National Immovable Asset Maintenance Management Planning Guidelines

for immovable assets

NATIONAL
IMMOVABLE
ASSET MAINTENANCE
MANAGEMENT
PLANNING
GUIDELINES

public works
Department:
Public Works
REPUBLIC OF SOUTH AFRICA

cidb
Construction Industry Development Board

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1. INTRODUCTION

Alongside accelerated delivery of new infrastructure, the South African government has identified the maintenance of infrastructure as a priority. The portfolio of public buildings that is used by the organs of state to deliver services is a key focus and improved maintenance will enable government to derive maximum value from these buildings over their lifetime.

This document provides guidance to the maintenance management personnel of public buildings on how to prepare Maintenance Management Plans. Notwithstanding this, the principles documented in this guideline are able to be applied to all forms of public sector immovable assets.

The effective planning, scheduling and budgeting of maintenance not only reduce maintenance costs, but also improve utilisation of the maintenance workforce by reducing delays and interruptions and ultimately improve the quality of maintenance work by adopting the best methods and procedures and assigning the best qualified workers for the job.

1.1 NATIONAL INFRASTRUCTURE MAINTENANCE STRATEGY

Government gave effect to its commitment to maintenance by the Cabinet's approval of the National Infrastructure Maintenance Strategy (NIMS) in 2006. The NIMS promotes sound maintenance of infrastructure and facilities across the whole of the public sector. Key documents that have been developed as part of the implementation of NIMS include the 'Maintenance Management Standard', the 'Maintenance Accounting Framework', the 'Maintenance Competency Profiles' and this 'Maintenance Planning Guideline for Immovable Assets'.

1.2 NATIONAL IMMOVABLE ASSET MAINTENANCE MANAGEMENT STANDARD

The National Immovable Asset Maintenance Management (NIAMM) Planning Guidelines for Immovable Assets derives its mandate from 'The National Immovable Asset Maintenance Management Standard'.

'The National Immovable Asset Maintenance Management Standard' specifies asset care requirements for immovable assets through the asset lifecycle and establishes standards for organisational arrangements, competences and requirements for professionals involved with asset lifecycle activities. Section 4.1 "Establishment of asset care objectives, strategies and plans", specifically 4.1.3 (g), says "a maintenance plan shall be developed and included in the lifecycle plan section of the asset management plan(s), indicating:

i. the maintenance type and approach (e.g. preventative or corrective, interval-based etc.) within the larger lifecycle strategy to be adopted for each asset type and asset portfolio, and for critical assets specifically;
ii. the appropriate level of reliability chosen given performance expectations and the costs involved to achieve and/or maintain that level of reliability;
iii. the maintenance actions (e.g. monitoring, testing, serving, repairs) to be adopted per asset type, asset group and for business-critical assets; and
iv. appropriate resourcing methods.

The requirements are further elaborated on in section 4.2 "Assets and asset management system performance and health monitoring", which calls for performance measures to be developed and for reporting arrangements to be documented.

Section 4.3 "Requirements for asset design and subsequent asset care activities" stipulates that assets be designed and planned to be maintainable.

PART A: PURPOSE, SCOPE AND DEFINITIONS

2. PURPOSE OF THE GUIDELINE

The purpose of this document is to guide the maintenance management personnel of immovable assets through the preparation of Maintenance Management Plans.

3. SCOPE OF THE GUIDELINE

3.1 MAINTENANCE AND RENEWAL OF IMMOVABLE ASSETS

This guideline is concerned with the maintenance and renewal of immovable assets. Maintenance ensures that an asset is able to perform a required function to a specific performance standard over its expected useful life, by keeping it in as near as practicable to its original condition. Maintenance is an operating expenditure (OPEX) activity.

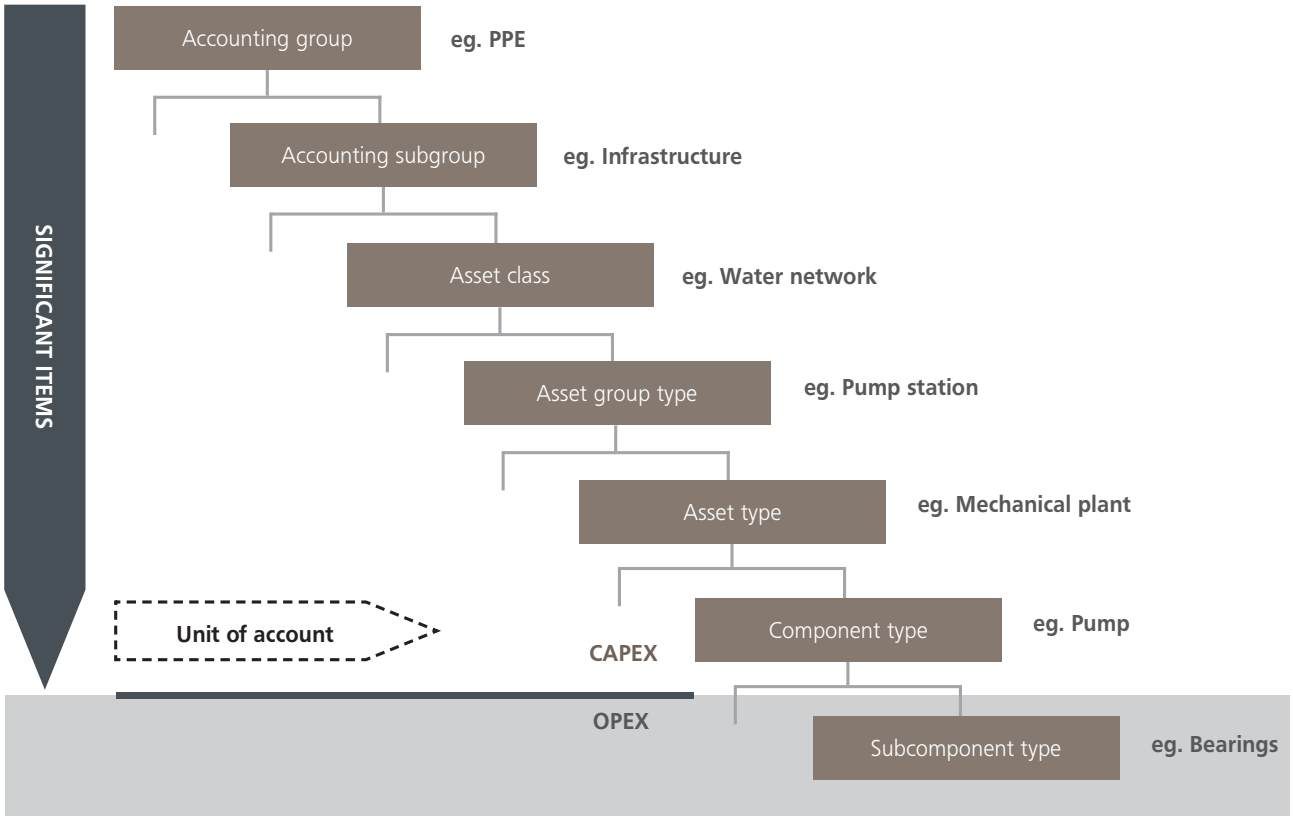
Over time, however, assets will be subjected to wear and tear, and eventually maintenance will not be enough to ensure the continued functioning of assets in the required condition, and to the performance standards specified. At this point, provided that there is continued demand for the asset, renewal becomes necessary. Renewal is an asset lifecycle activity on an existing asset that returns the service potential of the asset or expected useful life of the asset to that which it had originally. Renewal can include works to replace existing assets or facilities with assets or facilities of equivalent capacity or performance capability. Renewal is a capital expenditure activity.

3.2 IMMOVABLE ASSETS

Immovable assets in the public sector include facilities such as hospitals, schools, libraries, landfill sites, airports, harbours and prisons, as well as infrastructure networks or systems such as water supply systems, electricity distribution systems and road networks. Facilities and systems such as these tend to be complex assets, comprised of multiple components, each of which has independent physical or functional identity and specific attributes such as different life expectancy, maintenance and renewal requirements and regimes, risk or criticality.

Each component assumes asset status, meaning that the component is recognised and included in the entity's asset register as an unique asset. Maintenance planning is done at the level of asset component, and needs and plans are then aggregated to the asset type level, and further up to the service or asset portfolio being planned for. The structure determining how asset components are configured into larger facilities, networks and systems that together comprise an asset portfolio, is referred to as an asset hierarchy, shown in Figure 1.

FIGURE 1: ASSET HIERARCHY



This figure, using the example of a potable water pump station, demonstrates the following:

- A component, such as a pump or motor, is considered an asset and is capitalised in the entity's asset register. Whenever a component is renewed or replaced, that expenditure is considered capital expenditure.
- Components may be comprised of sub-components, in this instance bearings. Sub-components are considered consumables and small parts that are not capitalised. Instead, expenditure on sub-components are expensed.
- Components can be grouped into asset type, such as civil, electrical or mechanical assets. This is a particularly useful way of classification when maintenance activities are undertaken by type of discipline.
- The asset group type refers to the type of "facility". Most "facilities", such as pump stations, administration buildings, water treatment works, electrical sub-stations, hospitals, clinics, parks, dams, airports, harbours and prisons are comprised of several asset types, featuring civil, electrical and mechanical components.
- Asset class refers to a distinct asset portfolio, such as primary healthcare facilities, educational facilities, a potable water supply system, roads network or an electricity distribution system. It is at this level that the entity should prepare a portfolio asset management plan, when the entity has more than one asset portfolio.
- The accounting sub-group refers to the main groupings of assets included in the scope of the relevant accounting standard. GRAP 17: Property, Plant and Equipment for example refers to infrastructure and community facilities. In the example of Figure 1, water assets would be grouped under infrastructure, as would roads, electricity, solid waste, and information and communication infrastructure.
- The accounting group refers to the main accounting classification for assets. This could be property, plant and equipment (GRAP 17), investment property (GRAP 16) or heritage assets (GRAP 103).

3.3 RELATIONSHIP BETWEEN MAINTENANCE MANAGEMENT AND ASSET MANAGEMENT

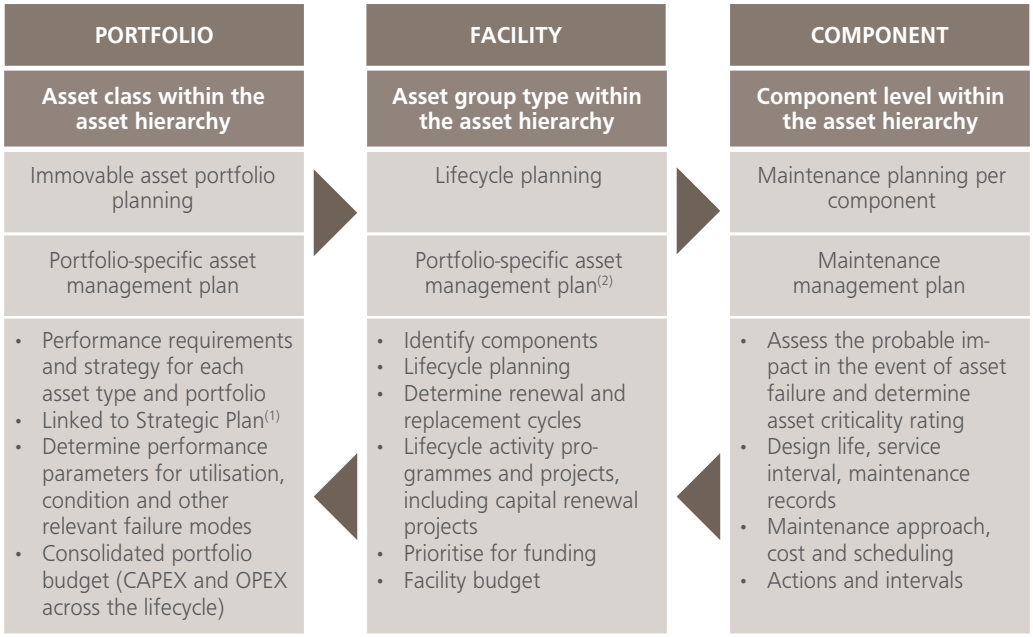
Maintenance and renewal are asset care activities within the asset lifecycle, amongst other activities such as asset planning, creation, operation, upgrading and disposal. Figure 2 depicts the full scope of asset lifecycle activities. Asset management is the practice concerned with whole-of-lifecycle management of assets to meet stated asset management objectives.

FIGURE 2: ASSET LIFECYCLE ACTIVITIES

Asset management interprets the operating environment and strategic objectives of the entity, and establish asset management objectives to ensure that value is derived from assets, and that this "value" contributes to the strategic objectives of the entity.

Maintenance objectives and priorities originate from an entity's asset management strategy and plan(s). In the event that the entity has only one asset portfolio (e.g. bulk water infrastructure), then the asset management strategy and plan will typically be contained in the entity's strategic asset management plan. When an entity has several asset portfolios (e.g. hospitals and, separately, clinics and administrative facilities), then the entity should prepare a strategic asset management plan that establishes asset management objectives, articulates the entity's asset management strategy, and prioritises available funding between asset portfolios. Individual asset portfolios are then planned for in portfolio-specific asset management plans that establish acceptable minimum performance requirements with respect to asset condition, performance, capacity and cost-of-operations, and that sets out the lifecycle strategy for assets in that portfolio. All relevant assets required to support service delivery for an entity should be considered when formulating these lifecycle plans.

FIGURE 3: PORTFOLIO, FACILITY AND COMPONENT PLANNING



Notes:

(1) In the event that the entity only has one immovable asset portfolio, it may prepare a strategic asset management plan that includes both its asset management strategy and lifecycle management plan for its immovable asset portfolio. The asset management strategy should clearly articulate asset management objectives that respond to, or are consistent with, the entity's strategic objectives, as well as a strategy for achieving stated asset management objectives. In the event that the entity has more than one immovable asset portfolio, it should prepare a strategic asset management plan, and portfolio-specific asset management plans for each immovable asset portfolio.

(2) A portfolio-specific asset management plan should always include a lifecycle strategy and lifecycle management plan for all immovable assets within the immovable asset portfolio. However, there are instances where a limited lifecycle plan may be prepared for a specific facility, such as when:

a. It is a highly unique facility employing new technology that operators and maintenance personnel do not have experience with, such as a new generation plant (for example a new generation nuclear power station);

b. A facility is considered highly critical and asset downtime or other forms of failure cannot be tolerated, or must be limited to within strict parameters; or

c. A new facility is designed, incorporating some new component types and/or process configurations, and the designer is required to develop a lifecycle management plan or components thereof.

4. PURPOSE OF A MAINTENANCE MANAGEMENT PLAN

The purpose of a maintenance management plan is to establish maintenance management objectives, as well as appropriate maintenance approaches, plans and schedules to ensure the optimum availability of assets and that they function within stated performance parameters.

