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Please note that this working draft has not been revised to follow the clause sequence or contents given in PC251/N46 ISO/WD XXXX-Y Asset management – Requirements. Apart from some very minor edits, it is the same draft that was provided as part of the NWIP

For the moment, please examine the guidance at a general level to see where additional material may be necessary, or current content omitted.

Please do not comment on the text contained within the marked boxes, as this is (or will be) taken directly from ISO XXXX-Y.

Please submit any comments in the template provided in PC251/N51, before **28 January 2011**

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Asset management — Guidelines for the application of ISO XXXX-Y

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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ISO XXXX-Z was prepared by Technical Committee ISO/TC 251, *Asset Management*

ISO XXXX consists of the following parts, under the general title *Asset management*

- Part X *Overview, principles and terminology*
- Part Y *Requirements*
- Part Z *Guidelines for the application of ISO XXXX- Part Y*

Introduction

For the purposes of this Part of ISO XXXX, asset management is defined in ISO XXXX-X, 3.2 as the:

systematic and coordinated activities and practices through which an organization optimally and sustainably manages its assets and asset systems, their associated performance, risks and expenditures over their life cycles for the purpose of achieving its organizational strategic plan

where an organizational strategic plan is defined in ISO XXXX-X 3.25 as the:

overall long-term plan for the organization that is derived from, and embodies, its vision, mission, values, business policies, stakeholder requirements, objectives and the management of its risks

Effective implementation of asset management requires a disciplined approach which enables an organization to maximise value and deliver its strategic objectives through managing its assets over their whole life cycles. This includes determination of appropriate assets to acquire or create in the first place, how best to operate and maintain them, and the adoption of optimal renewal, decommissioning and/or disposal options.

ISO XXXX-Y specifies the requirements for an asset management system. It can be used by an organization to establish an asset management system for optimally and sustainably managing its physical assets and asset systems over their life cycles.

This Part of ISO XXXX gives guidelines for the application of ISO XXXX-Y. It quotes the specific requirements from ISO XXXX-Y and follows with relevant guidance. Text given with an outlined box is an exact duplication of text from ISO XXXX-Y

This is the third Part of ISO XXXX on the topic of asset management, out of a family of three such standards; the others being:

ISO XXXX-X Asset management – Overview, principles and terminology

ISO XXXX-Y Asset management – Requirements

It is recommended that these other two Parts of ISO XXXX be read in conjunction with this one.

Asset management — Guidelines for the application of ISO XXXX-Y

1 Scope *(as amended at the "preliminary" meeting)*

This Part of ISO XXXX provides guidelines for the application of the requirements specified in ISO XXXX-Y. It provides guidance on the establishment, implementation, maintenance and improvement of a management system for asset management, and its coordination with other management systems.

This Part of ISO XXXX is applicable to all types and sizes of organization

This Part of ISO XXXX does not create any additional requirements to those specified in ISO XXXX-Y.

This Part of ISO XXXX consists of guidance and recommendations and is not intended for certification, regulatory, or contractual use.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO XXXX-X Asset management – Overview, principles and terminology

3 Terms and definitions

For the purposes of this Part of ISO XXXX, the terms and definitions in ISO XXXX-X *Asset management – Overview, principles and terminology*, apply.

4 Asset management system requirements

4.1 General requirements

The organization shall establish, document, implement, maintain and continually improve an asset management system in accordance with the requirements of this Part of ISO XXXX.

The organization shall define and document the scope of its asset management system.

Where an organization chooses to outsource any aspect of asset management, the organization shall ensure control over such aspects in accordance with the requirements of 4.4.2.

NOTE This Part of ISO XXXX requires that organizations establish, implement and maintain an asset management policy, strategy, objectives and plans. Figure 5 in ISO XXXX-X illustrates the relationship between the organizational strategic plan and these elements of the asset management system.

The above requirement is a general statement concerning the establishment and maintenance of an asset management system within an organization. “Establish” implies a level of permanency and the system should not be considered established until all its elements have been demonstrably implemented. “Maintain” implies that, once established, the system continues to operate appropriately – this requires active effort on the part of the organization. Many systems start well but deteriorate due to lack of review and maintenance. Several elements of ISO XXXX-Y (such as performance assessment and improvement 4.6, and management review 4.7) are designed to ensure active maintenance of the asset management system.

An organization seeking to establish an asset management system that conforms to ISO XXXX-Y should determine its current position with regard to its asset management by means of a review (see 4.1.2). In determining how it will fulfil the requirements of ISO XXXX-Y, the organization should consider the conditions and factors that affect, or could affect, its asset management; what policies it needs, and how it will manage its asset management risks. The level of detail and complexity of the asset management system, the extent of the documentation, and the resources devoted to it, are dependent on the nature size, structure, complexity) of an organization and its activities.

4.1.1 Asset management system

Organizations seeking to establish asset management systems that conform to ISO XXXX-Y should follow the recommendations and guidance provided below.

- a) The organization should establish and maintain an asset management system that conforms to all of the requirements of ISO XXXX-Y. This should also assist the organization in meeting legal, regulatory, statutory and other asset management related requirements that are applicable to it.
- b) The level of detail and complexity of the asset management system, the extent of documentation and the resources devoted to it are dependent on the size of the organization and the nature of its activities. The system should be of appropriate depth, detail and coverage to enable the organization to meet all of the requirements of ISO XXXX-Y.

NOTE Some organizations call this an Asset Management Regime or an Asset Management Business Model.

- c) An organization has the freedom and flexibility to define the boundaries of the asset management system and may choose to implement ISO XXXX-Y with respect to the entire organization, or to specific operating systems or units of the organization. However, care should be taken in defining the boundaries and the scope of the asset management system. The scope of the asset management system should cover the full portfolio of assets that are required for the successful delivery of the organizational strategic plan and not exclude any assets or asset systems that are critical to the business goals.
- d) It is likely that the organization’s asset management system draws upon processes already in existence and controlled within its quality, environmental and health and safety management systems, etc. While

there is no need to establish a separate asset management system in such cases, care should be taken to ensure that processes work together to form an effective overall system, and that there is effective control of this entire system by the relevant management and other personnel.

4.1.2 Review against ISO XXXX-Y

An organization seeking to develop and implement an asset management system which conforms to ISO XXXX-Y should conduct a review to compare the organization's current management of its assets against the requirements of ISO XXXX-Y and determine the extent to which these requirements are being met or whether improvements can be made. Such a review should map the requirements of ISO XXXX-Y against the organization's existing business processes to identify alignments and/or variations in terminology between the two.

The review will provide information which an organization can use to identify if there are any existing gaps in the asset management system with respect to the ISO XXXX-Y requirements, and will guide the organization in formulating plans for implementing and prioritizing improvements. Note, however, that compliance with all the requirements of ISO XXXX-Y represents the minimum standard that should be regarded as good asset management practice – it does not represent “best practice”, and should not be seen as a limiting goal (some organizations may need or wish to exceed the requirements of ISO XXXX-Y in their management of assets).

The aim of a review should be to consider how delivery of the organizational strategic plan is supported by, and reflected in the design of, the asset management system. An organization should consider, but not limit itself to, the following items within its review:

- the organizational strategic plan;
- legal, regulatory and other mandatory requirements;
- identification and evaluation of the asset management risks faced by the organization;
- existing asset management practices, process(es) and/or procedure(s);
- the performance of the assets and asset systems (including suitability, utilization, condition, longevity and costs);
- feedback from the investigation of previous incidents, accidents and emergencies;
- relevant management systems, competencies and available resources (internal and external).

A suitable approach to the review can include the use of checklists, interviews, direct inspection and measurement, results of previous management system audits or other reviews depending on the nature of the organization's activities. Where asset management processes already exist, they should be reviewed for adequacy against the requirements of ISO XXXX-Y.

It is emphasized that a review against ISO XXXX-Y is not a substitute for the implementation of the structured, systematic approach to asset management and adoption of continual improvement processes as described in 4.6 and 4.7. However, a periodic review can provide additional inputs to the planning of these processes.

4.2 Asset management policy

The organization's top management shall authorize an overall asset management policy.

The policy shall:

- a) be derived from, and be consistent with, the organizational strategic plan;
- b) be appropriate to the nature and scale of the organization's assets and operations;
- c) be consistent with other organizational policies;
- d) be consistent with the organization's overall risk management framework;
- e) provide the framework which enables the asset management strategy, objectives and plans to be produced and implemented;
- f) include a commitment to comply with current applicable legislation, regulatory and statutory requirements and with other requirements to which the organization subscribes;
- g) clearly state the principles to be applied, such as the organization's approach to health and safety or sustainable development;
- h) include a commitment to continual improvement in asset management and asset management performance;
- i) be documented, implemented and maintained;
- j) be communicated to all relevant stakeholders, including contracted service providers, where there is a requirement that these persons are made aware of their asset management policy-related obligations;
- k) be reviewed periodically to ensure that it remains relevant and consistent with the organizational strategic plan.

NOTE 1 Organizations may choose to have a detailed asset management policy for internal use which should provide sufficient information and direction to drive the asset management system (parts of which may be confidential) and have a summarized (non-confidential) version for dissemination to its stakeholders.

