvement throughout the design and procurement process, from early stages through to commissioning and handover, is captured by the increasing adoption of the Infrastructure Projects to Asset and Facility Management (A&FM) Integration Strategy and Building Information Modelling concepts and requirements. This philosophy is central to the achievement of service delivery objectives, and the lowest lifecycle cost.

When applying Systems Engineering to this engagement. Refer to:

- National Manual of Assets and Facilities Management, Volume 16, Chapter 1, Operations and Maintenance – Project Interface.

6.10.2 Maintenance Audits

Maintenance audits determine the following:

- Maintenance of the asset is being performed in accordance with the maintenance contract, maintenance plans and procedures
- Asset or maintenance is statutory compliant, and has best practice applied

For guidance on how to assess the strength of their maintenance operations environment the Entity should refer to:

- National Manual of Assets and Facilities Management, National Manual of Assets and Facilities Management, Volume 6, Chapter 2, Conduct of Maintenance, Formality of Maintenance Performance Procedure - EOM-ZM0-PR-000001.

Maintenance audits also focus on the effectiveness of key procedures through analysis of the Asset Management System. For example, the NMA&FM Work Closeout Procedure, when properly recorded, is able to provide data on the ability of staff to perform work 'right first time'. The ability to extract the required information relies on the application of a Systems Engineering approach to the design and execution of a maintenance history Procedure.



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The steps within these final stages of performing work are discussed further the Entity should refer to:

- National Manual of Assets and Facilities Management, National Manual of Assets and Facilities Management, Volume 6, Work History Procedure.
- National Manual of Assets and Facilities Management, National Manual of Assets and Facilities Management, Volume 7, Work Closeout Procedure.