A maintenance management plan should at least comprise the following:

i. The scope of assets included in the plan.

ii. Maintenance requirements and objectives and how they relate to asset management objectives.

iii. Asset criticality profile.

iv. Asset failure mode status (see Section 8.3.1 for failure modes).

v. Asset risk exposure by type of failure mode at appropriate levels within the asset hierarchy.

vi. The approach(es) to maintenance by asset type and/or component type as appropriate.

vii. For each component type, the actions and resources required to:

a. restore each component to working order based on the assessed condition of the component (condition-based maintenance);

b. repair components that have failed (corrective maintenance);
c. prevent failure based on monitoring the condition of components (preventative maintenance);
d. undertake scheduled maintenance, including the frequencies of thereof (preventative maintenance); and
e. prevent deterioration of the component based on the reliability of the component (preventative maintenance).

viii. Costing of resource requirements.
ix. A schedule of maintenance actions, prioritised based on risk exposure (maintenance priority).
x. A budget for maintenance actions prioritised based on risk exposure (maintenance priority).
xi. Maintenance management roles and responsibilities.

5. PLAN PREPARATION

A Maintenance Management Plan should be developed for both new and existing facilities. Ideally, a maintenance management plan should be developed for each facility. However, this guidelines focusses on the development, review and updating of a portfolio-level maintenance management plan that supports the asset management plan for a portfolio of assets.

5.1 NEW FACILITIES

The first version of the Maintenance Management Plan should be completed before the final project handover of a facility. The groundwork for the Maintenance Management Plan should be prepared during the design phase to ensure that maintenance input is considered during the design of the facility and to ensure that the specified equipment has local backup such as spares and qualified personnel.

5.2 EXISTING FACILITIES

Where no Maintenance Management Plan exists, the assets in the existing facility should be verified, the components identified and a condition assessment completed.

A Maintenance Management Plan can then be developed, taking cognisance of the condition of the components. This could include capital projects that improve the condition of the facility up to the minimum requirements.

If a Maintenance Management Plan exists, it should be evaluated based on the requirements of this guideline and amended if and where necessary.

6. DEFINITIONS AND ACRONYMS

6.1 DEFINITIONS

The following terms are relevant to this guideline:

COMPONENT

A component (Note 1) is a specific part of a complex item (Note 2) that has independent physical or functional identity and specific attributes such as different life expectancy, maintenance and renewal requirements and regimes, risk or criticality.

Note 1: A component is separately recognised and measured (valued) in the organisation's asset register as a unique asset record, in accordance with the requirements of GRAP 17 to componentise assets.

Note 2: A complex item is one that can be disaggregated into significant components. Infrastructure and buildings are considered complex items.

CONDITION

The physical state of the asset.

CONDITION ASSESSMENT OR CONDITION MONITORING

The inspection, assessment, measurement and interpretation of the resultant data, to indicate the condition of a specific component so as to determine the need for some preventative or remedial action.

CORRECTIVE MAINTENANCE

Maintenance carried out after a failure has occurred and intended to restore an item to a state in which it can perform its required function. Corrective maintenance can be planned or unplanned.

DEFERRED MAINTENANCE

The portion of planned maintenance work necessary to maintain the service potential of an asset that has not been undertaken in the period in which such work was scheduled to be undertaken.

EXISTING FACILITY

A facility that is already in operation and is subject to maintenance.

FACILITY

A complex comprising many assets (e.g. a hospital, water treatment plant or recreation complex) which represents a single management unit for financial, operational, maintenance or other purposes.

FAILURE

A component has suffered a failure when it is no longer capable of fulfilling one or more of its intended functions. A component does not need to be completely unable to function to have suffered a failure. For example: a pump that is still operating, but is not capable of pumping the required flow rate, has failed.

LEVEL OF SERVICE

Levels of service statements describe the outputs an entity intends to deliver to customers.

LIFE (OF AN ASSET)

A measure of the anticipated life of an asset or component, such as time, number of cycles, distance intervals, etc.

LIFECYCLE

The time interval that commences with the identification of the need for an asset and terminates with the decommissioning of the asset or any liabilities thereafter.

MAINTENANCE

All actions intended to ensure that an asset performs a required function to a specific performance standard(s) over its expected useful life by keeping it in as near as practicable to its original condition, including regular recurring activities to keep the asset operating, but specifically excluding renewal.

Note: Maintenance also specifically excludes restoring the condition or performance of an asset following a recognised impairment event, which would be classified as either renewal or upgrading, depending on the circumstances.

MAINTENANCE EXPENDITURE

Recurrent expenditure as required to ensure that the asset achieves its intended useful life. Maintenance is funded through the entity's operating budget, and such expenditure is expensed in the entity's Statement of Financial Performance.

MAINTENANCE MANAGEMENT PLAN

Describes the maintenance approach and actions for an asset, facility or portfolio of assets, with intended delivery methods and schedules, budget requirements and responsible parties.

MAINTENANCE OBJECTIVES

Objectives for what maintenance has to achieve to ensure the assets are in the right condition to meet the needs of the entity. Maintenance performance measures and targets are the means of assessing whether the maintenance objectives are being met.

MAINTENANCE STRATEGY

Interprets higher-order documents and formulates maintenance objectives and targets, establishes maintenance tactics, and defines maintenance roles and responsibilities.

MONITORING

Determining the status of a system, process, asset or an activity.

OBJECTIVE

Result to be achieved at strategic, tactical or operational level. Objectives can be set in a variety of domains or outcome areas (e.g. economic, social or environmental outcomes), or can relate to elements of the entity (e.g. corporate level or units in the entity), or can relate to processes, services, products, programmes and projects.

NEW FACILITY

A newly built, renovated or refurbished facility that is handed over for operation and maintenance.

PREVENTATIVE ACTION

Action to eliminate the cause of a potential nonconformity or other undesirable potential situation.

PREVENTATIVE MAINTENANCE

Maintenance carried out at pre-determined intervals, or corresponding to prescribed criteria, and intended to reduce the probability of failure or the performance degradation of an item. Preventative maintenance is planned or carried out on opportunity.

PREDICTIVE ACTIONS

Those maintenance actions that must take place because the likelihood of failure was predicted by condition monitoring activities.

PUBLIC BUILDING

A public building either belongs to or is used by any of the three spheres of government. Public buildings are used by organs of state to deliver services. Buildings are defined as any structure with a roof and commonly enclosed by walls, designed for storage, human occupancy, or shelter for animals, distinguished from other structures not designed for occupancy (such as fences or bridges). Fixed equipment, that is permanently attached to and a part of the operation of the building.

RELIABILITY-CENTRED MAINTENANCE

A process for optimising maintenance based on the reliability characteristics of the asset.

RENEWAL

Expenditure on an existing asset which returns the service potential of the asset or expected useful life of the asset to that which it had originally.

Note 1: Renewal can include works to replace existing assets or facilities with assets or facilities of equivalent capacity or performance capability.

Note 2: Expenditure on renewals is funded through the entity's capital budget, and such expenditure is recognised in the entity's Statement of Financial Position.

RISK

The effect of uncertainty on objectives. Risk events are events which may compromise the delivery of the entity's strategic objectives.

RISK EXPOSURE

The level of risk to which an entity is exposed to. Risk exposure is a function of the probability of an occurrence times the impact of that occurrence.

RISK MANAGEMENT

The application of a formal process that identifies the exposure of an entity to service performance risk and determines appropriate responses.

USEFUL LIFE

The useful life of an asset is the period over which an asset is expected to be available for use by an entity or the number of production or similar units expected to be obtained from the asset by an entity.

Acronyms relevant to this guideline include:

ACRONYMS

ACRONYM	DESCRIPTION
AM	Asset Management
APP	Annual Performance Plan
CIDB	Construction Industry Development Board
CoC	Certificate of Compliance
CoF	Consequence of Failure
CRC	Current Replacement Cost
DRC	Depreciated Replacement Cost
ENE	Estimates of National Expenditure
EUL	Estimated Useful Life
GRAP	Generally Recognised Accounting Practice
HR	Human Resources
IDMS	Infrastructure Delivery Management System
IPMP	Infrastructure Programme Management Plan
IPIP	Infrastructure Programme Implementation Plan
IT	Information Technology
HV	High Voltage
MDT	Mean Down Time
MKPA	Maintenance Key Performance Area
MMP	Maintenance Management Plan
MMS	Maintenance Management System
MRO	Maintenance, Repair and Operating Materials
MTBF	Mean Time Between Failures
MTBM	Mean Time Between Maintenance
MTEC	Medium Term Expenditure Committee

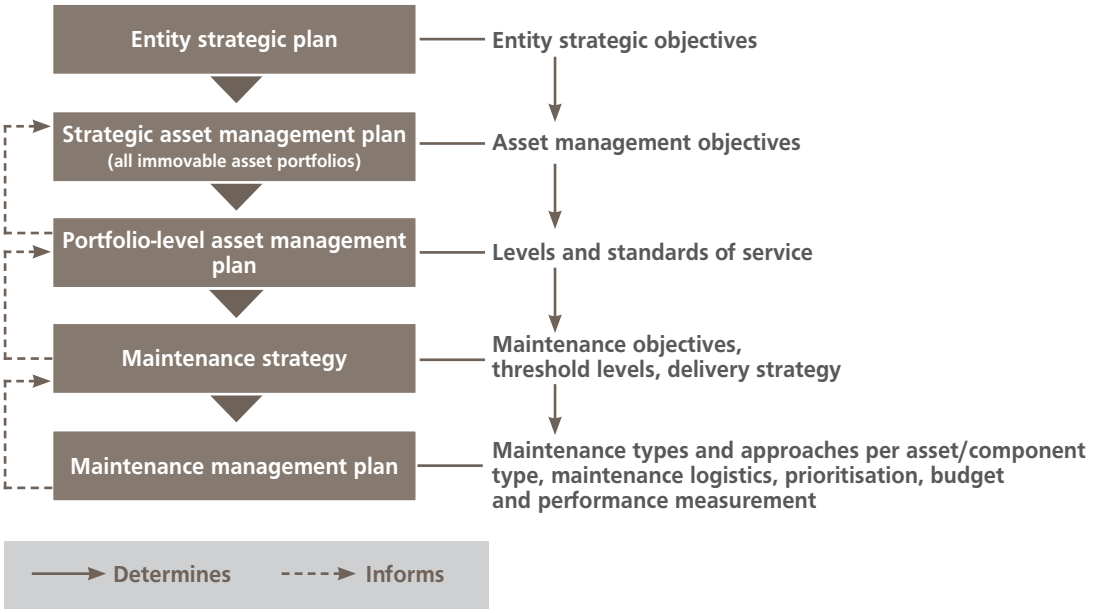
ACRONYM	DESCRIPTION
MTEF	Medium Term Expenditure Framework
MTTF	Mean Time To Failure
MTTR	Mean Time To Repair
MV	Medium Voltage
NIMS	National Infrastructure Maintenance Strategy
PFMA	Public Finance Management Act, 1999 (Act no 1 of 1999)
PM	Preventative Maintenance
PoF	Probability of Failure
PPP	Public Private Partnerships
RCM	Reliability-Centred Maintenance
RUL	Remaining Useful Life
RV	Residual Value
SANS	South African National Standard

PART B: MAINTENANCE PLANNING

7. THE MAINTENANCE PLANNING FRAMEWORK

As noted in Section 3.3, the asset management function interprets its entity's strategic objectives that tend to be outcomes-based into asset management objectives. Levels and standards of service are asset management objectives that define service output requirements in support of the entity's objectives. Levels and standards of service are defined in portfolio-specific asset management plans. The maintenance management function in turn interprets these levels and standards of service requirements and establish maintenance objectives, strategies and plans to ensure that assets deliver as expected.

FIGURE 4: CONTEXT FOR MAINTENANCE PLANNING



Levels of service tend to describe the type of infrastructure, accommodation or amenities that customers can expect, whereas standards of service generally relate to the quality of the customer experience. "Levels" imply that there are options structured in a hierarchy. Table 1 demonstrates some simplified examples of levels of service for selected asset portfolios. It demonstrates that for each service or asset portfolio there are multiple offerings, but customers can expect better or more sophisticated services at higher levels of service.

TABLE 1: SIMPLIFIED EXAMPLES OF LEVELS OF SERVICE FOR VARIOUS ASSET PORTFOLIOS

LEVEL OF SERVICE	BUILDING ACCOMMODATION	POTABLE WATER SUPPLY	ROADS
0	None	None	None
1	Temporary structure, limited service infrastructure, no air conditioning, open parking	Water point more than 200m distance	Tracks (in-situ material, compaction/grading to make passable)
2	Temporary structure or permanent structure, basic service infrastructure, dial-up connectivity, open parking, fenced facility	Communal standpipe less than 200m distance	Improved tracks (non-engineered, with gravel)
3	Permanent structure, full electricity, water and sanitation services' access, air conditioning, network connectivity, covered parking fenced with access control	Yard tap connection (single tap)	Engineered, with gravel
4	Permanent structure with full services and reasonable quality finishes, HVAC system, network connectivity, basement parking and security access control	15 – 25 mm ø connection to building (multiple taps)	Paved
5	Permanent structure with full services and high quality finishes, HVAC system, fibre optics connectivity, basement parking, security includes access control and CCTV	40 mm ø > customer connection	Paved heavy capacity

There are however other aspects to services that are also important to customers, such as service reliability, quality and safety, affordability or value for money, and responsiveness. These customer requirements are referred to "Standards of service" once they are formalised.

Assume, for example, that customers require a safe on-road experience. This will require attention to aspects such as:

- Number of traffic-related incidents related to road-surface condition (e.g. potholes)
- % Compliance with skid resistance standards
- Minimum illumination level (x) lux
- % of road signs in reasonable condition and clearly readable

Some standards of service incorporate more than one type of service requirement. Several of the above road safety measures also affect the customer experience relating to a convenient, smooth travel experience. A well-maintained road surface is not only safer, but also provides a more comfortable, smoother travelling experience. Standards of service should be specific, measurable, achievable, relevant and time-bound.

The performance measures supporting standards of service therefore define intervention levels that trigger maintenance responses. Some examples of standard of service performance measures and maintenance intervention levels for office accommodation are provided in Table 2.

TABLE 2: ILLUSTRATIVE STANDARDS OF SERVICE AND MAINTENANCE INTERVENTION LEVELS FOR OFFICE ACCOMMODATION

TYPICAL DIMENSIONS OF STANDARDS OF SERVICE	E.G.	ACCEPTABLE RANGE OR INTERVENTION LEVEL	MINIMUM ACCEPTABLE PERFORMANCE/ INTERVENTION LEVEL	DOMINANT ASSET FAILURE MODE
Overall quality	Grade B office standard	Condition range between "Very good" and 'Good"	Minimum acceptable condition for fittings a grade "Good"	Condition
Availability/ reliability/ responsiveness	Building required for operations 8am-5pm, 5 days a week	Response times for mechanical, electrical and plumbing failures	Within 2 hours of incident being reported	Performance
Comfort	Temperature	18 – 23°C	<= than 17°C and >= than 24°C	Performance
	Lighting	Lux level of 250	Less than 250	Performance
Health and safety	Fire protection	All fire protection systems inspected every three months	Every three months	Condition / performance (depending on nature of fire safety system)
	Structural integrity	Minimum accepted condition grade of "Fair" for all building structural elements	"Poor" condition or worse ("Very poor")	Condition
Affordability or value for money	Cost efficiency	Maintenance costs not to exceed R x/ m2	Maintenance costs exceeding R x/ m2	Cost-of-operations

The above table also demonstrates that there tends to be specific dominant failure modes such as condition that can cause standards of service obligations not to be met. Standards of service performance measures, and the failure modes linked to these, therefore tend to determine the type of maintenance necessary, and the maintenance approach to be followed. Reliability or safety related performance requirements are often linked with condition, requiring that a preventative maintenance approach is followed that may include asset inspection, testing and condition monitoring as appropriate to the type of asset.