NOTE 2 Organizations may also have one or more functional policies relating to specific asset management activities, such as capital investment, operation, maintenance or contracting. It is essential, however, that alignment is maintained between such functional policies and the overall asset management policy.

Organizations seeking to implement the requirements of ISO XXXX-Y on asset management policy, should consider the recommendations and guidance provided below:

- a) The asset management policy plays a leading part in driving the asset management system. The asset management policy is a means for top management to communicate to its managers, employees and stakeholders the organization's position and intentions with regard to asset management. It provides a high level statement of the organization's principles, approach and expectations relating to asset management. The asset management policy should be seen as the same level of commitment as an organization's safety policy. For example, the policy might start with the following:

We are committed to maximizing the return on our shareholder's investments through providing high value services to our customers in a legally and environmentally compliant and sustainable manner, without compromising the health and safety of our employees, customers or the public. We shall achieve this by ...

The asset management policy provides the framework around which the asset management strategy, objectives and plans are developed and implemented. The asset management policy should be drafted in such a way as to be consistent with the organization's overall approach to risk management.

- b) Top management should arrange for the production of the asset management policy. The steps to forming, implementing and maintaining the asset management policy would typically be as follows:
- Identify the requirements of the organizational strategic plan in terms of how it will be achieved through the management of the physical assets, and the principles that should be applied. These should reflect the requirements and potentially conflicting expectations of the organization's stakeholders.
 - The asset management policy should clearly define how it facilitates, supports and enables achievement of the organization's vision, mission and business objectives and align with the organization's other policies (such as safety and environmental policies). It should consider risks, objectives, strategy, constraints, boundaries, timescales and responsibilities.
 - Identify all legal, regulatory, statutory and other top management designated, mandatory asset management requirements (i.e. it is usual to include a compliance statement in the asset management policy).
 - Develop and agree the draft asset management policy at top management level, ensuring it is consistent with the organizational strategic plan.
 - Discuss the draft policy with the organization's relevant managers, employees and other stakeholders. Amend accordingly to achieve an appropriate level of consensus.
 - Ensure the policy is worded in a form and style that can be understood by all those to whom it is to be communicated.
 - Communicate the asset management policy to the relevant managers, employees and other stakeholders. This can be achieved by posting the document on notice boards, intranet, internet and by face-to-face activities such as briefings, meetings, etc. Many organizations display the policy prominently within their premises. Others use electronic means, e.g. via an intranet. The visible endorsement of top management is important in achieving the appropriate level of attention and commitment.
 - Ensure that the asset management policy has been communicated to all relevant personnel, and that it has been understood and accepted, i.e. check understanding throughout the business.
 - Ensure that the asset management policy remains relevant and is being complied with. It is essential that the asset management policy remains "alive" and relevant to the changing influences of business drivers and obligations.
- c) A policy statement could be used in a court of law, either in favour of the organization or against it. Therefore it would be prudent to have it reviewed by a person who is competent in legal matters.
- d) Adherence to the asset management policy is fundamental to the effective, efficient and safe management of an organization. Top management should therefore provide adequate arrangements (such as resources, communication, facilities, supervision and training) to ensure that the asset management policy is adhered to.
- e) It is important that, when developing its asset management policy, an organization considers the issues of sustainable development – an enduring, holistic approach to economic activity, environmental

responsibility and social progress. It should also consider how it can maintain an appropriate trade-off between long- and short-term requirements. The growing importance of climate change and its associated risks should not be underestimated in doing so.

- f) The asset management policy should be regularly reviewed, at a frequency determined by the organization, and following significant changes to the operational context of the organization. Issues identified should be addressed and changes, where appropriate, should be implemented. These reviews serve two purposes:
- to ensure that the asset management policy is current and effective;
 - to ensure that the policy is continuously improved in light of developments in appropriate fields such as technology, operations, asset care techniques, etc.

4.3 Asset management strategy, objectives and plans

4.3.1 Asset management strategy

The organization shall establish, document, implement and maintain a long-term asset management strategy which shall be authorized by top management.

NOTE 1 The time horizon for a long-term asset management strategy would normally be aligned with that of the organizational strategic plan.

The strategy shall:

- a) be derived from, and be consistent with, the asset management policy and the organizational strategic plan;
- b) be consistent with other organizational policies and strategies;
- c) identify and consider the requirements of relevant stakeholders;
- d) consider the life cycle management requirements of the assets;
- e) take account of asset-related risks (see 4.4.7), asset and asset system criticalities;
- f) identify the function(s), performance and condition of existing asset systems and critical assets;
- g) state the desired future function(s), performance and condition of existing and new asset systems and critical assets, on timescales aligned to those of the organizational strategic plan;
- h) clearly state the approach and principal methods by which assets and asset systems will be managed;

NOTE 2 This may include, for example, the criteria to be adopted for determining asset criticality and value, the life cycle and sustainability basis for asset management planning, the approach to asset risk and reliability management and the methods of optimization and decision-making.

- i) provide sufficient information, direction and guidance to enable specific asset management objectives and asset management plan(s) to be produced;
- j) include criteria for optimizing and prioritizing asset management objectives and plans;
- k) be communicated to all relevant stakeholders, including contracted service providers, where there is a requirement that these persons are made aware of their asset management strategy-related obligations;
- l) be reviewed periodically to ensure that it remains effective and consistent with the asset management policy and organizational strategic plan and with other organizational policies and strategies.

Organizations seeking to implement the requirements of ISO XXXX-Y on asset management strategy, should consider the recommendations and guidance provided below:

- a) The asset management strategy should set out how the asset management policy will be achieved. It is the co-ordinating mechanism for ensuring that activities carried out on physical assets are aligned to optimally achieve the organizational strategic plan. This requires a high level plan or scheme for converting the asset management policy into specific asset management objectives and activity plans across the whole asset portfolio.
- b) The asset management strategy should describe, at a high level, the mechanisms for achieving the requirements of ISO XXXX-Y throughout the activities of the business (including the methods of prioritization, optimization, sustainability and risk management). Where appropriate, this should also include reference to required performance and condition requirements for assets, or provide guidance to ensure that these are set out in derived asset management objectives and associated procedures or functional specifications.
- c) The asset management strategy should make reference to improvement programmes, and provide long-term guidance on continuous improvement. The duration of “long-term” will be dependent on the asset management policy and will vary from one organization to another and from one industry sector to another.
- d) The asset management strategy is often set out in terms of the major business functions (or organizational goals), natural groupings of the asset portfolio (for example, sites, areas or business units) or in terms of logical asset life cycle phases, ensuring the co-ordination and alignment of activities, processes and enablers (such as asset information).
- e) The asset management strategy should include references to strategic approaches to be adopted to enable the delivery of the asset management policy, such as whole -life costing, risk management and sustainability. This should be sufficiently detailed to enable their consistent and integrated application across the asset management system, and to provide adequate guidance for application through operational documents such as functional policies, and the development of appropriate improvement initiatives.
- f) The asset management strategy should be realistic, well thought out, appropriately detailed and it should take account of the views of all relevant stakeholders. Failure to do this could lead to unnecessary or inappropriate work being done, or failure to meet key business objectives.
- g) When establishing and reviewing its asset management strategy, the organization should ensure that it is derived from, and consistent with, its asset management policy, organizational strategic plan and other organizational strategies. The organization should also consider the following items:
 - stakeholder requirements/expectations that influence the management of the assets (including legal, regulatory, statutory and other asset management requirements);
 - the previous asset management strategy, if applicable, and any need for a transition plan;
 - existing asset management plan(s), if applicable;
 - changes in priorities that the organization is aware of, or that might arise in the future;
 - the forecast demand for the service or the product (including demographic and geospatial information and relevant trends);
 - the predicted availability and cost of necessary resources, raw materials and essential supplier services;
 - asset-related risks;
 - the physical condition of the assets, age profile, flexibility and suitability for the desired usage;

- asset deterioration mechanisms, and failure modes and effects;
 - historical asset-related information such as reliability, maintenance records, operational performance and condition data;
 - criteria for capital investments and for comparing options;
 - methods for determining optimum operating and maintenance strategies, including resources, task justifications and intervals, process(es) and/or procedure(s) and standards;
 - methods for efficient delivery of work and resources, such as work management systems, project and resource planning;
 - constraints including legal, regulatory, statutory, financial, resources, physical access, logistics and timescales;
 - the results of benchmarking, audit results and assessments of current and best practices;
 - the results of the management review (see 4.7);
 - scenario planning, “what if?” analysis, and contingency planning, i.e. considering the effects of unexpected events and possible responses. Scenario planning can become a complex task, therefore the organization should use appropriate tools and techniques;
 - sensitivity analysis: changing the values of key variables and assumptions in order to determine which are the most sensitive to fluctuations, thereby identifying risks and any requirements for improving the accuracy of the analysis. Organizations should use appropriate tools and techniques to carry out sensitivity analysis;
 - opportunities to achieve the asset management strategy in a more cost effective way, i.e. attaining the same objective at lower costs without compromising sustainability or risk exposure levels. Such opportunities can be identified through advances in technology, management practices, contractual arrangements, partnering, etc.;
 - opportunities to add value, i.e. increasing the worth of an asset/asset system compared to its costs, e.g. generating income from sharing an underused asset/asset system with another operator.
- h) The asset management strategy should demonstrate how the asset management policy is to be implemented and how it will support the organizational strategic plan. It should include the following items:
- the desired outcomes related to the existing or new asset(s);
 - the summaries of broad plans and programmes to achieve these desired outcomes with defined timescales and responsibilities. These should also include details of the resources that are needed to deliver the plans and the actions required to secure them;
 - the assumptions made and financial costing if appropriate;
 - the targets against which the performance of the asset management strategy can be measured (see 4.6.1).
- i) The means to effectively measure and report the performance and success of the asset management strategy should be described. In addition to targets, organizations should use a coordinated set of key performance measures to help them achieve this.
- j) The following is an example of a typical asset management strategy, derived from an organization's business strategy:

1) Business strategy

To improve the current profit before tax by 15% within a period of 3 years through expanding capacity to meet the predicted 10% increased customer demand, funded through private finance, which will be repaid through future profits.