8. MAINTENANCE STRATEGY

8.1 PURPOSE AND CONTENT OF THE MAINTENANCE STRATEGY

A maintenance strategy establishes maintenance objectives, as well as management and delivery arrangements for the maintenance function. Aspects to be included in the maintenance strategy includes:

- Maintenance objectives to be achieved (see Section 8.2), inclusive of monitoring and reporting arrangements.
- Maintenance delivery strategy – will maintenance be performed in-house, will selected elements of maintenance be contracted to service providers (e.g. mechanical maintenance, or all maintenance in a particular geographic region where there is limited or no in-house maintenance capability), or will all maintenance be outsourced? There are multiple options available for delivering on maintenance. The maintenance delivery strategy should take account of the scope and extent of assets and maintenance requirements inclusive of skills, tools and equipment, vehicles and workshops, and inventory requirements, systems and maintenance information. It should reflect on the capacity of

the entity to fulfil these requirements, include a market analysis to determine the extent to which functions can be fulfilled externally, any specific strategic objectives that the maintenance function must contribute to, and present the maintenance delivery strategy to be followed.

- Maintenance function organisational arrangements, inclusive of organisational structure, roles and responsibilities.
- Maintenance skills development plan.
- Maintenance information requirements and information management.
- Health and safety relating to the use and maintenance of assets.
- Key procedures, such as responding to incidents and the investigation thereof.
- Criteria for prioritising maintenance.

8.2 MAINTENANCE OBJECTIVES

Maintenance objectives are the goals to be achieved by the maintenance function to ensure that assets are in suitable condition to meet the requirements of the entity, in a manner acceptable to regulators and other stakeholders. Maintenance objectives are expressed as maintenance performance measures. When developing maintenance performance measures, entities should consider the "Monitoring and Evaluation Protocol for Immovable Assets", issued by the Department of Public Works and the CIDB.

From the point of view of a maintenance professional, maintenance performance measures can be broadly categorised into the following five areas: business management, service delivery reliability, maintenance organisation and leadership, maintenance equipment and process reliability, and works management. These are described in Table 3 below, whilst actual metrics are presented in Appendix A. Note that this is not an exhaustive list of maintenance performance measures.

TABLE 3: MAINTENANCE PERFORMANCE AREAS AND MEASURES

MAINTENANCE KEY PERFORMANCE AREA (MKPA)		DESCRIPTION	TYPICAL PERFORMANCE MEASURES
1.	Business management	This category of performance measures assess the quality of management of the maintenance function, and focusses on translating entity strategic objectives and standards of service into maintenance objectives. It includes assessment of maintenance strategy and the implementation thereof, selecting the right performance measures, communicating with stakeholders, driving continuous improvement and managing change.	• Total maintenance cost per annum as a percentage of the current replacement cost value of the asset portfolio • Asset portfolio health grade • Asset consumption ratio • Asset sustainability ratio • Asset renewal funding ratio
2.	Service delivery reliability	The core function of maintenance in the public sector is to ensure that assets are available and reliable so that services can be delivered as and when required.	• Asset availability • Asset uptime • Asset downtime
3.	Maintenance organisation and leadership	This category of performance measures focus on ensuring that maintenance staff are appropriately qualified and optimally assigned to achieve maintenance objectives.	• Maintenance training cost • Maintenance training hours • Rework • Maintenance training return on investment

MAINTENANCE KEY PERFORMANCE AREA (MKPA)		DESCRIPTION	TYPICAL PERFORMANCE MEASURES
4.	Maintenance equipment and process reliability	This category of performance measures focus on (1) understanding the characteristics, reliability, maintainability and criticality of assets to be maintained, and (2) selecting the most appropriate maintenance practices to ensure assets and processes continue to deliver as expected.	• Extent of assets for which criticality rating has been done • Total downtime • Scheduled downtime • Unscheduled downtime • Mean time between failures (MTBF) • Mean time between maintenance (MTBM) • Mean time to repair (MTTR) • Mean time to failure (MTTF) • Mean downtime (MDT
5.	Work management	This category of performance measures focus on the efficiency of maintenance operations, inclusive of maintenance planning, prioritisation, scheduling, execution, inventory management and quality assurance of work done.	• Preventative maintenance hours • Preventative maintenance cost • Corrective maintenance hours • Corrective maintenance cost • Condition-based maintenance hours • Condition-based maintenance cost • Scheduled compliance hours • Scheduled compliance cost • Maintenance shutdown cost • Actual cost vs. planning estimate • Actual hours vs. planning estimate • Planning variance index • Planner productivity • Work order aging • Work order cycle time • Preventative maintenance work orders overdue • Preventative maintenance yield • Inventory turnaround • Stock-outs • Maintenance material cost • Contractor cost • Continuous improvement hours

It is considered good practice to align or categorise maintenance performance measures to organisational outcome areas to ensure a consistent, internally coherent and aligned performance management framework for the entity as a whole, where management and employees have full line of sight on how their performance contribute to the success of the entity. Table 4 provides examples of types of maintenance performance measures aligned to organisational outcome areas.

TABLE 4: MAINTENANCE PERFORMANCE MEASURES LINKED TO ORGANISATIONAL OUTCOME AREAS AND STANDARDS OF SERVICE ATTRIBUTES

STANDARD OF SERVICE ASPECTS	STANDARDS OF SERVICE SUB-ASPECTS	MAINTENANCE PERFORMANCE MEASURE	MAINTENANCE KEY PERFORMANCE AREA (MPKA) – SEE TABLE 3	
Overall quality	Structure and fittings in acceptable condition	% of assets in acceptable condition band compared to total asset portfolio, measured in current replacement cost	4.	Maintenance equipment and process reliability
			5.	Work management
Availability/ reliability/ responsiveness	Availability	% Asset availability	2.	Service delivery reliability
	Continuous service delivery	Asset uptime	2.	Service delivery reliability
	Responsiveness	% of incidents responded to within committed response time limits	5.	Work management
Health and safety	Structural integrity	% of assets in "Poor" and "Very poor" condition	4.	Maintenance equipment and process reliability
			5.	Work management
	Employee and customer safety	Nr of health and safety incidents/annum	4.	Maintenance equipment and process reliability
		Nr of days since last reported health and safety incident	4.	Maintenance equipment and process reliability
		Nr of days lost due to accidents	4.	Maintenance equipment and process reliability
	Property damage as a result of asset failure	Rand value of property damage as a result of asset failure/annum	4.	Maintenance equipment and process reliability
Affordability or value for money	Overall value for money	Total maintenance cost per annum as a percentage of the current replacement cost value of the asset portfolio	1.	Business management
	Cost efficiencies	Maintenance unit cost	1.	Business management
	Productivity/efficiency	Mean time to repair	4.	Maintenance equipment and process reliability
		Inventory turnaround time	5.	Work management
		Stock-outs	5.	Work management
		Work order aging	5.	Work management
		Work order cycle time	5.	Work management
		Rework	3.	Maintenance organisation and leadership

8.3 CRITERIA FOR PRIORITISING MAINTENANCE

There will seldom be sufficient resources (human resources, financial resources, maintenance equipment and materials) to undertake all maintenance needs. This requires that maintenance must be prioritised, and the decision criteria used for maintenance prioritisation should be documented in the maintenance strategy. Maintenance activities are prioritised largely based on asset risk exposure. Asset-based risk exposure is determined by assessing:

- the consequence (impact) of failure of components; and
- the probability (likelihood) of failure of components for each component by considering its failure mode status e.g. its condition rating.

Both the consequence of failure and probability of failure are determined using rating scales that should be aligned with, or consistent with the entity's risk management framework, as follows:

FIGURE 5: CALCULATING RISK EXPOSURE

RISK EQUATION: **RISK EXPOSURE = PROBABILITY X CONSEQUENCE**

PROBABILITY OF FAILURE (PoF) **X** **CONSEQUENCE OF FAILURE (CoF)**

PROBABILITY GRADE	DESCRIPTION
1	Rare
2	Unlikely
3	Moderate
4	Likely
5	Almost certain

CONSEQUENCE GRADE	DESCRIPTION
1	Insignificant
2	Minor
3	Moderate
4	Major
5	Catastrophic

8.3.1 ASSESSING PROBABILITY OF FAILURE

Probability of failure refers to the likelihood of a risk materialising, or an asset failing. The probability rating scale, shown in Table 5, is used to assess the likelihood of a risk materialising. In an asset management context, the probability of failure rating scale is calibrated to the typical average lifespan of the immovable asset portfolio of the entity (in this case, a little over 30 years).

TABLE 5: PROBABILITY OF FAILURE RATING

PROBABILITY GRADE		DESCRIPTION	PROBABILITY
1	Rare	This risk is expected to occur after 51 years	0.013
2	Unlikely	This risk is expected to occur between 21 and 50 years	0.033
3	Moderate	This risk is expected to occur between 6 and 20 years	0.077
4	Likely	This risk is expected to occur between 1 and 5 years	0.333
5	Almost certain	This risk is expected to occur within 1 year	0.99

Assets tend to fail in particular ways, for example as a result of condition, or it may not perform according to expectations (performance failure), it may cost too much to operate and maintain (cost-of-operations failure), or the asset is under-utilised or over-utilised (utilisation or capacity failure). The way in which an asset can fail is referred to as an asset failure mode. Failure can be expressed as a continuum, consequently asset failure mode status is determined using a five-point grading scale, as shown for the condition failure mode in Table 6 below.

TABLE 6: CONDITION GRADING SCALE

GRADE	DESCRIPTION	DETAILED DESCRIPTION	INDICATIVE RUL
1	Very good	Sound structure, well maintained. Only normal maintenance required.	71 – 100% EUL
2	Good	Serves needs but minor deterioration (< 5%). Minor maintenance required.	46 – 70% EUL
3	Fair	Marginal, clearly evident deterioration (10–20%). Significant maintenance required.	26 – 45 % EUL
4	Poor	Significant deterioration of structure and/or appearance. Significant impairment of functionality (20–40%). Significant renewal/upgrade required.	11 – 25% EUL
5	Very poor	Unsound, failed needs reconstruction/replacement (> 50% needs replacement).	0 – 10% EUL

RUL	Remaining useful life
EUL	Estimated useful life

Note that the condition grading scale presented above assumes a parabolic deterioration curve applicable to many civil structures (see Figure 6). It is necessary to calibrate the condition grading scale, especially estimates of deterioration and impairment of functionality, as well as the indicative RUL for various component types. This generic condition grading scale must then be interpreted for component types, condition parameters to observe when conducting condition assessments must be specified and documented, and assessors trained in the use of condition grading scales as relevant. Table 7 illustrates some condition parameters to observe for selected component types when conducting building assessments. Examples of condition grading scales for selected components are included in Appendix B.

FIGURE 6: TYPICAL CONDITION DETERIORATION CURVE OF MANY CIVIL STRUCTURES

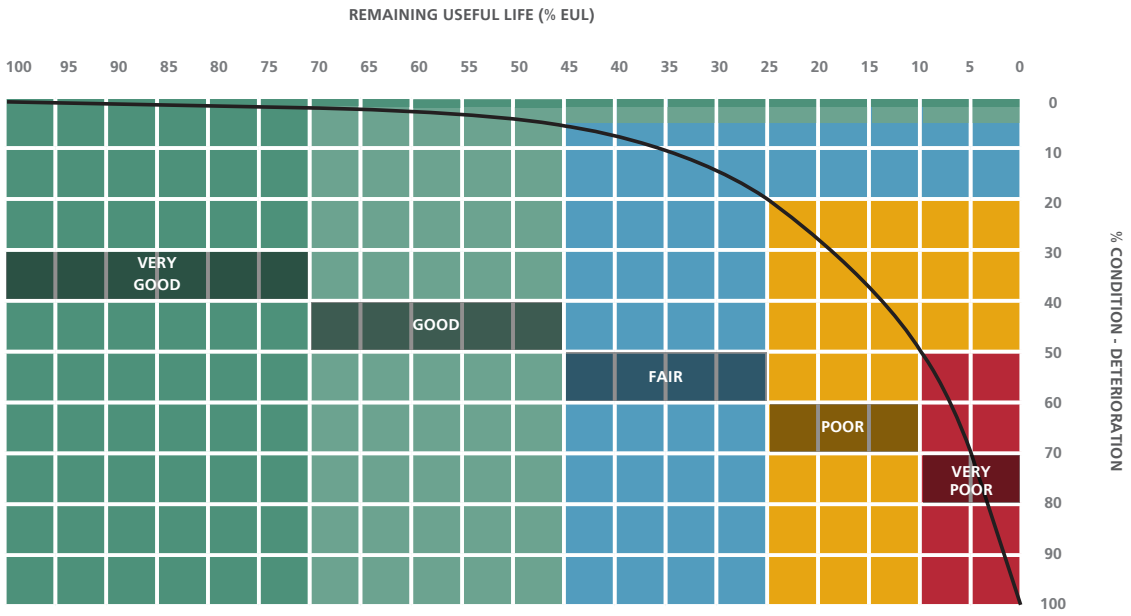


TABLE 7: EXAMPLES OF CONDITION PARAMETERS TO OBSERVE WHEN CONDUCTING BUILDING ASSESSMENTS

ASSET TYPE	COMPONENT TYPE		CONDITION PARAMETERS TO OBSERVE AND RECORD ON SITE
Electrical	Electrical reticulation	Transformers and switchgear	Oil leaks, silicon gel condition, visible overheating of cables
		Distribution boards	Cleanness, paintwork, cover plates
		Power outlets	Fixture to wall/power skirting, cover plates
		Fittings	Diffusers/bowls/shades, working
		Switches	Working, cover plates
	Telephone and IT	Distribution	Tidiness, cover plates
		Outlets	Fixture to wall/power skirting, cover plates
	Earthing/lightning protection	Copper/ aluminium	Tied to brackets, connected to down conductors, earthing installed
Air conditioning	Central plants	Chillers	Leaks, vibration, noise
		Fan motors	Vibration, noise
		Filters	Cleanness
	Small units	Window/wall, consoles, splits	Noise, vibration, filter condition
	Ventilation systems	Fans	Noise, vibration
Fire	Fire prevention	Fire hydrants and hose reels	Leaking, seals, water pressure
		Sprinklers	Leaking, water pressure
		Fire extinguishers	In place/missing, tested
	Fire detection	Control panel and detectors	Operation, alarm conditions

Some failure modes will tend to be more dominant than others depending on the type of assets and the operating environment. Condition generally tends to be the dominant failure mode for roads, whereas for electricity supply capacity and performance tend to be the leading failure modes. Over time, other failure modes may dominate, such as when roads are in good condition, but needs to be widened to accommodate traffic volume increases (capacity).

Probability of failure grades (Table 5) and failure mode grades (Table 6: Condition) both adopt a five-point grading system. Therefore, when undertaking asset-based risk assessments, the generic probability grade is substituted with the failure mode grade of an asset, as shown in Figure 7.

FIGURE 7: FAILURE MODE GRADE IN THE RISK EXPOSURE ASSESSMENT

RISK EQUATION: **RISK EXPOSURE = PROBABILITY X CONSEQUENCE**

PROBABILITY OF FAILURE (PoF) **X** **CONSEQUENCE OF FAILURE (CoF)**

PROBABILITY GRADE		DESCRIPTION	PROBABILITY
1	Rare	This risk is expected to occur after 51 years	0.013
2	Unlikely	This risk is expected to occur between 21 and 50 years	0.033
3	Moderate	This risk is expected to occur between 6 and 20 years	0.077
4	Likely	This risk is expected to occur between 1 and 5 years	0.333
5	Almost certain	This risk is expected to occur within 1 year	0.99

SUBSTITUTE WITH...

ASSET FAILURE MODE RATING

8.3.2 ASSESSING THE CONSEQUENCE OF FAILURE

A risk impact rating scale is an useful instrument to assess the consequence of a risk materialising across several impact categories. Table 8 provides an example of an impact of failure rating scale. Note the following about the risk impact rating scale:

TABLE 8: IMPACT OF FAILURE RATING SCALE

IMPACT RATING	ORGANISATION'S ABILITY TO COPE WITH IMPACT	ASSUMED MONETARY VALUE (FOR PURPOSES OF PRIORITISATION ONLY)		IMPACT CATEGORY				
		RISK COST RANGE	ASSUMED RISK COST	SERVICE DELIVERY PERFORMANCE	HEALTH AND SAFETY	ENVIRONMENTAL DAMAGE	ORGANISATIONAL IMAGE	DIRECT COSTS (REPAIR, LOST INCOME, THIRD PARTY DAMAGE)
1. Insignificant	Is readily absorbed under normal operating conditions	< R 200 000	R 100 000	Service delivery interruption of less than 2 hours, limited to one or a few non - critical customers	Health impact limited to first aid at most	Minor transient environmental damage, visual effects only	Individual interest only, no community concern	R 100 000
2. Minor	Can be managed under normal operating conditions	R 200 001 - R 1 000 000	R 500 000	Service delivery impact of between 2-6 hours, affecting one or few customers,or service delivery impact of less than 2 hours affecting several street blocks	Minor health impact of a temporary nature on small number of people	Minor damage to environment, longer effect	Minor community interest, minor local media report	R 500 000
3. Moderate	Can be managed but requires additional resources and management effort	R 1 000 001 - R 5 000 000	R 2 500 000	Service delivery interruption affecting a whole village, suburb or neighourhood for up to 2 hours	Serious health impact on small number or minor impact on large number of people	Moderate environmental impact. Prosecution expected	Public community discussion, major local media interest	R 2 500 000
4. Major	Will have a prolonged impact and extensive consequeces	R 5 000 001 - R 30 000 000	R 15 000 000	Service delivery interruption affecting a major node or which exceeds the maximum duration allowed for one event in terms of legislation	Extensive injuries or significant health impacts, single fatality. May result in inquiry or prosecution	Major long term environmental impact. Prosecution expected	Major loss in community confidence	R 15 000 000
5. Catastrophic	Irreversible and extensive impacts or significantly undermining key business objectives	> R 30 000 000	R 40 000 000	Non-achievement of legal mandate	Multiple fatalities. Likely to result in commission of inquiry and prosecution	Serious damage of national importance and irreversible impact. Prosecution expected	National media	R 40 000 000

- There is a range of possible impact categories, such as service delivery, health and safety, social development, economic development and environmental protection. These impact categories should be consistent with the entity's strategic objectives/desired outcome areas and it's asset management policy as contemplated in SANS 55001: Requirements for an asset management system, and will typically also include some additional impacts such as direct costs and organisational image.
- In the event that the entity does not have a risk impact rating scale, it does not have clearly defined strategic objectives/desired outcome areas, and its AM policy also does not provide guidance, the impact rating scale provided may be used to conduct risk assessments, but would need to be calibrated with respect to the risk cost range, taking into account the size of the entity and its risk appetite.
- The most important decision in the calibration of the risk cost range is the median cost (assumed risk cost) for Impact rating 5 (catastrophic). This should be decided taking into account the entity's materiality limit, the average cost of a high value facility owned or operated by the entity, and the cost of the most significant past risk event known to staff.
- A risk impact can be rated anywhere between 1 (insignificant) and 5 (catastrophic). For each level of risk impact, there is a qualitative description that generally describes the extent to which the entity can cope with the risk, and an assumed risk cost. The assumed risk cost is used for prioritisation purposes, and is not necessarily the actual risk cost.
- Where applicable, the risk impact rating scale can be enhanced by adding a spatial scale of impact column.

SANS 55001 Cl 6.2.1.2b requires organisations to "review the importance of assets related to their intended outcomes, objectives and product or service requirements". SANS 55002 Cl 6.2.2.1 advises that a "risk ranking process can determine which assets have a significant potential to impact on the achievement of AM objectives". These are what are considered "critical assets": assets that have a high consequence of failure (e.g. are likely to result in a more significant financial, environmental and social cost in terms of their impact on organisational objectives and service delivery). Note that this definition speaks to consequence, not probability. Therefore, redundancy, which reduces the probability of failure, is generally not considered in assigning criticality grades. Consequently, the more critical an asset is rated, the greater management attention it receives, and generally, the higher priority it receives in terms of budget prioritisation.

TABLE 9: ASSET CRITICALITY RATING SCALE

CRITICALITY GRADE	CRITICALITY DESCRIPTION	CONSEQUENCE OF FAILURE	QUALITATIVE DESCRIPTION
1	Cursory	Insignificant	Is readily absorbed under normal operating conditions
2	Non-critical	Minor	Can be managed under normal operating conditions
3	Important	Moderate	Can be managed but requires additional resources and management effort
4	Critical	Major	Will have a prolonged impact and extensive consequences
5	Most critical	Catastrophic	Irreversible and extensive impacts, or significantly undermining key business objectives

To truly determine the impact of failure of assets, each asset should be assessed against a risk impact matrix such as the one presented in Table 8. The risk impact rating scale and the asset criticality rating scale are both 5-point rating systems. The risk impact rating (consequence of failure) then determines the asset criticality. For example, an asset with an impact or consequence rating of "4" (major impact or consequence) is then given an asset criticality rating of "4" (critical asset).

It is often not practical to assess the consequence of failure for each asset (component) in the entity's asset portfolio, as the extent of assets may number anywhere between thousands and millions of components. There are two approaches to dealing with the challenge to undertake asset criticality assessment cost-effectively.

The basic approach to determining asset criticality is to make general assumptions about the impacts of failure at the component type level based on defined characteristics, and then to apply asset criticality ratings to all components in the asset portfolio accordingly.

As an example, the larger a water pipe, the more customers it can generally serve, and losses and service delivery impacts resulting from large pipe bursts tend to be more severe than those related to smaller pipes. Following this logic, a rule set such as the following can be developed:

TABLE 10: ASSET CRITICALITY RATING RULE SET FOR WATER PIPES (ILLUSTRATIVE)

CRITICALITY GRADE	WATER PIPE DIAMETER SIZE
1: Cursory	<=110 mm dia
2: Non-critical	>110 to 160 mm dia
3: Important	>160 to 300 mm dia
4: Critical	>300 to 900 mm dia
5: Most critical	>900 mm dia

Another way to achieve the same result would have been to ascribe a criticality value to pipes based on the number of connections on that pipe e.g. ascribe a criticality value of "1" to a pipe with between 1 – 10 connections, and a criticality value of "5" to a pipe with more than 500 connections.

The same type of logic can be applied to other asset portfolios. It generally stands to reason that higher order roads (e.g. trunk roads, primary distributors, freeways and major arterials) have a greater consequence of failure than local access (residential) roads. Therefore, one can reasonably establish a rule set for asset criticality for roads based on road class. Similarly, a HV transformer will be given a higher asset criticality rating than a MV transformer. Bridge collapse can very likely lead to multiple fatalities, and bridges should therefore be rated as "5" (most critical assets), regardless of type (e.g. vehicular, pedestrian or utility services bridge).

The basic approach tends to work well for a first-sweep assessment of asset criticality, but may fail to address issues such as the unique nature of particular customers, or the environmental impacts of asset failure. Infrastructure or other immovable assets serving areas such as central business districts, government precincts or special economic zones, or critical customers such as power stations, tertiary hospitals or large private sector clients may not always be of sufficient capacity to warrant a high criticality rating in terms of the general criticality rule set. The consequence of failure of such assets may however have major or catastrophic regional or national impacts on the economy, on service delivery and on reputation.

It is therefore advisable to follow a three-step approach to determining asset criticality, as follows:

1. Establish a general rule set for asset criticality for all assets in the asset portfolio(s) and rate assets accordingly;
2. Identify critical customers/facilities/areas served and the immovable assets serving these critical customers/facilities/areas; and
3. Review and adjust the criticality ratings of the immovable assets serving critical customers/facilities/areas.

8.3.3 RISK EXPOSURE RATING AND MAINTENANCE PRIORITY

At this point, asset-based risk exposure can be calculated as the product of probability of failure (based on failure mode status) and consequence of failure (based on asset criticality rating). The highest possible risk rating is 25, as both the

probability/failure mode and consequence/asset criticality rating scales are 5-point rating scales (5 x 5 = 25). Risk exposure can then be presented in a risk matrix as follows:

FIGURE 8: UNMODERATED RISK MATRIX

PROBABILITY	CONSEQUENCE: Insignificant	Minor	Moderate	Major	Catastrophic
Almost certain	5	10	15	20	25
Likely	4	8	12	16	20
Moderate	3	6	9	12	15
Unlikely	2	4	6	8	10
Rare	1	2	3	4	5

From the above, a risk exposure classification system can be established as shown in Table 11, and risk exposure be restated in the risk exposure matrix as depicted in Figure 9. The asset risk exposure rating then determines the asset's maintenance priority.

TABLE 11: RISK EXPOSURE CLASSIFICATION (UNMODERATED) AND MAINTENANCE PRIORITY

RISK EXPOSURE DESCRIPTION	DENOTED AS...	RISK EXPOSURE SCORE RANGE	MAINTENANCE PRIORITY	
Low	L	1-5	L	1
Moderate	M	6-9	M	2
Significant	S	10-14	S	3
High	H	15-19	H	4
Extreme	E	20-25	E	5

FIGURE 9: RESTATED RISK EXPOSURE MATRIX (UNMODERATED)

PROBABILITY	CONSEQUENCE: Insignificant	Minor	Moderate	Major	Catastrophic
Almost certain	L	S	H	E	E
Likely	L	M	S	H	E
Moderate	L	M	M	S	H
Unlikely	L	L	M	M	S
Rare	L	L	L	L	L

This is generally a perfectly rational and simple system to apply. But the system frays at its edges, particularly with regards to risk events where the consequence is catastrophic but the probability is rare, such as for a dam wall or a bridge, resulting in a low risk exposure rating. Management tends not to pay too much attention or allocate much resources to low risks. As a consequence, the entity may be ill prepared to deal with such an event should it materialise. Figure 10 below shows a moderated risk exposure matrix.

FIGURE 10: MODERATED RISK EXPOSURE MATRIX

PROBABILITY	CONSEQUENCE: Insignificant	Minor	Moderate	Major	Catastrophic
Almost certain	M	S	H	E	E
Likely	L	M	S	E	E
Moderate	L	M	S	H	E
Unlikely	L	L	M	H	H
Rare	L	L	M	H	H

The key difference between this and the unmoderated risk exposure matrix (Figure 9) is that risk events with consequence ratings of "major" or "catastrophic" are rated as at least "high" risks, even when the likelihood of them occurring is unlikely or rare.

9. MAINTENANCE MANAGEMENT PLAN

9.1 PURPOSE AND CONTENTS OF THE MAINTENANCE MANAGEMENT PLAN

The maintenance management plan determines the maintenance type and approach per asset or component type, as appropriate, addresses maintenance logistics' requirements, presents maintenance budget requirements and prioritises this budget based on funding availability, and presents maintenance performance targets to be achieved given budget availability. The contents of the maintenance management plan have been listed in Section 4.

9.2 PLANNING HORIZON

The planning horizon of a maintenance management plan should be calibrated to that of the entity's asset management plan, as the asset management plan must address the full lifecycle that maintenance forms a part of. Good practice dictates that an asset management plan adopts a planning horizon equivalent to the longest estimated useful life of an asset group type (facility) in the asset portfolio. However, some immovable assets have what are referred to in accounting terms as indefinite lifespans. An example of such a facility is a dam that can potentially have a lifespan exceeding 200 years. It is not practical to plan over such a long period, and any financial projections over a period exceeding 30 years tend to be questionable. Therefore the planning horizon of asset management plans tend to be limited to around 30 years, though an entity may elect to project selected elements (such as asset renewal needs) over a longer period to better understand long term trends.