2) Corresponding asset management strategy

To upgrade the core infrastructure, to meet the increased demand, by efficiently investing up to £XXm investment over the next 5 years and development and implementation of optimal operating and maintenance strategies.

4.3.2 Asset management objectives

The organization shall establish and maintain asset management objectives, which shall:

- a) be measurable (i.e. quantified and/or capable of being demonstrated as achieved through objective assessment);
- b) be derived from, and consistent with, the asset management strategy;
- c) be consistent with the organization's commitment to continual improvement;
- d) be communicated to all relevant stakeholders, including contracted service providers, where there is a requirement that these persons are made aware of their obligations;
- e) be reviewed and updated periodically by the organization to ensure that they remain relevant and consistent with the asset management strategy;
- f) consider legal, regulatory, statutory and other asset management requirements;
- g) take account of the expectations of relevant stakeholders and financial, operational and business requirements;
- h) take account of asset management related risks;
- i) consider improvement opportunities including new technologies and asset management tools, techniques and practices (see 4.6.5.2).

NOTE Objectives may be set for the asset management system, asset management activities and/or the performance or condition of asset systems or assets.

Organizations seeking to implement the requirements of ISO XXX1 on asset management objectives, should consider the recommendations and guidance provided below:

- a) It is necessary to ensure that measurable asset management objectives are established throughout relevant parts of the organization to enable the asset management policy to be implemented and the asset management strategy to be achieved.
- b) Asset management objectives should be derived from, and be consistent with, organizational objectives.
- c) Using pertinent information or data, appropriate levels of management should identify, establish and prioritize asset management objectives. During the establishment of asset management objectives, consultation with those most likely to be affected should assist in ensuring that the objectives are reasonable and more widely accepted. To help ensure achievable asset management objectives are set,

it is also useful to consider information or data from sources external to the organization, for example, contractors, key suppliers or other stakeholders.

- d) Asset management objectives should be kept to a limited number of clear goals and should be as “SMART” as possible, i.e.:
- Specific
 - Measurable
 - Achievable
 - Realistic
 - Time-based
- e) Care should be taken not to set asset management objectives without due consideration of the cost (including lost income) of achieving those objectives. Potential conflict between objectives should also be identified and resolved. This will involve consideration of the business impact for each objective, and optimization (see 4.3.3.2) to determine the best value combination of partial achievements.
- f) The following provides an example of two asset management-related objectives developed within the same organization:

To satisfy a 10% demand growth within three years, and provide a minimum of 15% return on investment, without compromising health and safety. Timetables that deliver a train every five minutes in central areas and every 10 minutes elsewhere – all day, every day.

Using the above examples as illustrations, the organization should ensure that:

- the objectives are achievable, i.e. they are technically feasible, affordable, resources capable, timescales viable, etc.
 - any inherent conflict is resolvable, i.e. the expenditure and resources necessary to deliver the stated service (train every five minutes) will not prevent the organization from achieving a “15% return on investment”. “Stretch” targets are valuable, provided that those charged with achieving them can be persuaded of their achievability.
- g) Wherever possible, ratios of output to cost or input (such as the unit cost of service or product) are preferable. Objectives (or targets) set without due consideration of the associated cost/income might be counterproductive and act to the overall detriment of the organization. Similarly, absolute requirements on maximum expenditure, or reductions in costs, should be avoided as they can lead to unnecessary lost opportunities or false economies. However, it is acknowledged that in certain circumstances it will be impracticable to set objectives as ratios, and absolute requirements will be appropriate (such as those driven by new legislation).
- h) Asset management objectives may take the form of specific performance and condition targets, these are discussed further below.

The asset management performance and condition targets should translate the organizational strategic plan and associated asset management policy, strategy and objectives into practical measures that can be achieved and maintained through asset management plan(s) and operational control. Targets should be optimized in terms of asset performance and/or condition, cost and retained risk. Optimized performance and/or condition targets should be established through an iterative process between the asset management policy, strategy and objectives. However, organizations should also consider that any changes, such as those to the asset management plan(s) and operational control, can affect the optimized targets. This might require the targets to be re-optimized.

Without a clearly defined organizational strategic plan and the associated asset management policy, strategy and objectives, it is difficult to set appropriate and realistic performance/condition targets for the assets.

Asset performance/condition targets can be measures of:

- service/supply standards;
- levels of service/supply;
- reliability, availability, maintainability;
- functionality;
- survivability;
- capacity, output quantity, output quality;
- customer satisfaction;
- safety and/or environment impact;
- legislative, regulatory or statutory compliance or a combination of the elements above.

Performance targets should be aligned with, and provide adequate coverage of, business objectives.

Care should be taken in defining performance targets that focus on isolated aspects of performance. Many of the potential metrics for an asset management system refer to interrelated behaviours of the system, whose net effects should be addressed using an holistic approach. Poor definition of performance targets might encourage individual activities to be managed in isolation, without due consideration of their impact on overall system performance and to the overall detriment of the organization.

For example, a target focussed solely on maintenance expenditure might encourage efforts to reduce this cost, without due regard to the impact on the organization that might arise from any resulting increase in plant failures and downtime. Where possible, this should be addressed by defining performance targets in the form of ratios, such as cost of maintenance per unit of production/uptime/ service/income.

The essence and challenge of asset management is to align the performance of the assets with the organizational strategic plan. In order to achieve this, the objectives have to be translated into practical targets and measures for the assets. The following provides an example of this process:

Asset management objective: timetables that deliver a train every five minutes in central areas and every 10 minutes elsewhere – all day, every day.

Achieving this objective would require:

- a certain number of trains with a specified level of availability;
- a specified level of availability of the infrastructure system including track, signals, switching gear, power, etc.;
- scheduling systems and resources to ensure appropriate operators, train dispatch and timing controls.

The optimum level of availability for such a complex system could be best determined through simulation modelling. The output of such modelling would provide optimum availability targets for individual components (train, track, signals, etc.) and for the whole system. Therefore the output of such analyses would be the performance target for a component asset/asset system and might be similar to the following:

To achieve an average of 97% system availability on the route.

Such an availability target assumes reliability characteristics for each component of the system, normally expressed as Mean Time Between Failure (MTBF) or Mean Time To Failure (MTTF) and Mean Time To Repair (MTTR). Such component characteristics may be estimated directly, or calculated from reliability studies, risk assessments, deterioration modelling or optimization studies.

System performance modelling in this manner can:

- establish whether an objective is realistic;
- establish optimized plans for achieving its objectives (including design specifications, maintenance schedules and capital investments);
- identify the assets (or their components) that are critical to achieving the objective;
- determine the probable total cost of achieving such an objective;
- provide a baseline against which to measure actual performance (thereby verifying/updating assumptions and improving future prediction accuracy).

Other factors also have to be considered in determining and achieving the availability of the system, such as human performance, resources, knowledge, skills, motivation/culture and cash flow constraints. However, these can all be taken into account during the modelling process, and explored for potential business impact or sensitivity.

4.3.3 Asset management plan(s)

The organization shall establish, document and maintain asset management plan(s) to achieve the asset management strategy and deliver the asset management objectives across the following life cycle activities:

- a) creation, acquisition or enhancement of assets;
- b) utilization of assets;
- c) maintenance of assets;
- d) decommissioning and/or disposal of assets.

NOTE 1 Creation, acquisition or enhancement includes design, modification, procurement, construction and commissioning.

NOTE 2 Maintenance also includes inspection, condition monitoring, functional testing, repair, refurbishment, and/or life extension of assets. Replacement of individual assets may also be considered as maintenance of asset systems.

NOTE 3 Asset management plan(s) can be for individual assets, asset types, asset systems, whole asset portfolios and/or the overall asset management system. However, it is essential that the plans are clearly linked to the asset management strategy and objectives that they are intended to achieve.

The development of asset management plan(s) and life cycle activities shall include consideration of the impact of actions in one life cycle phase upon the activities necessary in other life cycle phases.

The asset management plan(s) shall be optimized and the actions prioritized. Multiple plans (for example, covering a portfolio of asset systems or assets) shall be jointly optimized and prioritized, taking into account overall value, resource requirements, interdependencies, risks and performance impact.

NOTE 4 Developing, optimizing, prioritizing and integrating asset management plan(s) are iterative processes that start with the development or update of the asset management strategy.

The asset management plan(s) shall include documentation of:

- a) the specific tasks and activities (actions) required to optimize costs, risks and performance of the assets and/or asset system(s);
- b) the designated responsibilities and authorities for the implementation of such actions and for the achievement of asset management objectives;
- c) the means and time scales by which these actions are to be achieved.

The asset management plan(s) shall be communicated to all relevant stakeholders to the level of detail appropriate to their participation or business interests in the delivery of the plan(s).

In the development of asset management plan(s), the organization shall ensure that appropriate arrangements, functional policies, standards, process(es) and/or procedure(s), asset management enablers and resources are made available for the efficient and cost effective implementation of the plan(s).

NOTE 5 It is essential that the plan(s) are realistic and can be implemented.

The asset management plan(s) shall include actions to improve the asset management system (see 4.6.5 and 4.7).

The asset management plan(s) shall be reviewed periodically by the organization to ensure that they remain effective and consistent with the asset management strategy and objectives.

4.3.3.1 General

Organizations seeking to implement the requirements of ISO XXXX-Y on asset management plan(s), should consider the general recommendations and guidance provided below:

- a) The asset management plan(s) should identify the various tasks that need to be implemented in order to meet each asset management objective. They should provide for the allocation of appropriate responsibility and authority for each task and allocate timescales to each individual task, in order to meet the overall timescale of the related asset management objective. They should also provide for the allocation of suitable resources (e.g. financial, human, equipment, logistics) for each task.
- b) When establishing and maintaining its optimized asset management plan(s), an organization should consider:
 - the asset management policy and strategy;
 - existing asset management objectives and performance and condition targets;
 - risk management (see 4.4.7);
 - historical and predicted asset condition, deterioration and failure mechanisms, and performance profiles;
 - uncertainty in data, knowledge and planning assumptions (this should be reflected in the risk assessment, and in the review or updating of the plans and future data collection requirements);
 - life cycle costs;
 - financial and resource capabilities or constraints;
 - legal, regulatory, statutory and other asset management requirements;
 - scheduling constraints, seasonality and other business environment variables;
 - lead times for manufacture, obtaining customer information, planning consents, funding approvals, etc;
 - programming works, mobilization and access to the asset or to a scarce or key resource;
 - improvement objectives;
 - results of the management review (see 4.7);
 - opportunities for achieving the asset management plan(s) in a more cost effective way (that might have been missed during the strategic planning stage or not available then), i.e. achieving the same objective/level of required performance/ condition for lower costs without compromising sustainability or risk exposure levels. Such opportunities can be identified through the optimization process, tactical planning, availability of discounts on goods and services, etc.;
 - opportunities for adding value (where appropriate and which might have been missed during the strategic planning stage or not available then), i.e. increasing the worth of an asset/asset system compared to its costs. Provided it is desirable overall for the organization to do so, it should look for ways to increase productivity without increasing costs or compromising sustainability or risk exposure levels.

- c) Asset management plan(s) should be produced with due regard for their broader impact on the business. Failure to consider the full impact of asset management decisions can have adverse effects such as:
- poor environmental performance (e.g. from out-dated technology) adversely affecting the organization in terms of regulatory or statutory penalties, loss of reputation and business and increased scrutiny of the organization's asset management;
 - extensive downtime for maintenance, etc. resulting in poor service to customers;
 - loss of essential expertise or knowledge from within the organization through outsourcing of critical activities;
 - increased health or safety risks to personnel (e.g. exposing personnel to a hazardous environment instead of employing available and cost-effective remote technology);
 - additional cost or lost income due to the poor timing of planned activities;
 - plans that are unachievable in the timescale required because they were produced without the appropriate involvement of third parties such as suppliers or contractors.
- d) Those who have responsibility for delivering the management plans should be clearly identified. Many organizations define this responsibility within job descriptions, whilst others include specification of responsibility for delivering the asset management plan(s) with the plan itself.
- e) Asset related performance, expenditure and risk should be jointly managed and planned to establish their combined impact on the business. Appropriate methods of evaluating and optimizing the tradeoffs between these elements should be employed.
- f) The asset management plan(s) should include long-term asset replacement programmes to provide an overview of future asset replacement requirements and associated funding needs so that replacement alternatives and expenditure smoothing can be planned ahead.
- g) Conversely, plans generated from other management systems can have an adverse impact on the asset management plan(s) and also require due consideration, e.g. a sales plan committing the organization to a level of output that is unsustainable and does not allow for necessary maintenance activities to be adequately carried out.

4.3.3.2 Optimization of asset management strategy and plans

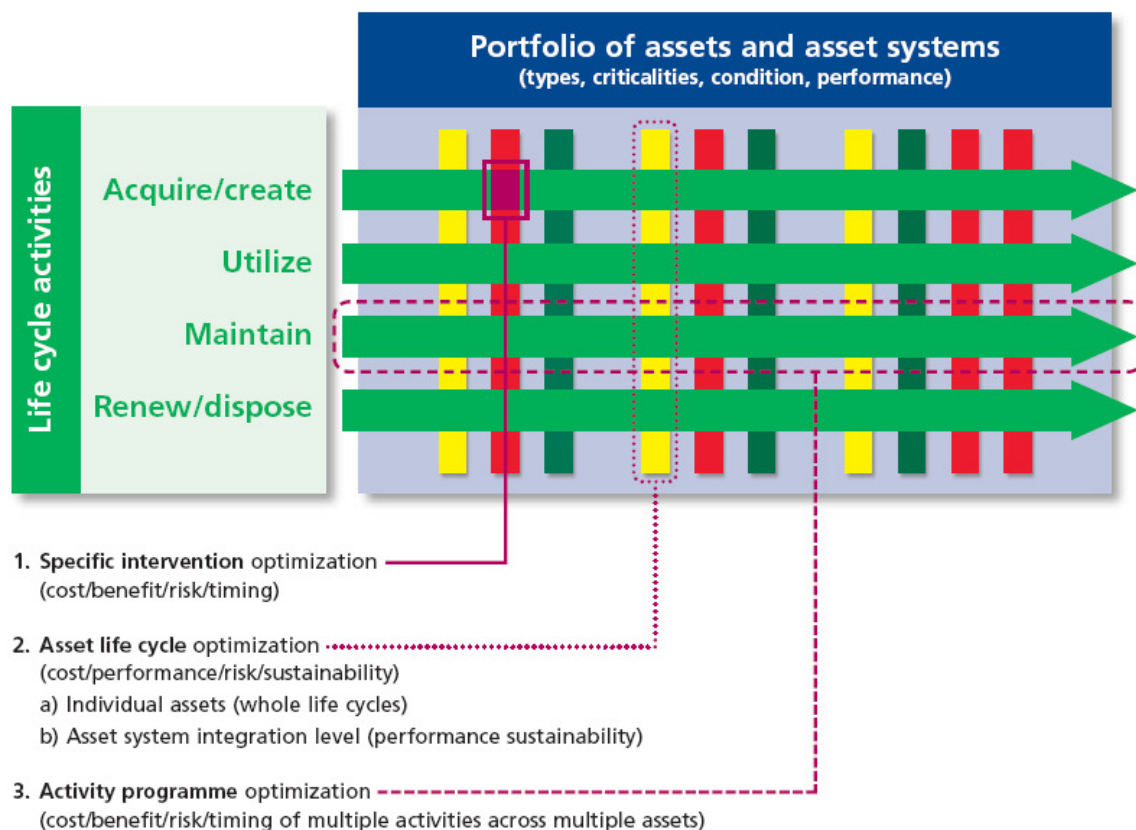
A key feature of good asset management strategy and plans is the optimization of costs, risks and performance over short and long timeframes, in the face of conflicting stakeholder expectations. The processes of optimization are critical, therefore, to the quality of the asset management strategy and the effectiveness and efficiency of asset management plan(s).

When optimizing their asset management strategy and plans, organizations should consider the recommendations and guidance provided below.