Within the overarching planning horizon adopted for the maintenance management plan, which should be calibrated to that of the asset management plan, the maintenance management plan should cover the following planning horizons:

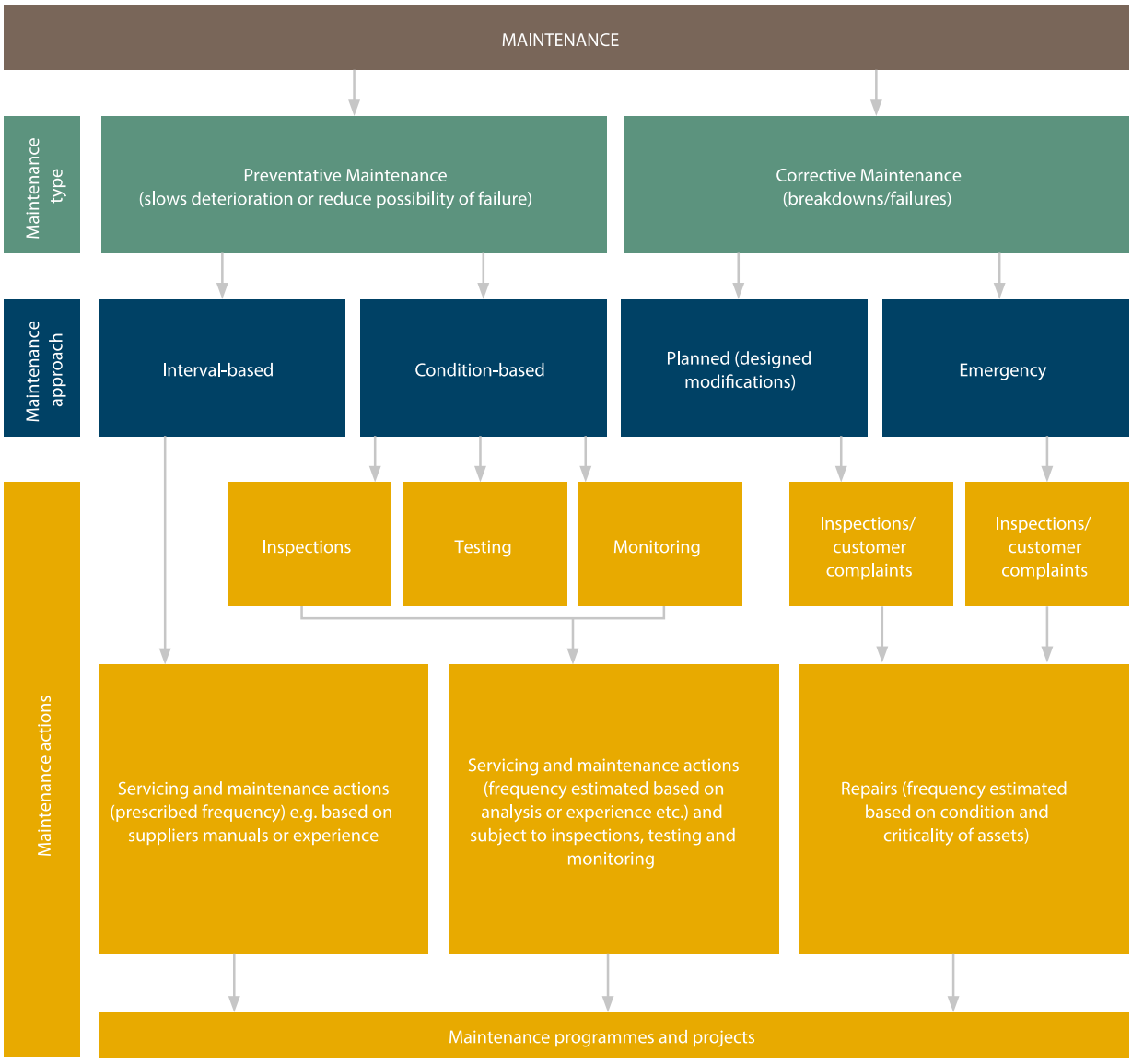
- Long-term planning: Planning for maintenance of both existing and future assets for the period adopted for the asset management plan. Maintenance objectives, actions and performance indicators over the long term plan should be scheduled in the same time brackets (e.g. 3 ten-year blocks in the event that a 30 year planning horizon is adopted).

- Medium-term planning: The MTEF cycle is the first three-year cycle of the long term plan and maintenance objectives, actions and performance indicators should be scheduled on an annual basis.
- In-year planning: The current financial year is the first year of the maintenance management plan and maintenance objectives, actions and performance indicators should be scheduled on a quarterly basis.
- Short-term planning (implementation planning): Short term planning covers the next three months of the in-year planning. It focuses on determining all actions required to perform maintenance tasks and includes maintenance job planning.

9.3 DETERMINING THE MAINTENANCE TYPE AND APPROACH

Maintenance is the implementation of normal actions, periodic and generally minor in nature, that ensure the sustained functionality and performance of an asset in line with its design and operational requirements. These activities do not include asset renewal, capital improvement, assembly of new assets, alteration or expansion of existing assets to accommodate a change of function. There are two types of maintenance: corrective and preventive maintenance, as shown in Figure 11, and various approaches that can be followed to maintain assets, such as interval-based, condition-based, emergency or planned maintenance.

FIGURE 11: MAINTENANCE HIERARCHY



Corrective maintenance is carried out after fault recognition and is intended to put an item back into a state in which it can perform a required function. This type of maintenance can be an emergency repair, unscheduled or planned repair based on inspection or customer complaints. This method of maintenance forms part of many organisation's maintenance operations. It is also often the most expensive as downtime, high overtime expenses and high requirements on spare parts inventory is required to respond effectively and restore the systems to operation.

Preventative maintenance can be divided into two categories, interval based and condition based. Interval based maintenance is carried out in accordance with an established time schedule or an established number of units of use, e.g. number of machine hours. This type of maintenance can be guided by supplier's manuals or experience. Condition based preventative maintenance involves inspection of assets, testing and parameter monitoring to determine if any maintenance is needed and then carrying out any requirements identified. The performance and parameter monitoring may be scheduled on request or continuously.

The maintenance management function determines the maintenance type and approach, as well as maintenance actions necessary for all immovable assets. As a general rule, the type of maintenance and the approach to maintenance is determined by component type, rather than for each component individually, unless there are specific unique requirements stated by the original equipment manufacturer, and there are multiple components of the same type provided by various manufacturers. This is because there are simply too many components to plan for each separately, and because components of a certain type tend to share maintenance characteristics.

The maintenance type and approach for each component will be determined by considering:

- Maintenance requirements and objectives established for assets;
- Any statutory requirements for condition monitoring or testing of assets e.g. inspection of electricity distribution equipment, fire-fighting equipment, hydraulic inspections or dam safety inspections;
- The nature of the component and the extent to which it lends itself to preventative maintenance, and the cost of preventative maintenance;
- Asset age, failure mode status and risk exposure;
- The extent of a particular component and of components per asset type, as well as the geographic area(s) over which they are located that also affects the costs of maintenance;
- The manufacturer or designer's recommended approach for maintenance, as well as industry best practice; and
- Any known constraints such as funding or delivery capacity constraints.

There are however instances where the maintenance approach should be tailored to specific conditions and requirements, such as when:

- There is a change in the demand for an asset, which may include significantly higher or lower levels of utilisation, or the asset may be decommissioned until such time that demand warrants it, for example power stations;
- Assets decommissioned at end-of-life, but where the entity remains responsible for active after life care, such as in the case of landfill sites;
- Capital renewal, upgrading, modification or repurposing projects or programmes have been approved for assets – these may at least interrupt scheduled maintenance activities, or may alter the maintenance type, approach or frequency of future maintenance activities;
- Assets nearing end-of-life, but which are expected to operate at full capacity; and/or
- Assets at end-of life, but which are expected to function beyond estimated life expectancy without renewal in the short to medium term (asset sweating).

TABLE 12: EXAMPLES OF MAINTENANCE APPROACHES PER COMPONENT TYPE

COMPONENT TYPE	DESCRIPTOR TYPE	WORKFLOW DESCRIPTION	ROLLED UP ACTIVITY DESCRIPTION	WORK PACKAGE	ANNUAL OCCURRENCE	MAINTENANCE PRIORITY (1-5)
Air conditioning	All subclasses of this component have the same maintenance activities	6 Monthly service	Service	• Inspect for physical damage • Check filter condition, clean/ replace as required • Check dip tray, clean as required • Check electrical connection • Check operation of all controls and safety • Clean unit casing	2	3
Air conditioning	All subclasses of this component have the same maintenance activities	Yearly service	Service	• In addition to 6 month inspections • Check refrigerant coil and Operating Pressure, clean as required	1	1
Auto Recloser	All subclasses of this component have the same maintenance activities	Annual Inspection	Inspection	• Check Insulators for chips, cracks and pollution levels • Control cubicles must be checked for defects • Check for SF6 gas leaks or oil leaks • Check for corrosion or rust and check that earth straps are in good condition. • All defects must be reported to for maintenance to be scheduled	1	1
Auto Recloser	All subclasses of this component have the same maintenance activities	05 Yearly Inspection and Service	Inspection and Service	• Test breaker protection and operation • Control cubicle checks • Replace battery • Bushings should be checked, and cleaned if necessary as per manufactures manual	0,2	5

COMPONENT TYPE	DESCRIPTOR TYPE	WORKFLOW DESCRIPTION	ROLLED UP ACTIVITY DESCRIPTION	WORK PACKAGE	ANNUAL OCCURRENCE	MAINTENANCE PRIORITY (1-5)
Batteries	All subclasses of this component have the same maintenance activities	1 Monthly Inspection	Inspection	• Check battery electrolyte levels • Clean battery studs and cables ends • Tighten terminals. • Battery equalize charge	12	1
Batteries	All subclasses of this component have the same maintenance activities	4 Yearly Service	Service	• Preform Battery boost charge • Preform a Discharge test on battery • Battery boost after discharge test • Clean and top up	0,25	1
Batteries	All subclasses of this component have the same maintenance activities	3 Monthly Testing	Testing	• Conduct Monthly Inspection and record the following Test on a log sheet: - voltage readings per Cell - current readings per Cell - specific gravity readings per Cell - temperature readings per Cell	4	1
Battery Charger	All subclasses of this component have the same maintenance activities	Yearly Inspection	Inspection	• Isolate charger from the battery and main supply • Check and clean ventilation of the charger case • Check the condition of the charging cables at the entry point to the charger • Charging plugs and sockets for evidence of overheat-ing • Pay attention to points where cables are severely flexed • Check all indication lights, relay for proper functioning	1	1

COMPONENT TYPE	DESCRIPTOR TYPE	WORKFLOW DESCRIPTION	ROLLED UP ACTIVITY DESCRIPTION	WORK PACKAGE	ANNUAL OCCURRENCE	MAINTENANCE PRIORITY (1-5)
Carports	All subclasses of this component have the same maintenance activities	5 Yearly Service	Service	• Repair and perform general maintenance including repainting of roof and poles	0,2	1
Channel	All subclasses of this component have the same maintenance activities	Yearly Service	Service	•Remove silt, soil, vegetation •Clean trash grids	1	1
Channel	All subclasses of this component have the same maintenance activities	Yearly I nspection	Inspection	•Check for cracks, damage (structural) •Check for erosion, silting, obstructions •Check for silting up at inlet structures i.e. grid inlets, kerb inlets, etc.	1	1
Commuter shelter	All subclasses of this component have the same maintenance activities	3 monthly Inspection	Inspection	•Check condition of shelter and clean up	4	1
Commuter shelter	All subclasses of this component have the same maintenance activities	5 Year Service	Service	•Perform general maintenance including repainting of roof and structure	0,2	3

COMPONENT TYPE	DESCRIPTOR TYPE	WORKFLOW DESCRIPTION	ROLLED UP ACTIVITY DESCRIPTION	WORK PACKAGE	ANNUAL OCCURRENCE	MAINTENANCE PRIORITY (1-5)
Control panel	All subclasses of this component have the same maintenance activities	6 Monthly inspection	Inspection	• Check for arcing of contacts • Check for local hot spots within the panel with infrared temperature sensing instrument. • Check operation of pilot lights, volt and ammeters. Check starter overload settings • Check wiring for damage • Check and tighten all connections, clean boards internally	2	1

9.4 MAINTENANCE LOGISTICS

Maintenance logistics include all the resources and arrangements necessary to implement the maintenance management plan. Following are some examples of maintenance logistical requirements to be addressed in maintenance management plans:

TABLE 10: TYPICAL HIGH-LEVEL MAINTENANCE LOGISTICAL REQUIREMENTS

CATEGORY	ITEM
Workflow management / procedures	Management of system or facility shutdowns
	Preventative maintenance
	Corrective maintenance
	Disaster responses/recovery
	Health and safety related procedures
	Incident responses
	Post incident evaluation
	Supplier contract management and performance assessment
	Internal performance assessment
Human resources	Maintenance management staff
	Maintenance planners
	Maintenance personnel (by discipline, trade and skills level)
	Support staff (call center operators, stores personnel, cleaners etc.)
	Skills development requirements

CATEGORY	ITEM
Electronic maintenance management systems	System functionality
	System workflow configuration
	Document management
	Integration with other systems (e.g. general ledger, asset register, procurement system and HR system)
	Reporting requirements
	User access
	Hardware (computers, printers, handheld devices etc.)
	Audit trail
	System change control
Tools and equipment	General tools required (type)
	Specialised tools including testing and monitoring equipment (type)
	Vehicles – general (note type and specification e.g. 1 ton bakkie)
	Vehicles – specialised (note type and specification e.g. cherry-picker)
	Health and safety equipment (type)
	Compliance requirements (e.g. statutory requirements for ladder inspections)
	Tool maintenance
	Tool calibration
	Arrangements relating to the issuing of and control over tools and equipment issued
Accommodation of maintenance operations and access to sites where maintenance work is to be done	Location
	Facilities (inclusive of function(s), size and lay-out)
	Consents, wayleave applications and approvals and/or work permits
	Physical access to sites where maintenance work is to be undertaken e.g. security access/keys
Procurement	Supplier agreements - professional services and labour
	Supplier agreements – supply of tools
	Supplier agreements – spare parts and consumables
	Warrantees and guarantees
Inventory	Stores – fixed and mobile
	Capital spares
	Rotating capital spares and “swop” arrangements with suppliers
	Just-in-time delivery arrangements

9.5 DETERMINE RESOURCE REQUIREMENTS

9.5.1 PREVENTATIVE MAINTENANCE

Having established maintenance approaches as appropriate for all component types in the asset portfolio(s) under the control of the entity, the next step is to calculate resources necessary to implement the required maintenance. This is done as follows:

- Estimate the resource requirements for each work package specified per component type. Resource requirements include labour, vehicles, machinery, tools and equipment, spare parts and consumables, as necessary to execute the work package;
- Estimate the cost of each element of the work package, and determine a work package cost;
- Quantify the number of work packages per component type for each planning period by the stipulated maintenance frequency for each work package;
- Quantify the number of work packages required per component type (taking into account frequency) by the number of components per component type, and determine the cost of work packages per component type, for each planning period; and
- Calculate the following: (1) total cost of preventative maintenance, (2) total resource requirements by type of resource and (3) the total cost per type of resource.

9.5.2 CORRECTIVE MAINTENANCE

Estimate corrective maintenance requirements based on past experience and failure probability, and calculate total resource requirements and total corrective maintenance cost.

9.5.3 TOTAL MAINTENANCE REQUIREMENTS

Calculate total resource requirements and total costs for both preventative and corrective maintenance.

9.5.4 COMPARE RESOURCE REQUIREMENTS WITH RESOURCE AVAILABILITY

Resource requirements should be compared with resource availability. In the event that financial resource requirements exceed funding availability, the entity should consider the following options, depending on the extent of funding shortfalls and the duration thereof:

- Prioritising maintenance actions and deferring some maintenance work (short to medium term option);
- Revisiting maintenance objectives and standards (short to medium term option);
- Optimising maintenance operations by exploring opportunities for greater cost efficiencies (short to medium term option); and/or
- Rationalising and optimising the asset portfolio(s) (medium to long term option).

When there are resource constraints other than funding availability, such as the availability of skilled maintenance operators or machinery, the maintenance management plan should propose programmes, projects or actions as necessary to address such constraints, in line with legislation, relevant national or provincial policies, and the strategic objectives of the entity.

9.6 MAINTENANCE SCHEDULING

Having performed the planning tasks in Section 9.5, maintenance planners will now have identified resource requirements in terms of:

Preventative maintenance:

- work packages per component type;

- the resource requirements and cost of a work package;
- the total number of work packages based on the extent of assets and the frequencies at which they are to be undertaken; and
- the periods in which they are to be undertaken (next three months, first financial period, MTEF cycle and longer periods).

Corrective maintenance:

- Extent and cost of corrective maintenance.