- a) Organizations should adopt robust and auditable methods for optimization, appropriate to the criticality and complexity of the decisions being made, and ensure consistent assumptions about the significance of contributing factors.
- b) Optimization involves processes of:
- identifying all factors that can influence the required strategy or decision;
 - determination of their significance (including interdependencies and conflicting objectives);

- analysis of trade-offs, alternative decision options and scenarios, including sensitivity to the uncertainty in data or assumptions;
 - selection of the best value compromise within any non-negotiable constraints or obligations.
- c) The best value compromise should be considered as the strategy or decision that results in the lowest combination of life cycle costs, risks, performance or service losses and other negative effects on business goals (such as damage to reputation or sustainability). This optimization criterion is sometimes known as the “Total Cost of Ownership” or “Total Business Impact”. Care should be taken to determine the appropriate weighting, significance or criticality of contributing factors to this total “cost” or “impact”, and to communicate and explain the optimization results to stakeholders in terms of the compromises that are necessarily involved. Organizations should be careful, for example, to avoid the language and concepts of “balancing” costs and risks: the balance point (equal significance or impact) is not the same as the optimal combination (lowest combined cost or impact).
- d) An organization should develop the criteria for optimization and prioritization from the organization’s strategic values and goals, through a “top down” determination of criticality and appropriately weighted objectives. The practical evaluation, however, of “what is worth doing, when” should be developed through a “bottom up” approach, starting with the optimization of specific tasks or interventions on discrete assets, and building up to the optimal coordination of all life cycle activities for an asset or asset system, and finally to the optimal programming of multiple activities across multiple assets. Figure 1 shows how these three major areas of optimization apply to an asset portfolio. These represent optimization of:
- 1) individual interventions or actions upon individual assets (such as “is this maintenance task on this equipment item worthwhile and, if so, when?”);
 - 2) task combinations on the same asset, or different assets within an asset system:
 - the various life cycle activities for the same asset, i.e. the best combination of investment, utilization, maintenance and renewals. For example, there may be an interaction between the optimal cleaning cycle for a heat exchanger and the economic life of the heat exchanger tubes (due to cumulative damage caused by the cleaning process.);
 - the activities on various components of an asset system where interdependencies exist, such as train wheel-rail interfaces, air conditioning or cooling systems and the equipment/facilities they are protecting.
 - 3) activity programme delivery, such as critical path identification, resource levelling and work bundling (for example, shutdown strategies, where there may be benefits for combining tasks to share access opportunities or other overheads).
- e) The level of precision, the method and the resources applied for optimizations should be proportionate to the criticality and complexity of the individual cases. Optimization methods may be qualitative or they may be quantitative, in which case the optimization should also include the correct mathematical treatment of reliability and risk elements, and of the trade-off between conflicting factors in order to identify the best value compromise.

Figure 1 – Primary requirements for optimization of asset management activities



4.3.4 Contingency planning

The organization shall establish, implement, and maintain plan(s) and/or procedure(s) for identifying and responding to incidents and emergency situations, and maintaining the continuity of critical asset management activities.

In developing its plan(s) and procedure(s), the organization shall consider:

- a) asset-related risks that, if realized, could result in incidents or emergency situations;
- b) potential disruptions to its critical asset management activities;
- c) the most appropriate actions for responding to an incident or emergency situation, and mitigating the likely consequences;
- d) the competence and training of personnel required to respond to emergencies;
- e) the needs of relevant stakeholders who may be affected by incidents or emergency situations, or who may be required to support the organization to respond to such events.

The plan(s) and/or procedure(s) shall identify how the organization will respond to, and manage, incidents and emergency situations, and shall include information on:

- a) essential personnel, emergency services and external agencies, including contact details;

- b) arrangements for internal and external communication;
- c) how the organization will maintain or restore its critical asset management activities in the event of a disruption;
- d) the provision of resources, and the maintenance of any equipment, facilities or services that could be required during disruptions, incidents or emergency situations;
- e) recording of essential information whilst responding to, and managing, incidents and emergencies;
- f) the process for returning to normal operations.

The organization shall periodically review, test and, where deemed necessary, revise its plan(s) and/or procedure(s) for incident and emergency preparedness and response and continuity of important asset management activities.

NOTE It is essential that the organization's contingency plans are reviewed after testing or the occurrence of incidents, emergency situations or disruptions.

4.3.4.1 General

The organization should assess emergency and incident response needs, plan to meet them, develop procedures and processes to cope with them, test its planned responses, and seek to improve the effectiveness of its responses where necessary. The organization should, for example, consider potential emergencies arising from:

- significant failure of critical assets resulting in the loss of service or supply to customers or a hazardous condition arising;
- extreme weather conditions, e.g. strong winds, floods, heavy snowfall, lightning strikes;
- unplanned release of hazardous liquids or gases;
- explosion or fire;
- loss of power supply or control systems;
- a combination of events or risks which may result in an emergency situation.

Many organizations will find linkage to the risk assessment process and use of risk identification activities useful in determining which incidents and emergencies to consider.

The organization should develop, identify and provide appropriate emergency equipment, and regularly inspect and preferably test its availability and performance. Contingency plans (see 4.3.4.2) should address both the immediate consequences of incidents and, where appropriate, the steps up to, and including, the re-establishment of stable and secure supply/service to customers.

Practice drills should aim to test the effectiveness of the most critical parts of the emergency plan(s) and to test the completeness of the emergency planning process. While desktop exercises can be useful during the planning process, practice drills should be as realistic as possible to be effective. This can require full-scale

incident simulations to be conducted. Where appropriate and practicable, the participation of external emergency services in practice drills should be encouraged.

The results of emergencies, incidents and practice drills should be evaluated, and changes that are identified as being necessary should be implemented.

Contingency plans should be regularly reviewed by the organization, at a frequency determined by the organization, to ensure that they are current, i.e. effectively address the current risks to the organization. Further guidance on the establishment of business continuity management can be found in BS 25999-1.

4.3.4.2 Contingency plan(s)

The contingency plan(s) should outline the actions to be taken when specified emergency situations arise, and should include the following:

- identification of potential incidents and emergencies and combinations of incidents and emergencies;
- identification of the individual to take charge during the emergency;
- details of actions to be taken by personnel during an emergency, including those actions to be taken by external personnel;
- responsibility, authority and duties of personnel with specific roles during the emergency;
- provision for safety and status briefings for personnel;
- provision of welfare support and relief for personnel likely to be engaged for prolonged periods dealing with the emergency;
- evacuation procedures;
- identification and location of any hazardous materials, and emergency action required;
- interface with external emergency services;
- communication with statutory bodies, neighbours and the public;
- protection of vital records and equipment;
- availability of necessary information during the emergency, e.g. plant layout drawings, hazardous material data, procedures, work instructions and contact telephone numbers. Consideration should be given to assuring access to information when normal methods of information storage and retrieval and normal methods of communication may not be fully functional.

The involvement of external agencies in emergency planning and response should be clearly documented. Where appropriate, these agencies should be advised as to the possible circumstances of their involvement and provided with such information as they require in facilitating their involvement in response activities. Consideration should also be given to including external agencies either as participants or independent observers during emergency exercises.

4.3.4.3 Emergency equipment and resources

Emergency equipment and resource needs should be identified, and equipment should be provided in adequate quantity. The location and access arrangements for such emergency equipment should be documented and communicated. The location of the equipment and resources should take account of the nature of the potential risk such that access to the equipment and resources will not be compromised should any incident or emergency occur.

Equipment should be inspected and preferably tested at specified intervals for continuing availability and operability.

Examples include the following items:

- alarm systems;
- fault finding equipment;
- tools;
- critical spares;
- communication systems (including call centres resources where appropriate);
- means of transport (e.g. all-terrain vehicles), obstacle removing equipment (e.g. chainsaws, cutting equipment, cranes and hoists), protective clothing;
- adequate levels of competent staff available to mobilize to required schedule;
- information, e.g. plans, procedures, drawings, maps, contact numbers;
- emergency lighting and power;
- fire-fighting equipment, flood recovery equipment and first aid equipment.

4.4 Asset management enablers and controls

4.4.1 Structure, authority and responsibilities

The organization shall establish and maintain an organizational structure of roles, responsibilities and authorities, consistent with the achievement of its asset management policy, strategy, objectives and plans. These roles, responsibilities and authorities shall be defined, documented and communicated to the relevant individuals.

NOTE There is no need to establish a separate organizational structure provided the organization's structure is consistent with achieving the requirements set out in Clause 4.

Top management shall provide evidence of its commitment to the development and implementation of the asset management system and the continuous improvement of its effectiveness by:

- a) appointing a member of top management who, irrespective of other responsibilities, shall be responsible for the overall design, maintenance, documentation, review and improvement of the organization's asset management system;
- b) appointing member(s) of management whose responsibility is to ensure that the assets and assets systems deliver the requirements of the asset management policy, strategy, objectives and plans and who have the authority to achieve this;
- c) identifying and monitoring the requirements and expectations of the organization's stakeholders and taking corresponding and timely action, to the extent that these have implications for the organization's management of its assets;
- d) ensuring that the asset management policy and strategy are consistent with the organizational strategic plan;
- e) considering the adverse impact that the asset management policy, asset management strategy, asset management objectives and asset management plan(s) might have on other aspects of the organization. Conversely, considering whether plans generated from other parts of the organization might have an adverse affect on asset management;
- f) ensuring the viability of the asset management policy, asset management strategy, asset management objectives and asset management plan(s);
- g) ensuring asset-related risks are identified, assessed and controlled, and are included in the organization's overall risk management framework;
- h) ensuring the availability of sufficient resources;
- i) communicating to all relevant stakeholders the importance of complying with the requirements of the asset management system in order to achieve its organizational strategic plan.

Organizations seeking to implement the requirements of ISO XXXX-Y on structure, authority and responsibilities, should consider the recommendations and guidance provided below.

- a) The successful implementation of asset management requires the commitment of top management. Top management should assign clear responsibilities for the management of asset systems including appropriate accountability for their performance (this may be financial and non-financial) and responsibility for investments/expenditure. Those individuals placed in such positions are sometimes referred to as Asset Managers. Top management should ensure that those with such responsibilities have accepted them and have adequate authority to carry them out effectively. Top management should also ensure that those who are given responsibilities are competent, have adequate resources to

discharge their duties and the operational freedom to optimize the cost/effectiveness of these resources in line with the asset management policy, strategy and objectives.