Maintenance scheduling involves the optimal allocation of resources to execute maintenance requirements, taking into consideration aspects such as the following:

- Factors impacting on maintenance capacity (e.g. unavailability of maintenance personnel due to training, normal leave, sick leave and other administrative duties, and unavailability of maintenance facilities, tools and equipment due to maintenance or upgrading);
- Resource availability and the need for resource levelling;
- Geographical scale and asset dispersion;
- Existing resource deployment arrangements (e.g. location of depots, roaming maintenance crews);
- Compliance dates for statutory monitoring and testing of assets;
- The need to adhere to maintenance priorities;
- Non-negotiable asset uptime requirements;
- Lead times for the supply of goods and services;
- Seasonal and weather considerations; and
- The impacts of public holidays, school holidays and construction holidays.

Having undertaken the above, the entity should be in a position to determine the extent to which maintenance actions can be implemented with the existing resource arrangements, as well as requirements such as overtime provision and the need for external support. The maintenance schedule should also feature structured programmes, projects and actions, considering opportunities for packaging similar activities in particular locations or areas.

10. BUDGETING FOR MAINTENANCE

The maintenance budget is prepared in accordance with the requirements of the Standard Charter of Accounts, as applicable to the entity. Accordingly, maintenance requirements are aggregated to the level of asset group type in the "Project segment" (though detailed maintenance needs should be retained in the maintenance management plan, its maintenance schedule and the entity's maintenance management system), and all other segments in the Chart are also completed. The maintenance budget should be supported by documented maintenance performance measures, indicating the outputs and outcomes to be achieved through implementation of the maintenance budget.

When determining the cost of maintenance the maintenance planning function should check the status of the guarantee or warranty for components or the extended contract conditions for contractors and suppliers and ensure that the replacement or the repair of equipment is not covered under such documents. The maintenance cost should be reduced by the amount that is covered by the guarantee or extended contract conditions.

11. SCHEDULING, COSTING AND BUDGETING FOR ASSET RENEWAL

Planning for asset renewal is done in the asset management plan, and financial requirements are included in the entity's capital budget as per the requirements of the Standard Charter of Accounts. As with maintenance, asset renewals planning takes account of asset criticality and renewals forecasting is done on the basis of likely condition deterioration. Condition is determined either through physical inspection or, where asset condition cannot be easily ascertained (e.g. for buried assets such as pipes), based on remaining useful life.

There are a number of ways in which renewals forecasting can be done. Where sufficient data exists, software can be employed to undertake predictive renewals modelling to identify the most advantageous approach to renewals (i.e. the most optimum renewal point resulting in lowest lifecycle cost).

The most common approach towards renewals planning is to:

- Componentise the entity's asset register;
- For each component in the asset register, establish its age, estimated useful life and current replacement cost;
- Determine the condition of each asset, or assume a condition grade based on remaining useful life;
- Establish the renewals intervention point, which may vary for different assets. The renewals intervention point can be determined either on the basis of remaining useful life (e.g. when the asset has three years' remaining useful life or less), or on condition (e.g. poor condition or very poor condition);
- Based on current age and condition, and the renewals intervention point established, forecast the year in which renewal will be required; and
- Estimate the cost of renewal as the accumulated depreciation, calculated as a percentage of current replacement cost, for the asset up to the year in which renewal is required.

It is a common feature of public sector spending over the long term that infrastructure delivery is cyclical: government alternately spend more on infrastructure development in some years, and then in following years spend more on social programmes, and then again more on infrastructure development in the next cycle of spending.

This tends to have the effect that infrastructure renewal needs "lump" or concentrate in particular periods, which may, together with other lifecycle needs, place strain on the entity's financial resources or delivery capacity to implement in particular periods. So, asset management planners tend to "smooth" renewals, considering service continuity, risk exposure, funding availability and delivery capacity.

Asset management planners also often tend to schedule renewals into programmes where many assets of similar nature require renewal, such as for road resurfacing or pipe renewal programmes.

PART C: PLAN SUPPORT AND IMPLEMENTATION

This section describes support that should be in place to implement the Maintenance Management Plan.

12. PRIORITISING BUDGET ALLOCATIONS

12.1 BUDGET PRIORITISATION

It is often the case that lower budgets are allocated than requested by the maintenance planning function. Such lower budget allocations must then be prioritised in accordance with objective decision criteria, such as:

- First allocate the available budget to components with a maintenance priority rating of "5" and "4";
- Secondly to address statutory maintenance requirements (e.g. compulsory testing, monitoring and servicing);
- Thirdly to preventative maintenance of moderately critical components and deferred maintenance from the previous budget cycle; and
- Finally, to the remaining corrective maintenance.

12.2 DEFERRED MAINTENANCE

The maintenance management function should determine whether deferred maintenance is likely to impact on:

- the useful life expectations of assets; and on
- affected business operations, commitments to customers and/or legislative requirements regarding the availability of asset-based services, and operating income projections.

In the event that asset useful lives may be impacted upon as a result of deferred maintenance, or where operating income may be affected, the assets in question should be impaired following the prescripts of the relevant accounting standards on impairment. Where customer commitments may be affected, the entity should communicate any impacts with the customers concerned.

Any maintenance action deferred due to inadequate budgets should be classified as such on the maintenance schedule. It must also be indicated from which budget cycle it has been deferred. The accrued deferred cost should be declared in the entity's Statement of Financial Position, under the notes regarding property, plant and equipment, or such other accounting group as relevant.

13. RESPONSIBILITY FOR THE MAINTENANCE MANAGEMENT PLAN

In terms of the Public Finance Management Act (PFMA) the Accounting Authority/Officer of an entity must in the financial delegations of the entity, include the function of maintenance planning as determined in the 'Maintenance Competency Framework'. The Accounting Authority/Officer must delegate the function of maintenance planning to a responsible person. The Accounting Authority/Officer must ensure that the person appointed to the position to which the function is delegated, has sufficient competency and capacity to prepare a Maintenance Management Plan. This person will assume the responsibility of maintenance planning as part of his or her job functions and will undertake the necessary actions to prepare a Maintenance Management Plan.

The maintenance planning function should prepare a Maintenance Management Plan as a collaborative effort with the maintenance personnel, the contractor, the professionals and where specialist installations form part of the facility, the original equipment manufacturer.

14. UPDATING OF A MAINTENANCE MANAGEMENT PLAN

A Maintenance Management Plan should be updated at appropriately defined intervals, informed by:

- any changes in the regulatory environment;
- any changes in organisational, asset management or maintenance objectives;
- ongoing condition monitoring and condition assessments or audits, and changes in the status of asset failure modes; and/or
- changes in the asset portfolio resulting from new asset additions, renewals, upgrading, decommissioning or disposal.

The cost schedule should be updated annually to current values.

15. APPROVAL OF A MAINTENANCE MANAGEMENT PLAN

The Accounting Officer must approve the Maintenance Management Plan at least annually or when required by National Treasury.

16. ACTIONING THE PLAN

The maintenance planning function should interact with the maintenance operational unit to ensure that the plan is implemented. This should include:

- Determine the job content and maintenance procedures.
- Determine work plan or schedule: This entails the sequence of the actions in the job and establishing the best methods and procedures to accomplish the job.
- Establish resources required for the job.
- Plan and order parts and material or appoint contractors.
- Determine whether special tools and equipment are needed and obtain them.
- Assign workers or appoint contractors with appropriate skills.
- Review safety procedures.
- Assign cost accounts and complete the work order.

17. MAINTENANCE RECORDS

The maintenance planning function should ensure effective communication of the Maintenance Management Plan and schedule to maintenance operations. Job cards are critical in communicating these actions and in building historical records. It assists the maintenance planning function with determining frequency of maintenance, average maintenance time for various jobs, capital required for equipment and human resource costs.

The maintenance planning function should ensure that a File (Record) Plan is prepared and submitted with the Maintenance Management Plan for approval by the National Archives. Such a File Plan should make provision for the storage of maintenance documentation according to the approved numbering system of the File Plan. This includes:

- maintenance procedures;
- warranty information; and
- technical documentation.

In addition to this, the maintenance planning function should implement record management to track:

- job cards and work orders by component;
- scheduled and unscheduled maintenance actions;
- reports of ongoing work activity;
- parts and materials inventory;
- maintenance calls; and
- service calls and dispatches.

APPENDIX A: MAINTENANCE PERFORMANCE MEASURES

TABLE A.1: MAINTENANCE BUSINESS MANAGEMENT

NORMS, INTERPRETATION AND REPORTING ARRANGEMENTS FOR MAINTENANCE BUSINESS MANAGEMENT PERFORMANCE MEASURES ARE DESCRIBED IN THE "NATIONAL IMMOVABLE ASSET MAINTENANCE MANAGEMENT MONITORING AND EVALUATION PROTOCOL"

<table>
<tr><th>PERFORMANCE MEASURE</th><th>DESCRIPTION</th><th>FORMULA</th></tr>
<tr><td>Repairs and maintenance as a % of CRC</td><td>This ratio has two applications. Applied to budgeting, it gives an indication of the adequacy of budgeted expenditure for repairs and maintenance of assets. Applied to actual expenditure, it tests whether the entity spent adequately on repairs and maintenance.</td><td>$\frac{\text{Repairs and maintenance}}{\text{CRC of immovable assets}} \times 100$</td></tr>
<tr><td>Asset consumption ratio</td><td rowspan="2">Measures the extent of consumption (accumulated wear and tear) of an asset portfolio, which is indicative of the overall health and ability of the asset portfolio to continue to provide service delivery and/or economic benefits, and the extent of asset renewal required.</td><td>$\frac{DRC - RV}{CRC - RV} \times 100$</td></tr>
<tr><td>Asset portfolio health grade</td><td>Calculated using the asset consumption ratio, and then selecting the appropriate option below to rate asset portfolio health grade:
<table>
<tr><th>GRADE</th><th>DESCRIPTION</th><th>(DRC-RV)/(CRC-RV)</th></tr>
<tr><td>1</td><td>Very good</td><td>65% or more</td></tr>
<tr><td>2</td><td>Good</td><td>52.3% to 65%</td></tr>
<tr><td>3</td><td>Fair</td><td>46.7% to 52.3%</td></tr>
<tr><td>4</td><td>Poor</td><td>40% to 46.7%</td></tr>
<tr><td>5</td><td>Very poor</td><td>40% or less</td></tr>
</table></td></tr>
<tr><td>Asset sustainability ratio</td><td>Measures the extent to which an entity replaces the asset value consumed during a period of review in order to maintain service delivery capabilities. It is a measure of the extent to which the entity maintains the value of its capital stock or productive capacity.</td><td>$\frac{\text{Capital renewal and replacement expenditure}}{\text{Depreciation expense}} \times 100$</td></tr>
</table>

PERFORMANCE MEASURE	DESCRIPTION	FORMULA
Asset renewal funding ratio	Measures the extent to which asset renewal is accommodated in the long term financial plan, as identified in the asset management plan. Whereas the asset sustainability measures past renewal activity, the asset renewal funding ratio provides management with a view on future renewal needs, and planned expenditure in relation to future needs.	$\frac{\textit{NPV of planned capital renewals over 10 years}}{\textit{NPV of required capital expenditure over 10 years}} \times 100$
Green renewals agenda ratio	The green renewals agenda ratio provides information on the size of the renewals programme and the percentage of planned expenditure on this programme earmarked for green renewals.	$\frac{\textit{NPV of planned green renewal expenditure over 10 years}}{\textit{NPV of required renewal expenditure over 10 years}} \times 100$
Deferred maintenance	This metric quantifies the portion of planned maintenance work necessary to maintain the service potential of an asset that has not been undertaken in the period in which such work was scheduled to be undertaken.	$\frac{\textit{Value of planned maintenance for FP - Actual expenditure on maintenance}}{\textit{Value of planned maintenance for FP}}$ *FP: Financial period*
% of PPE and intangible assets impaired	An impairment loss is the amount by which the carrying amount of an asset exceeds its recoverable amount. This ratio measures the value of assets impaired compared to the carrying value of property, plant and equipment (PPE) and intangible assets for a financial period.	$\frac{\textit{Impairment on PPE and Intangible assets}}{\textit{Carrying value of PPE and Intangible assets}} \times 100$

TABLE A.2: SERVICE DELIVERY RELIABILITY

PERFORMANCE MEASURE	DESCRIPTION	FORMULA
Asset availability	Availability measures the degree to which an asset is ready to be operated. There are several ways to measure asset availability, depending on the reasons factored that can cause an asset not to be available. Two measures of availability are:	$\frac{MTBF}{MTBF - MTTR}$ *where* *MTBF=mean time between failures of the asset* *MTTR=mean time to repair*
		$\frac{Uptime\ (hrs)}{Total\ available\ hrs^* - Idle\ hours} \times 100$ *Total available hrs* = (365 days x 24 hrs)* *= 8 760 hrs*
Asset uptime	Uptime is the amount of time an asset is actively producing a product or providing a service.	*Total available time – (Idle time + Total downtime)*
Asset downtime	Downtime is the amount of time an asset is not capable of running.	*Scheduled Downtime + Unscheduled Downtime*

TABLE A.3: MAINTENANCE ORGANISATION AND LEADERSHIP

PERFORMANCE MEASURE	DESCRIPTION	FORMULA
Maintenance training cost	This metric measures the annual investment in training in maintenance employees and is expressed as cost per employee.	$\frac{Total\ maintenance\ training\ cost}{Number\ of\ internal\ maintenance\ employees}$ OR as a percentage of the total maintenance labour cost: $\frac{Total\ maintenance\ training\ cost}{Total\ internal\ maintenance\ labour\ costs} \times 100$
Maintenance training hours	This metric measures the number of hours of training that maintenance personnel receive annually, and is expressed as hours per employee.	$\frac{Training\ hours}{Number\ of\ maintenance\ employees}$

PERFORMANCE MEASURE	DESCRIPTION	FORMULA
Rework	Rework is corrective work done on previously maintained equipment that has prematurely failed due to maintenance, operations or material problems. This metric identifies and quantifies work resulting from premature failures caused by errors in maintenance or operation of the equipment or material quality issues.	$\frac{\textit{Corrective work* identified as rework}}{\textit{Total maintenance labour hours**}}$ *Corrective Work is work done to restore the function of an asset after failure or when failure is imminent. **Maintenance Labour hours includes all hours for normal operating times, as well as outages, shutdowns and turnarounds.
Maintenance training return on investment	This metric is the ratio of the benefit to the cost of training internal maintenance employees. It is used to motivate investment in maintenance training.	$\frac{\textit{Business benefits}}{\textit{Maintenance training costs}} \times 100$

TABLE A.4: MAINTENANCE EQUIPMENT AND PROCESS RELIABILITY

PERFORMANCE MEASURE	DESCRIPTION	FORMULA
Extent of asset criticality assessment	This metric is the ratio of the number of assets in an asset portfolio for which criticality analysis has been done, divided by the total number of assets in the asset portfolio, expressed as a percentage. The aim is to identify those assets with the most serious consequences should they fail, and to focus management attention and prioritise resource allocation to these assets.	$\frac{\textit{Number of assets assigned a criticality rating}}{\textit{Number of assets in the asset portfolio}} \times 100$
Total downtime	This metric measures the total amount of time the asset has not been capable of running. It is identify problem areas to minimise downtime.	*Scheduled downtime + unscheduled downtime*

PERFORMANCE MEASURE	DESCRIPTION	FORMULA
Scheduled downtime	This metric allows evaluation of the total amount of time an asset has not been capable of running due to scheduled maintenance work. It can be used to analyse the impact of scheduled maintenance work on capacity and production, and to minimise downtime.	*Sum of asset downtime identified on the Weekly Schedule*
Unscheduled downtime	This metric allows evaluation of the time that an asset is not capable of running due to unscheduled repairs. It can be used to understand the impact of unscheduled work on capacity and production, and maintenance productivity in order to minimise downtime.	*Sum of asset downtime not included in the maintenance schedule*
Mean time to failure (MTTF)	The average length of operating time to failure of a component or asset. This is a measure of asset reliability and also known as Mean Life. This metric is used to assess the reliability of components or assets. Reliability is usually expressed as the probability that an asset or component will be perform its intended function without failure for a specified time period under specified conditions. A higher MTTF indicates higher asset/component reliability.	$\frac{\text{Operating time to failure (hrs)}}{\text{Number of assets/component runs to failure}} \times 100$
Mean time between failures (MTBF)	This is the average length of operating time between failures for an asset or component, and is a measure of reliability. Reliability is usually expressed as the probability that an asset or component will be perform its intended function without failure for a specified time period under specified conditions. An increase in MTBF indicates improved asset reliability.	$\frac{\text{Operating time (hrs)}}{\text{Number of failures}}$

PERFORMANCE MEASURE	DESCRIPTION	FORMULA
Mean time between maintenance (MTBM)	This metric measures the average length of operating time between one maintenance event and the next maintenance event for an asset or component. This metric is used to: • Assess the effectiveness of the maintenance approach for an asset or component; and to • Optimise maintenance scheduling and productivity by minimising the number of trips to a specific asset or component.	$\frac{\textit{Operating time (hrs)}}{\textit{Number of maintenance events*}}$ **Any maintenance, whether preventative or corrective, that causes the asset not to be available for service/production*
Mean time to repair (MTTR)	This is the average time needed to restore an asset to its full operational capabilities after a failure. It is expressed as the probability that an asset or component can be restored to its specified operable condition within a specified interval of time. MTTR is used to: • Measure the maintainability of a repairable asset or component; and/or • Assess the effectiveness of maintenance plans and procedures.	$\frac{\textit{Total repair time (hrs)}}{\textit{Number of repair events}}$
Mean downtime (MDT)	This metric measures the average downtime required to restore an asset or component to its full operational capabilities. It includes the time from failure to restoration of an asset or component.	$\frac{\textit{Total downtime (hrs)}}{\textit{Number of downtime events}}$

TABLE A.5: MAINTENANCE WORKS MANAGEMENT

PERFORMANCE MEASURE	DESCRIPTION	FORMULA
Preventative maintenance hours	This metric quantifies the percentage of maintenance labour hours used to perform fixed interval maintenance tasks, regardless of asset or component condition at the time. The aim of this metric is to quantify the labour resource impact of work done on preventive maintenance tasks. This metric provides insight into the quality of preventive activities, when compared to the percentage of labour hour trends of all maintenance work types.	$\frac{\textit{Preventative maintenance hours*}}{\textit{Total maintenance hours}}$ *X 100* **Maintenance labour hours needed to replace or restore an asset or component at fixed intervals, regardless of condition.*
Preventative maintenance cost	This metric measures the maintenance cost incurred to perform fixed interval maintenance tasks, regardless of asset or component condition at the time. This metric aims to quantify the financial impact of preventive maintenance tasks. This metric provides insight into the effectiveness of preventative maintenance activities compared to the percentage of cost trends of all maintenance work types.	$\frac{\textit{Preventative maintenance cost*}}{\textit{Total maintenance cost}}$ *X 100* **The labour, material and service cost (including preventative maintenance performed by operators).*
Corrective maintenance hours	This metric calculates the percentage of total maintenance labour hours used to restore an asset or component to a functional state after failure. This metric aims to quantify the labour resource impact of work done on corrective maintenance tasks.	$\frac{\textit{Corrective maintenance hours*}}{\textit{Total maintenance hours}}$ *X 100* **Labour employed to restore the function of an asset or component after failure. Includes both internal and external labour applied to corrective maintenance.*

PERFORMANCE MEASURE	DESCRIPTION	FORMULA
Corrective maintenance cost	This metric calculates the percentage of total maintenance costs incurred to restore an asset or component to a functional state after failure. It aims to quantify the financial impact of corrective maintenance tasks.	$\frac{\textit{Corrective maintenance cost*}}{\textit{Total maintenance cost}} \times 100$ **Corrective maintenance cost = Labour and materials, including contractor costs where applicable, for work done to restore the function of an asset or component after failure.*
Condition-based maintenance hours	This metric calculates the percentage of maintenance labour hours spend to measure, analyse and compare asset condition against standards or conventions to identify, analyse and correct condition-based issues. This metric quantifies the labour resource impact of condition-based (preventative) maintenance tasks.	$\frac{\textit{Condition-based maintenance hours*}}{\textit{Total maintenance labour hours}} \times 100$ **The percentage of maintenance labour hours used to measure, analyse and asset condition against standards/ conventions to detect, analyse and correct condition-based issues.*
Condition-based maintenance cost	This metric measures the maintenance cost incurred to measure, analyse and compare asset condition against known standards or conventions to detect, analyse and respond to condition-based issues.	$\frac{\textit{Condition-based maintenance cost*}}{\textit{Total maintenance cost}} \times 100$ **All costs incurred to undertake condition-based maintenance activities, including labour, laboratory and related services costs.*
Scheduled compliance hours	This metric measures adherence to the maintenance schedule expressed as a percentage of total time available to schedule. It measures compliance to the maintenance schedule and reflects the effectiveness of the work scheduling process and execution thereof.	$\frac{\textit{Scheduled work performed (hrs)*}}{\textit{Total time available to schedule (hrs)**}} \times 100$ **Actual hours worked on scheduled work as per the maintenance schedule.* ***Total labour hours available to schedule excluding vacation leave, sick leave and other time that maintenance staff is not available for maintenance operations e.g. training time.*
Scheduled compliance cost	This metric measures adherence to the maintenance schedule expressed as a percentage of total maintenance cost.	$\frac{\textit{Rand value of scheduled work performed (hrs)}}{\textit{Total maintenance cost}} \times 100$

PERFORMANCE MEASURE	DESCRIPTION	FORMULA
Maintenance shutdown cost	This metric measures the total cost incurred in a planned maintenance shutdown, expressed as a percentage of the total maintenance cost for the period in which the shutdown(s) occurred. The primary aim of this metric is to identify opportunities for cost reduction.	$\frac{\textit{Maintenance shutdown cost*}}{\textit{Total maintenance cost}} \times 100$ **Total cost incurred to prepare and execute all planned maintenance shutdown or outage activities. It includes staff costs incurred for planning and management of the maintenance activities related to shutdown and the cost of temporary facilities and rental equipment directly related to maintenance activities performed during the-shutdown.*
Actual cost vs. planning estimate	This metric is the ratio of actual cost incurred on a work order to the estimated cost for that work order. It measures the accuracy to which work is planned and the efficiency of planned work execution.	$\frac{\textit{Actual work order cost*}}{\textit{Planned cost**}} \times 100$ **The final cost of the work order after it is closed.* ***The planner's estimate of cost to complete the work order, excluding contingencies.*
Actual hours vs. planning estimate	This metric is the ratio of the actual number of labour hours reported on a work order to the estimated number of labour hours planned for that work order. It measures the accuracy with which work is planned and the efficiency of planned work execution.	$\frac{\textit{Actual work order hours*}}{\textit{Planned hours**}} \times 100$ **The quantity of hours reported on a work order after it is closed.* ***The planner's estimate of hours needed to complete the work order.*
Planning variance index	This metric measures the percentage of planned work orders closed where actual cost varied within acceptable parameters of the planned cost. An acceptable parameter would be normally be a variance of upto 15% variance. The aims of this measure is to determine the accuracy with which work is planned and the efficiency of the execution of planned work.	$\frac{\textit{Number of closed planned work orders where actual costs are within planned cost}}{\textit{Total number of planned work orders closed**}} \times 100$

PERFORMANCE MEASURE	DESCRIPTION	FORMULA
Planner productivity	This metric measures the average amount of planned work a maintenance planner delivers per month. It is calculated using either planned labour hours planned for, or number of job plans prepared.	$\text{Labour hours} = \frac{\text{Total of planned labour hours}}{\text{Number of months}}$ *AND/OR* $\text{Job plans} = \frac{\text{Number of job plans}}{\text{Number of months}}$
Work order aging	This metric measures the age of active work orders by using the "Work Order Creation Date" and comparing it to "Today's Date", expressed in number of days. This metric aims to: • Track work order aging to ensure effective work order backlog management; and to • Verify that the work order priority system is applied as planned. Work orders are typically classified into age range categories based on their individual age. Outputs of this metric can be used to: • Review and update the backlog; or to • Identify and rectify the causes of work orders that are not being completed in a timely manner, based on priority and age.	*Today's date – Work order creation date** **The date the work order was entered into the maintenance management system.*

<table>
<tr><th>PERFORMANCE MEASURE</th><th>DESCRIPTION</th><th>FORMULA</th></tr>
<tr><td>Work order cycle time</td><td>This metric measures the time taken from the creation of a work under until it is closed in the Maintenance Management System (MMS).

The aim is to measure how long it takes to complete work to aid future planning.

This metric can be further refined by analysing work order cycle times per type of work order.</td><td>Work order completion date* - Work order creation date

*The date the work order was closed in the MMS, and all data relevant to that work order has been captured within the MMS.</td></tr>
<tr><td>Preventative maintenance work orders overdue

(measured by date convention)</td><td>This metric is a measure of the total of all active preventive maintenance work orders (not yet actioned, ongoing or not closed) in the MMS not completed by the due date.

The aim is to review the preventative maintenance work order backlog, and to develop plans to address overdue tasks.</td><td>Work orders overdue = Current date – Due Date

Group overdue preventative maintenance work orders into categories based on the length of time that the order is overdue:

<table><tr><th>CATEGORY</th><th>CRITERION</th></tr><tr><td>1</td><td>Due date > 0 and <=30 days overdue</td></tr><tr><td>2</td><td>Due date > 30 and <=90 days overdue</td></tr><tr><td>3</td><td>Due date > 90 days overdue</td></tr></table></td></tr>
<tr><td>Preventative maintenance work orders overdue

(measured in hours)</td><td>This metric is a measure of the total of all active preventive maintenance work orders (not yet actioned, ongoing or not closed) in the MMS not completed by the due date.

The aim is to review the preventative maintenance work order backlog, and to develop plans to address overdue tasks.</td><td>Or if preventative maintenance is executed by hours:

<table><tr><th>CATEGORY</th><th>CRITERION</th></tr><tr><td>1</td><td>Hrs Past scheduled Time > 0; <= 25%</td></tr><tr><td>2</td><td>Hrs Past scheduled Time > 25%; <= 50%</td></tr><tr><td>3</td><td>Hrs Past scheduled Time >= 50%</td></tr></table>
(Current interval hours* - Planned interval hours**) / Planned interval hours X 100

* Number of actual operating hours on an asset since the last preventative maintenance task was performed.

** Number of planned operating hours on an asset between scheduled preventative maintenance tasks.</td></tr>
</table>

PERFORMANCE MEASURE	DESCRIPTION	FORMULA
Preventative maintenance yield	This metric measures the volume of corrective maintenance work that results directly from preventative maintenance work orders. The aim of this metric is to measure the effectiveness of preventative maintenance programmes in identifying potential failures.	$\frac{\textit{Corrective work identified from preventative maintenance work orders*}}{\textit{Preventative maintenance hours}} \times 100$ **Corrective work identified through preventive maintenance tasks and completed prior to asset failure.*
Inventory turnaround	This metric measures how often average inventory is "turned" during a given period (normally one year). It is an efficiency ratio that assesses the appropriateness of storeroom inventory levels.	$\frac{\textit{Value of inventory issued}}{\textit{Average inventory}}$
Stock-outs	This metric measures the frequency that stock is not available from stores when requested. A stock-out happens when the item requested is on the stores' inventory list, but there is insufficient or no stock available to fill the requisition. Stock-outs can delay maintenance operations and possibly production or service delivery. Common causes of stock-outs include: • Under-estimation of demand, and therefore ordering in insufficient quantities • Assuming a shorter lead time for delivery of stock than is the case • Late delivery by the supplier • Quality issues with the item, causing returns to the supplier • The safety stock level was set too low • The supplier does not delivery because of outstanding invoices to be paid	$\frac{\textit{Number of stores' requisition forms not met because of stock-outs}}{\textit{Total number of stores' requisition forms submitted}} \times 100$

PERFORMANCE MEASURE	DESCRIPTION	FORMULA
Maintenance material cost	This metric measures the total cost incurred for materials, supplies and consumables needed to undertake both preventative and corrective maintenance for a specified time period, expressed as a percentage of the total maintenance cost for the period. The aim is to monitor the contribution of maintenance material costs to total maintenance costs. This allows comparison to benchmarks to identify cost efficiency improvement opportunities.	$\frac{\textit{Maintenance material cost*}}{\textit{Total maintenance cost}} \times 100$ **Cost of all maintenance, repair and operating materials (MRO) used during the period, including stocked MRO inventory used, as well as materials, supplies and consumables directly purchased.*
Contractor cost	This metric measures contractor costs as a percentage of total maintenance costs incurred to maintain assets. The aim is to quantify contractor costs for comparison and benchmarking purposes.	$\frac{\textit{Contractor maintenance cost*}}{\textit{Total maintenance cost}} \times 100$ **Includes contractor maintenance labour and materials costs, as well as outages, shutdowns or turnarounds.*
Continuous improvement hours	This metric establishes the percentage of maintenance employee labour hours used on continuous improvement activities. This metric aims to track the investment in continuous improvement activities.	$\frac{\textit{Maintenance labour hours applied to continuous improvement*}}{\textit{Total maintenance employee hours}} \times 100$ **Continuous improvement initiatives and activities include, for example, work process redesign, lean maintenance, six sigma and work sampling.* *Aspects that could be improved include, for example, customer service, availability and reliability, maintainability, productivity, safety, environmental health and costs.*

APPENDIX B: EXAMPLES OF CONDITION GRADING

TABLE B.1: BATTERY AND BATTERY CHARGER CONDITION GRADING SCALE

GRADE	DESCRIPTION	DETAILED DESCRIPTION OF BATTERIES AND BATTERY CHARGER CONDITION
1	Very good	All battery elements intact, and no defects notable. No damage to cables or leaking from the battery or evidence of corrosion. No notable local hot spots.
2	Good	Minor deterioration (< 5%); on battery casing or cables, some surface damage but no excessive corrosion. No visible discharge. No evidence of overheating on charger plugs or sockets.
3	Fair	Functionally sound batteries and charger but showing signs of wear and tear (10-20%); minor corrosion evident and small amount of flexing on cables. Small amount of discharge from batteries; or larger amount from small proportion (10%). Notable hot spots - but only minor damage to elements wear it occurs. Further deterioration likely.
4	Poor	Significant deterioration of batteries and charger (20-40%); both still function but affected by deteriorated elements. Notable discharge occurring and flexing of cables. Hot spots and clearly worn or damaged areas around them. Overheating clearly evident on charger plugs and/or socket.
5	Very poor	Batteries or charger no longer functioning or clearly about to stop functioning (>50% needs replacement). Completely worn cables or discharge becoming hazardous. Charger plug or socket burned through. Batteries discharging faster than rated amp hours.