- b) The responsibilities and authorities of all persons who perform duties that are part of the asset management system should be defined. Such definitions should, among others, be developed for the following people:
- top management;
 - asset managers;
 - engineers, designers and technical specialists;
 - process operators;
 - maintenance personnel;
 - inspectors;
 - contractors;
 - those responsible for asset management training and facilitation of the asset management processes and techniques.
- c) Asset management responsibilities and authorities should be documented in a form appropriate to the organization. This can take one or more of the following forms, or an alternative of the organization's choosing (see 4.4.5):
- working procedures and task descriptions;
 - job descriptions;
 - induction training package (see 4.4.3).

If the organization chooses to issue written job descriptions covering other aspects of employees' roles and responsibilities, then asset management responsibilities should be incorporated into those job descriptions.

- d) The organizational structure of roles, responsibilities and authorities plays a significant part in the successful implementation of asset management.

An organizational structure that creates compartmentalized functions, responsibilities and performance measures should be avoided. Key requirements of asset management are a life cycle approach and optimization, and these are difficult to achieve when activities are considered in isolation. For example, whole life cost cannot be optimized if only project expenditure is considered without considering the subsequent performance/income and asset care/maintenance implications. Similarly, operating costs cannot be optimized without considering the effect on productivity and risk.

Top management should endeavour to create an organizational structure of roles, responsibilities and authorities that facilitates the visibility and comparison of asset/product/service related performance or income with the associated effort and expenditure. There are benefits and disadvantages to any given structure of roles, responsibilities and authorities. The nature of the organization's business, and indeed its culture, will affect the choice of structure to be adopted. For example, some organizations have achieved this through the creation of profit/investment centres and others through activity based costing, combined with the allocation of apportioned/estimated revenues and inter-departmental service level agreements.

Such arrangements should provide for:

- readily identifying the value of capital and operating related expenditure and the life cycle (or long-term) impact of any changes in expenditure;
 - accountability for asset performance and the associated expenditure;
 - the avoidance of conflicting departmental performance measures where such measures could result in the gain for one department being to the overall detriment of the organization;
 - the avoidance of reliance upon annual budgets/funding cycles, which may obstruct the adoption of a life cycle approach;
 - motivating the whole team to be continually looking for ways to optimize performance, expenditure and levels of retained risk;
 - the responsibility and authority for readily implementing changes that would be beneficial for the organization.
- e) Organizational structures should be clearly communicated to all relevant employees, via an organization chart or other means, and kept updated.
- f) In addition to assigning responsibility for ensuring that the assets and asset systems deliver the required outcomes, top management should assign responsibility for the effective management of the organization's asset management system (processes). It is unlikely that the assets will perform satisfactorily over time unless the asset management system is operating effectively.
- g) Top management should identify the requirements and expectations of all of the organization's stakeholders. The employment of techniques, such as stakeholder needs analysis, employee/customer surveys, suggestion boxes, discussion forums and demand management should be considered (see 4.4.4).
- h) Top management is normally best placed to ensure that the asset management, policy and strategy are consistent with the organizational strategic plan and to identify where poor asset performance might jeopardize the achievement of the organizational strategic plan.
- i) Top management should ensure that adequate resources are available for establishing and maintaining the asset management system, including equipment, human resources, expertise and training. Resources can be considered adequate if they are sufficient to deliver asset management plan(s) and activities, including performance measurement and monitoring. For organizations with established asset management systems, the adequacy of resources can be at least partially evaluated by comparing the planned achievement of asset management objectives with actual results. Consideration should also be given to whether the resources provided were excessive.
- j) 4.3.3.1 (g) provides guidance on, and examples of, the potential adverse impact that asset management plan(s) might have on other parts of the organization and conversely, the impact that plans generated in other parts of the organization might have on asset management.
- k) Top management should communicate to the organization and to relevant third parties the importance of meeting its asset management requirements in order to achieve its organizational strategic plan (see 4.4.4).
- l) Ultimate responsibility for the identification, assessment and management of risks rests with top management. It is therefore essential that they are satisfied with the associated procedures and activities, and that all concerned are aware of, and have accounted for, these risks. The organization should have an organizational risk register and it is essential that significant asset related risks are recorded in this register (see 4.4.7).
- m) Top management should ensure the viability of the asset management strategy, objectives, targets and plans. The act of producing them is no guarantee that they are achievable. Therefore an assessment of the organization's asset management strategy, objectives, targets and plans (maintenance and capital

works) should be carried out, at intervals determined to be appropriate by top management (see 4.6.5 and 4.7).

4.4.2 Outsourcing of asset management activities

Where an organization chooses to outsource any aspect of asset management that affects conformity with the requirements of Clause 4, the organization shall ensure control over such aspects. The organization shall determine and document how these parts will be controlled and integrated into the organizations' asset management system. The organization shall also identify and document:

- a) the processes and activities that are to be outsourced (including the scope and boundaries of the outsourced processes and activities and their interfaces with the organization's own processes and activities);
- b) the processes and scope for the sharing of knowledge and information between the organization and the contracted service provider(s);
- c) authorities and responsibilities within the organization for managing the outsourced processes and activities.

Many asset management organizations have developed contracting strategies and supply chain alliances to provide them with asset management services. Business relationship models, such as engineering, procurement and construction (EPC), public-private partnerships (PPP), private finance initiatives (PFI) and build-operate-transfer contracts (BOT), have emerged to enable combinations of organizations to deliver complex asset investments and asset management programmes. Such contracts can result in an organization effectively outsourcing most of its asset management activities from asset management strategies, objectives and plans down to the activities in the asset management plan(s).

A requirement of ISO XXXX-Y is to ensure that risk, value and sustainability are managed across contractual boundaries, and that the asset owner and asset manager retain appropriate controls across contractual boundaries. This is particularly relevant where services are provided by third party organizations that do not have a long-term stake in the success of the organization. For this reason, ISO XXXX-Y requires demonstrable governance with clearly established authorities and responsibilities. Many organizations achieve this by forming alliance relationships with their suppliers, whereby rewards and penalties are aligned to the performance of the assets or asset systems and to the achievement of the asset management objectives.

Where an organization chooses to outsource any of the requirements (or part of the requirements) set out in ISO XXXX-Y, the organization is required to ensure control over such processes. For example, a contracted service provider may be required to develop asset management plan(s) and also to implement them. In such an instance the organization should ensure that the asset management plan(s) are consistent with its own asset management policy, strategy, objectives and targets. Furthermore, it should also have to ensure that all of the other requirements of ISO XXXX-Y are complied with, e.g. life cycle and sustainability considerations, controlled implementation of the asset management plan(s), performance monitoring and continual improvement.

When determining the proposed extent of outsourcing, the organization should ensure that the relevant aspects and requirements of ISO XXXX-Y are clearly identified in contract specifications and that they are understood in the tendering process. The roles, authority and responsibilities of all parties in the contract should be clearly stated and agreed. The outsourcing of asset management responsibilities should be defined in measurable terms.

An organization may establish that the terms and conditions of existing contract arrangements do not adequately address aspects of ISO XXXX-Y. The assessment of risk arising from such situations, and the steps required to control or mitigate such risks, should be handled in accordance with 4.4.7.

4.4.3 Training, awareness and competence

The organization shall ensure that any person(s) under its direct control undertaking asset management related activities has an appropriate level of competence in terms of education, training or experience.

NOTE Levels of appropriate asset management competence can be ascertained through the use of a competency requirements framework (see the Bibliography for examples of relevant competency requirements frameworks).

Where asset management activities are outsourced, the organization shall ensure that contracted service providers have arrangements in place to ascertain and demonstrate that their staff are competent.

The organization shall develop plans for the human resources required to develop and implement its asset management system. The organization shall identify the competency requirements for these human resources and plan the training necessary for them to achieve these competencies. It shall arrange for provision of this training and retain associated records.

The organization shall establish, implement and maintain process(es) and/or procedure(s) to make persons working under its control aware of:

- a) the asset management related risks associated with their work activities and the asset management benefits of personal performance;
- b) their roles and responsibilities and the importance in complying with the asset management policy, process(es) and/or procedure(s) and plan(s);
- c) the potential consequences of departure from specified asset management process(es) and/or procedure(s).

4.4.3.1 General

Training and competence requirements, plans and resources should be matched to the asset management plan(s), ensuring that the necessary human resources are in place to meet the short, medium and long-term commitments of the plan. In addition, organizations should consider the following recommendations and guidance:

- a) Organizations should have effective procedures for ensuring the competence of employees to carry out their designated asset management functions.
- b) The following elements should be included in the asset management training, awareness and competence process:
 - a systematic identification of the asset management awareness and competencies required at each level and function within the organization;
 - arrangements to identify and remedy any shortfalls between the employee's current and required levels of asset management awareness and competency;
 - provision of any training identified as being necessary, in a timely and systematic manner;
 - assessment of employees to ensure that they have acquired, and that they maintain, the asset management knowledge and competency required;
 - maintenance of appropriate records of employees' training and competency.