TABLE B.2: BITUMEN SURFACE CONDITION GRADING SCALE

GRADE	DESCRIPTION	DETAILED DESCRIPTION OF BITUMEN SURFACE CONDITION
1	Very good	Very few slight surfacing defects or no surfacing defects. No large or excessive cracking, no separation of aggregate or wearing course- no exposure to underlying areas.
2	Good	Acceptable condition, few surface defects. Slight evidence of surface cracking / surface failures / aggregate loss. Severity of defects is low.
3	Fair	Intermittent / scattered occurrence of surfacing defects with moderate severity (or general occurrence of minor defects). Binder becoming dull and brittle / distinct surface cracks visible from moving vehicle with some spalling / aggregate loss becoming easily discernible from moving vehicle / significant surface failure diameters of ~ 150mm. More severe surfacing defects are only localised in extent. Shoulder of road section showing erosion/ damage, some road edge breaks noted.
4	Poor	Significant deterioration of structure and/or appearance (20-40%); A general more frequent occurrence of surfacing defects with high severity. Binder dull and brittle / surface cracks opening up with spalling / aggregate loss easily discernible from moving vehicle / significant surface failure diameters of ~ 200mm and evidence of frequent larger potholes. Significant road edge breaks.
5	Very poor	An extensive occurrence of surfacing defects with high severity. Binder very dull and brittle / surface cracks open with severe spalling / general disintegration of surface layer / surface failure diameters of ~ 300mm over large areas, and many large potholes.

TABLE B.3: CAR PORT CONDITION GRADING SCALE

GRADE	DESCRIPTION	DETAILED DESCRIPTION OF CAR PORTS CONDITION
1	Very good	Excellent physical condition; very good strength and stability. No corrosion or damage evident. Paint not chipped, faded or cracking. Nets / roof with no visible holes or fading.
2	Good	Minor deterioration (< 5%); some surface damage to the structure but no excessive corrosion, staining or loss of stability. Paint only slightly faded. Nets / roof with no visible holes or fading.
3	Fair	Sound structure but showing signs of wear and tear (10-20%); visible corrosion and staining, weakness at joints and connections. Paint starting to look faded or crack/chip. Some small areas of damage to roof element.
4	Poor	Significant deterioration of steel structure and/or appearance (20-40%); significant loss of stability or deformation to structure, significant corrosion or staining. Paint chipped/ cracked and notably faded appearance. Nets / roof with notable holes or corrosion.
5	Very poor	Serious structural problems from corrosion or physical damage. Unsound (>50% needs replacement) no longer reliable as structure, about to collapse or majority of structure has collapsed. Potentially causing safety risk. Nets / roof at point of collapse or with expansive holes and corrosion.

TABLE B.4: CIRCUIT BREAKER PANEL CONDITION GRADING SCALE
TABLE B

GRADE	DESCRIPTION	DETAILED DESCRIPTION OF CIRCUIT BREAKER PANEL CONDITION
1	Very good	Well maintained and secured panel; all components intact, and no defects notable. No damage to wires or arcing of contacts. No noticeable local hot spots and all circuit breakers are operable.
2	Good	Minor deterioration (< 5%); some surface damage to the panel but no excessive corrosion, loose wires or arcing of contacts. All buttons/switches operate and bus bars secure. Only minor wear and tear on wires, breakers or circuit breaker.
3	Fair	Functionally sound circuit breaker panel but showing signs of wear and tear (10-20%); corrosion or exposed/loose components. Notable hot spots - but only minor damage to elements wear it occurs. Specific element not working. Some misalignment or heating evident of bushings, insulators or gaskets. Further deterioration likely.
4	Poor	Significant deterioration of circuit breaker panel (20-40%); function affected by deteriorated components. Notable arcing of contacts and wear and tear on wiring, breakers or insulators. Missing or notably loose components; or excessive corrosion to panel. Deteriorated elements e.g. breakers or bus bars, affecting function. Hot spots and clearly worn or damaged components where they occur. Gas or oil leak noted, component will be barely serviceable.
5	Very poor	Circuit breaker panel not serving purpose due to serious physical defects; unsound (>50% needs replacement). Elements getting stuck, major corrosion to elements and not serviceable. Not able to function or evidently about to fail in performing function.

TABLE B.5: CULVERT CONDITION GRADING SCALE

GRADE	DESCRIPTION	DETAILED DESCRIPTION OF CULVERT CONDITION
1	Very good	Well maintained culvert structure and wing walls, no spalling and/or cracks, excellent physical condition; very good strength and stability.
2	Good	Minor deterioration (< 5%); some surface damage to the structure but no excessive corrosion, staining, cracking or loss of stability. No erosion around wing walls.
3	Fair	Functionally sound culvert but showing signs of wear and tear (10-20%); some minor cracking, staining or signs of tree root penetration. Some erosion occurring around wing walls. Evidence of minor concrete deterioration. (Corrosion on galvanised steel culvert occurring)
4	Poor	Significant deterioration of culvert structure and wing walls structure and/or appearance (20-40%); culvert functioning but problems owing to significant infiltration, loss of stability or deformation, significant cracking and other physical damage.
5	Very poor	Serious structural problems having a detrimental effect on the performance of the culvert. Unsound (needs replacement).

TABLE B.6: FIRE PROTECTION CONDITION GRADING SCALE

GRADE	DESCRIPTION	DETAILED DESCRIPTION OF FIRE PROTECTION CONDITION
1	Very good	Sound physical condition – no evident problems. No loose wires/ incidents of faulty equipment. No leaks and regularly serviced.
2	Good	Minor deterioration due to normal wear and tear (< 5% of component), sound structural condition – no evident problems. No loose wires/ incidents of faulty equipment. No leaks and serviced regularly. Water pressure adequate and seals only showing slight aging.
3	Fair	Marginal, clearly evident deterioration (10-20%). Loose wires occurring in some equipment in the building but no incidents of faulty equipment or leaks occurring. Water pressure adequate and seals showing evident aging. Further deterioration likely.
4	Poor	Significant deterioration of appearance (20-40%). Loose wires evident and some incidents of faulty equipment or leaks occurring. Water pressure is low and seals at point of breaking. Detection elements faulty or physically damaged, hoses notably worn and some sprinkler fixtures missing.
5	Very poor	>50% of equipment need replacing, serious repairs or is missing. Deterioration will cause secondary damage to structure through leaking. Exposed wiring evident, water pressure low and seals in-adequate. Equipment un-serviceable and building posing public health and safety risk.

TABLE B.7: LOAD CONTROL SET CONDITION GRADING SCALE

GRADE	DESCRIPTION	DETAILED DESCRIPTION OF LOAD CONTROL SET CONDITION
1	Very good	Well maintained and secured load control set; all components intact, and no defects/surface damage or abnormal sounds.
2	Good	Minor deterioration (< 5%); some surface damage to the enclosure structure but no excessive corrosion on housing/chassis, no loose connections, all components intact. Serves purpose.
3	Fair	Functionally sound load control set, but showing signs of wear and tear (10-20%); some significant surface damage to external structure (enclosure). Noticeable rattle in the structure.
4	Poor	Significant deterioration of unit (20-40%); load control set functioning but problems owing to significant physical damage to structure; burns, corrosion, and missing or loose components; damaged readings display.
5	Very poor	Load control set not serving purpose due to serious physical defects; unsound (>50% needs replacement).

TABLE B.8: PLUMBING CONDITION GRADING SCALE

GRADE	DESCRIPTION	DETAILED DESCRIPTION OF PLUMBING CONDITION
1	Very good	Sound physical condition – no evident problems. No leaking, no staining of toilets/basins, no elements missing or obviously damaged. Pipes and bathroom fixtures in-tact.
2	Good	Normal wear and tear of elements (< 5% of component), but still function smoothly. No leaking or missing components. Minor staining and infrequent cracking on small proportion of components.
3	Fair	Marginal, clearly evident deterioration on components (10-20%). Minor components need replacement or repair but still functional at adequate level of service. Infrequent leaks noted - around some taps or toilet fixtures. Minor staining or basins or toilets. Occasional missing elements - not affecting overall provision of plumbing to building. Further deterioration likely.
4	Poor	Significant deterioration of appearance (20-40%). Sanitary ware damaged, notable leaks in pipes, taps or toilets. Missing components starting to affect provision of plumbing service to building (no toilet seats on majority of toilets, taps can't open/close). Noted wet spots around plumbing fixtures - deterioration affecting other components. Cracks and staining on toilet bowls/seats and on the basins.
5	Very poor	More than 20% of sanitary systems not working and leaks evident. Severe aesthetic deterioration and >50% needs replacing - notable leaks and staining to components. Might cause a health and safety risk and damage to other building elements. Major work or replacement required urgently

TABLE B.9: PUMP CONDITION GRADING SCALE

GRADE	DESCRIPTION	DETAILED DESCRIPTION OF PUMP CONDITION
1	Very good	Pump in sound physical condition, operable and well-maintained, no visible leaks, all bolts and fasteners in place and tightened. Pump performing to design standard.
2	Good	Acceptable physical condition of pump but showing minor deterioration (< 5%). Performance not affected.
3	Fair	Functionally sound pump, but showing some deterioration (10-20%). Some moving parts require lubrication, loose bolts and/or fasteners. Work required but pump is still serviceable.
4	Poor	Pump functional but damage affecting performance, notable physical deterioration (20-40%), visible leakage, corrosion and mechanical damage. Substantial work required in the short-term, pump barely serviceable.
5	Very poor	A high risk of breakdown with a serious impact on performance. Pump has serious physical defects; major leaks; high noise levels. Unsound (> 50% needs replacement).

TABLE B.10: ROAD AND PEDESTRIAN BRIDGE SUPER-STRUCTURE CONDITION GRADING SCALE

GRADE	DESCRIPTION	DETAILED DESCRIPTION OF ROAD AND PEDESTRIAN BRIDGE SUPER-STRUCTURE CONDITION
1	Very good	Sound physical condition; no structural damage. No evidence of impact damage. No obvious cracking. Expansion joints clear of grit and visibly in-tact. No evident cracking or corrosion on edge beams. No encroaching vegetation.
2	Good	Minor deterioration (< 5%); No evident structural damage, hairline cracking on edge beams. Expansion joints showing minor wear and tear. No visible corrosion.
3	Fair	Moderate deterioration evident (10-20%); some cracking and/or corrosion visible. Isolated areas of damage on structure. Some encroaching vegetation. Minor drainage issues.
4	Poor	Significant deterioration of structure and/or appearance (20-40%); structural cracks, or serious concrete spalling or extensive corrosion evident on edge beams. Expansion joints exhibiting notable wear and tear. Notable encroaching vegetation. Significant drainage problems. Levels between bridge and approaches affected.
5	Very poor	Structurally failed or failure imminent, severe structural damage. Severe concrete spalling or severe corrosion evident on edge beams, reinforcing bar exposed. Expansion joints worn down or blocked with grit. Drainage not functioning correctly. Health and safety hazards exist which present a possible risk to public or staff safety.

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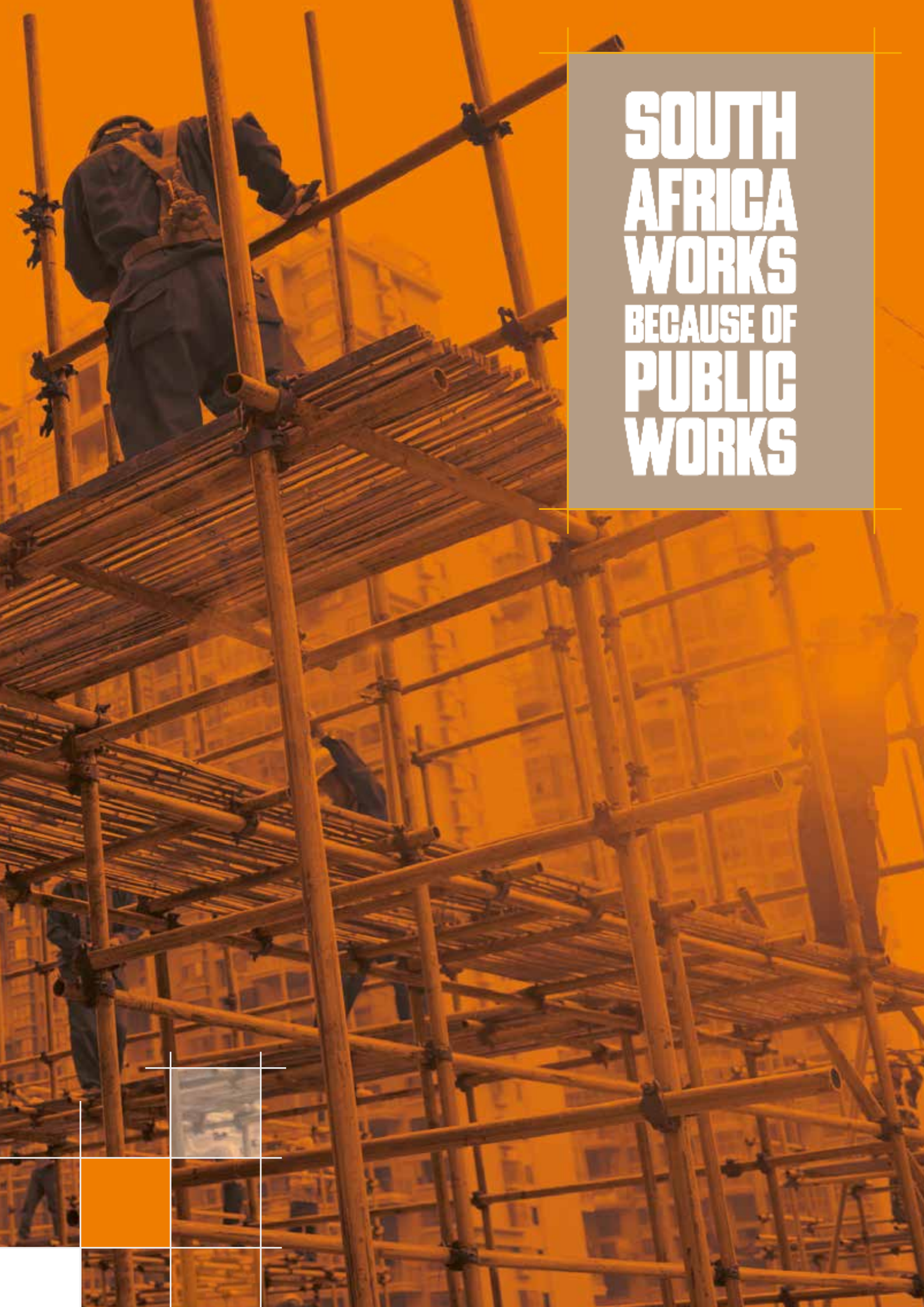
NOTES



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July 2017