- c) An asset management awareness and training programme (which may form part of a wider programme of training) should be established and maintained to address the following areas:
- provide employees with an understanding of the organization's asset management arrangements and the employees' specific roles and responsibilities in these arrangements;
 - ensure the systematic induction of employees as they enter the organization, transfer between business units or sites, or change jobs or roles;
 - provide training in local asset management arrangements and risks, precautions to be taken and procedures to be followed (this training should be provided before work commences);
 - provide specific in-house or external training for employees with specific asset management roles, e.g. risk management, life cycle costing, optimization, reliability engineering, maintenance, inspection, condition monitoring, root cause analysis;
 - describe the roles and responsibilities (including corporate and individual legal responsibilities) of top management for ensuring that the asset management system functions to control risks and reduce potential losses to the organization to tolerable levels;
 - ensure that training and awareness programmes are provided for contractors and temporary workers engaged in the organization's asset management activities;
 - ensure the systematic provision of ongoing update and refresher training for all employees in the organization.
- d) Relevant to their role, the organization should establish, implement and maintain process(es) and/or procedure(s) to make persons working under its control aware of:
- asset management related risk consequences (actual or potential) of their work activities, their behaviour, and the asset management benefits of improved personal performance;
 - their roles and responsibilities and importance in achieving conformity to the asset management policy and process(es) and/or procedure(s) and to the requirements of the asset management system, including emergency preparedness and response and contingency planning requirements (see 4.3.4) and impact on other management processes;
 - the potential consequences of departure from specified process(es) and/or procedure(s).
- e) Training procedures should take into account differing levels of:
- authority;
 - responsibility;
 - ability;
 - language skills and literacy;
 - risk.
- f) The effectiveness of training and the resulting level of competency should be evaluated. This can involve assessment as part of the training exercise, and/or appropriate field checks to establish whether competency has been attained, or to monitor the medium-term impact of training delivered.
- g) The organization should consult and seek feedback regarding any training, awareness and competence shortfalls from employees and contractors to facilitate ongoing improvements and ensure future requirements are identified and met.

4.4.3.2 Competencies in asset management

Activities and processes within the asset management system require the integration and alignment of many aspects of a business, and depend upon a wide variety of individual and corporate competences. An organization that is heavily dependent upon the performance of physical assets should actively monitor, develop and maintain an appropriate balance of these competencies. In particular, the asset management system should provide for adequate skills and competencies in the performance of the following key activities and processes (see Bibliography for examples of relevant competency requirements frameworks).

4.4.4 Communication, participation and consultation

The organization shall ensure that pertinent asset management information is effectively communicated to and from employees and other stakeholders, including contracted service providers.

The organization shall ensure consultation with stakeholders that is relevant and appropriate to their involvement in:

- a) the development of the asset management strategy, objectives and plan(s);
- b) the development of functional policies, engineering standards, process(es) and/or procedure(s);
- c) risk assessments and determination of controls;
- d) incident investigation;
- e) the continual improvement of the asset management system.

The organization, through the processes of communication and consultation, should encourage participation in good asset management and support for its asset management, policy strategy and objectives from those affected by its activities or interested in its asset management system.

Communication is not just about the distribution of information; it should ensure that asset management information is provided, received and understood across the organization. Effective communication is a two-way process, both top-down and bottom-up.

Consultation is the process by which management and other persons, or their representatives, jointly consider and discuss issues of mutual concern. It involves seeking acceptable solutions to problems through the general exchange of views and information.

Examples of those who may be interested in, or affected by, an organization's asset management system include customers, organization owners or investors, employees at all levels of the organization, suppliers and contracted service providers, local society, emergency services, insurers, government or regulatory bodies, external inspectors or auditors.

The appropriate use of consultation and participation can be a powerful aid to the development of the workforce, promoting teamwork, individual and collective responsibility and accountability, and helping to create an organizational culture of continuous improvement. Examples of good practice mechanisms in consultation and communication with employees and contractors include:

- a) inclusion of asset management issues in:
 - formal management and employee meetings and consultations;
 - briefings for employees contractors and other interested parties.

- b) initiatives to encourage employee asset management consultations, review and improvement activities, including the development and/or modification of:
 - asset management plan(s);
 - functional policies;
 - standards;
 - process(es) and/or procedure(s).
- c) employee involvement in risk identification, assessment and control;
- d) employee involvement in incident investigation;
- e) formal and informal channels for feedback to management, through mechanisms including suggestion boxes, telephone “hotlines”, management visits;
- f) use of organizational intranet systems for timely dissemination of pertinent information;
- g) knowledge management systems;
- h) notice boards containing asset management performance data and other pertinent asset management information;
- i) asset management newsletter.

Where appropriate, organizations should effectively and proactively communicate with their customers. Examples of good practice in consultation and communication with customers include:

- newsletters;
- press releases;
- informative websites;
- customer surveys;
- demand management advice to customers;
- research to establish customers’ willingness to pay for a specified level of service;
- customer charters and published compensation schemes;
- provision of public information where asset management activities are being carried out in publicly-accessible areas, e.g. road works, construction sites;
- customer call centres, messages, announcements, etc., in particular when a loss of service has occurred.

The organization should document and promote the manner in which it consults with, and communicates, pertinent asset management information to and from its employees, contractors, customers and other interested parties.

4.4.5 Asset management system documentation

The organization shall establish, implement and maintain up-to-date documentation to ensure that its asset management system can be adequately understood, communicated and operated. The asset management

system documentation shall include:

- a) a description of the main elements of the asset management system and their interaction, and direction to related documents;
- b) the asset management policy, strategy, and objectives;
- c) documents, including records, required by Clause 4 of this specification.

The organization shall establish documented procedure(s) and/or operating criteria if their absence could lead to failure to achieve its asset management policy, asset management strategy, asset management objectives or to control identified asset management risks.

NOTE 1 The asset management policy, strategy and other elements of the asset management system do not have to be produced as separate documents.

NOTE 2 It is important that documentation is proportional to the level of complexity and risks being managed. It should also be appropriate to the level at which the documentation will be used and kept to the minimum required for effectiveness and efficiency.

Organizations seeking to implement the requirements of ISO XXXX-Y on asset management system documentation, should consider the recommendations and guidance provided below.

- a) Documentation enables communication of intent and consistency of action. The organization should have sufficient up-to-date documentation in place to ensure that its asset management system can be adequately understood and effectively and efficiently worked to. It is not a requirement to put in place specific documents for asset management, provided that existing documentation and processes meet the requirements of ISO XXXX-Y. As a general rule, documentation should only be created when it adds value.

The extent of the asset management system documentation can differ from one organization to another due to:

- the size of the organization and the type of activities;
- the complexity of processes and their interactions;
- the competence of personnel;
- the extent to which it is necessary to demonstrate fulfilment of the asset management system requirements.

- b) The organization should review its documentation needs before developing any new documentation to control its asset management activities. In practice, organizations often have in place documentation at operational levels within functions or departments, but the co-ordination and alignment of activities may not be well controlled, particularly where these documents have originated in different business streams or even different organizations. Furthermore, a limited number of new documents are sometimes required to manage the continuous improvement and co-ordination of the asset management system with the operational procedures.
- c) There is no requirement to develop documentation in a particular format in order to conform to PAS 55-1. There is no requirement to create a discrete asset management manual to describe the scope of the asset management system, its main elements and their interaction. The organization should decide what form best meets its business needs. For many organizations a separate asset management policy and asset management strategy, together with a document describing the scope, key accountabilities and

operational documentation of the asset management system, provide value and improve organizational alignment. This approach can be particularly convenient and effective if an organization already has an established management system in place, in order to describe the interrelationships between the existing system and the requirements of ISO XXXX-Y.

- d) There are relatively few elements of the asset management system for which ISO XXXX-Y specifically requires explicit documentary evidence. These include:
- an asset management policy;
 - an asset management strategy;
 - asset management plan(s);
 - roles, responsibilities and authorities;
 - how outsourced parts of management system will be controlled and integrated into the organizations' asset management system (see 4.4.2);
 - records (see 4.6.6).
- e) ISO XXXX-Y requires an organization to establish and maintain further documentation if its absence could lead to failure to:
- achieve its asset management policy, asset management strategy, asset management objectives;
 - control identified asset management risks;
 - efficiently and cost effectively implement its asset management plan(s).

In other words, the degree of documentation should consider the potential need and usage – it is not sufficient to adopt a policy of standardization whereby the same level of detail is applied in all circumstances. The organization should consider “what if?” in determining the level of documentary coverage that is appropriate in each area or activity.

- f) Each organization should determine the extent of documentation required and the media to be used. In addition to those identified in d) above, ISO XXXX-Y makes reference to a limited number of types of documentation which can be used within an asset management system. These include functional policies, strategies, procedures, standards and operating criteria. Organizations may also utilize types of documentation such as technical specifications, technical instructions, work instructions or guidance notes to control asset management activities.
- g) Asset management functional policies, supporting the overall asset management policy, provide a framework for the control of a specific asset management related activities (such as capital investment, purchasing, operations, customer service, maintenance, contracting, safety and environmental management – see 4.4.5 i). Functional policies are normally mandatory within an organization, and can be described using different names in different contexts. It is essential that such documents comply with policies adopted by the organization which define at high level the organization's principles and requirements (these include the asset management policy). Functional policies should also be consistent and guided by the asset management strategy where they relate to the management of activities within the asset management system.
- h) Functional policies provide the workforce with clarity for what is expected of them and the boundaries for any permissible deviance. They assist managers to implement stated asset management objectives and plans, and they should also constrain them within carefully defined boundaries. When formulating functional policies, care should be taken not to conflict with other such policies or restrict managers to the extent that they are unable to take appropriate action for the optimal life cycle management of the assets. Similarly, the functional policies should be appropriate to the criticality and value of the assets and activities to which they apply.

- i) Organizations can have a number of asset management functional policies, functional strategies and functional plans. Typically these can include:
- asset accounting and activity costing;
 - maintenance, inspection, condition and performance monitoring;
 - asset operation or utilization;
 - planning and budgeting;
 - capital investment and life cycle costing;
 - contingency planning and emergencies;
 - data, information and knowledge management;
 - demand management and customer expectation policy;
 - energy efficiency and environmental aspects, e.g. renewable resources, recycling, waste management, air purity, hygiene;
 - human resources, skills development and competencies;
 - innovation and change management;
 - asset modifications, replacement, disposal, recycling;
 - risk assessment and management;
 - safety, health and environmental management;
 - spares, materials and purchasing;
 - contractor and supplier management;
 - interfacing with regulatory bodies.
- j) Based on the documentation criterion in e) above, one of the more significant documentation requirements can be for an organization to establish documented procedures. The term “procedure” is often used in management system standards and there can be confusion as to what a procedure is and how it relates to a process. In simple terms, a process is an activity, and a procedure is the formalization of the process, stating how the process should be performed (see PAS 99). A procedure may be documented, but does not have to be (see ISO XXXX-X, 3.27).
- k) It is for an organization to determine whether it needs to document a procedure in order to provide assurance as described in e) above. Examples of documented procedures which an organization decides it needs to establish to control its asset management activities may include procedures for:
- • design, procurement, construction, installation and commissioning of new equipment;
 - review, approval and control of contracts;
 - operation of plant and equipment;
 - repair, maintenance and inspection activities;
 - calibration and maintenance of tools and test equipments;

- renewal, refurbishment, modification and disposal of equipment;
- management of spares.

4.4.6 Information management

The organization shall identify the asset management information it requires to meet the requirements of Clause 4 of this specification considering all phases of the asset life cycle. The information shall be of a quality appropriate to the asset management decisions and activities it supports.

The organization shall design, implement and maintain a system(s) for managing asset management information. Employees and other stakeholders, including contracted service providers, shall have access to the information relevant to their asset management activities or responsibilities. Where separate asset management information systems exist, the organization shall ensure that the information provided by these systems is consistent.

The organization shall establish, implement and maintain procedure(s) for controlling all information required by Clause 4 of this specification. These procedures shall ensure:

- a) the adequacy of the information is approved by authorized personnel prior to use;
- b) information is maintained and adequacy assured through periodic review and revision, including version control where appropriate;
- c) allocation of appropriate roles, responsibilities and authorities regarding the origination, generation, capture, maintenance, assurance, transmission, rights of access, retention, archiving and disposal of items of information;
- d) obsolete information is promptly removed from all points of issue and points of use, or otherwise assured against unintended use;
- e) archival information retained for legal or knowledge preservation purposes is identified;
- f) information is secure and, if in electronic form, is backed up and can be recovered.

Good asset management requires meaningful, quality, timely asset and asset management information. Asset management information is essential for achieving an effective and efficient asset management system and for the continual improvement of that system. Asset management information includes asset registers, drawings, contracts, licences, legal, regulatory and statutory documents, policies, standards, guidance notes, technical instructions, procedures, operating criteria, asset performance and condition data, tacit knowledge and all types of asset management records. Further information on documentation is identified in 4.4.5 and records in 4.6.6.

Organizations seeking to implement the requirements of ISO XXXX-Y on information management, should consider the following recommendations and guidance:

- a) Organizations should identify the information essential to meeting the requirements of ISO XXXX-Y. An organization should consider the level of accuracy and completeness for different information items that are necessary to support the delivery of its asset management strategy, objectives and plan. Asset management information should be capable of enabling an organization to:
 - optimize its asset management strategy and optimize/prioritize its asset management plan(s);
 - assess the financial benefits of planned improvement activities;

- determine the operational and financial impact of asset unavailability or failure;
- make life cycle cost comparisons of alternative capital investments;
- identify expiry of warranty period and warranty;
- determine the end of economic life of assets/asset systems, e.g. the point in time when the asset related expenditure exceeds the associated income;
- determine the cost of specific activities (activity based costing), e.g. the total cost of maintaining a specific asset(s)/asset system;
- obtain/calculate asset replacement values;
- undertake financial analysis of planned income and expenditure;
- obtain/calculate the financial and resource impact of deviating from plans that might result in a change in asset availability or performance (e.g. what is the financial impact of deferring the maintenance of a specific generator by six months);
- assess its overall financial performance;
- undertake the ongoing identification, assessment and control of asset related risks;
- comply with statutory and regulatory obligations.

- b) Asset information should normally be assigned at the lowest component level of an asset or asset system that requires discrete replacement or maintenance actions. For example, if the organization's maintenance strategy were always to run a particular pump to failure and then replace it, there would be little point in recording information (and procedures) for replacing the component pump seal. The normal level of detail required, therefore, is at the maintainable unit level (sometimes this is referred to as a "Maintenance-Significant Item"). However, information attributed at a lower component detail may be worthwhile for the identification of failure modes and the diagnosis of failure root causes.

The organization should compare the cost of establishing, collecting and maintaining asset information with the value derived from analysing and using it, i.e. its criticality to business decisions and granularity, precision or level of detail that is needed. Failure adequately to consider these compromises can result in poorly and inconsistently populated information systems and degraded information quality. This degraded quality can damage the credibility of the information provided and it can also lead to unnecessary costs being incurred.

In establishing its asset information management system(s), the organization should consider the identification and definition of items of information that will be managed during the asset life cycle, and for a defined period beyond the disposal of assets, in accordance with the organization's requirements including legal, regulatory, statutory and other asset management requirements that are applicable to it. Examples of information to be considered include the following:

- descriptions of assets, their functions and the asset system they serve;
- unique asset identification numbers;
- locations of the assets, possibly using spatial referencing or geographical information systems;
- the criticality of assets to the organization;
- details of ownership and maintenance demarcation where assets interface across a system or network of assets;

- engineering data, design parameters, and engineering drawings;
- details of asset dependencies and interdependencies;
- vendor data (details of the organization that supplied the asset);
- commissioning dates and data;
- the condition and duty of assets;
- condition and performance targets or standards;
- key performance indicators;
- asset related standards, process(es) and procedure(s);
- access planning and work schedules;
- details of the tasks to be carried out;
- work instructions together with diagrams and reporting requirements, legal obligations and safety/environmental considerations;
- task risk assessments and control measures;
- criteria of non-conformance and the actions to be taken;
- when assets were last maintained/inspected and when these tasks are next due;
- list of overdue/outstanding tasks;
- historical record of planned and unplanned maintenance tasks performed,
- details of historical asset failures, causes and consequences (if known);
- operational data including performance characteristics and design limits;
- details of emergency plans including responsibilities and contact details;
- identities and levels of spares held, interchangeability, specifications and storage locations;
- financial data including, where available, cost of historical and planned maintenance tasks, operating costs, downtime impact, current asset replacement value, original purchase cost;
- asset related contractual information.
- Systems for managing asset information can use a range and combination of media and technologies. The systems should enable an organization to identify, collect, retain, transform and disseminate its asset management information. These systems can range from straightforward paper based systems to sophisticated electronic solutions. It is for an organization to decide which types of systems best meet its needs for particular applications. The more sophisticated examples can integrate many of the following components:
 - asset registers;
 - document management systems;

- work/programme planning and scheduling systems;
 - materials management systems;
 - spares inventory systems;
 - purchasing systems;
 - decision-support systems, e.g. maintenance optimization, capital expenditure planning, whole life costing models, etc;
 - asset utilization systems;
 - performance reporting systems;
 - geographical information systems (GIS) and spatial analysis toolkits (for the analysis of GIS data);
 - asset possession/shutdown/outage planning systems;
 - SCADA (Supervisory Control and Data Acquisition Systems);
 - condition monitoring systems;
 - automation systems;
 - knowledge management systems;
 - staff location, scheduling and despatch systems.
- c) It is not necessary for an organization to establish a complete asset management information system in-house. Component parts or systems forming the whole asset management system may be supplied by others. However, it is essential that all component systems, irrespective of source, are compatible with the whole system and that the information provided by these component systems is consistent and contains suitable cross references to allow cross system analysis.
- d) The systems for managing asset management information should be designed so that data and information is readily accessible and available to all relevant personnel under routine and non-routine conditions, including emergencies. For example, this should ensure that up-to-date plant engineering drawings, hazardous material data sheets, procedures and instructions are available to process operators, and all who can require them in an emergency.

All information, including documentation, required for the operation of the asset management system and the performance of the organization's asset management activities should be controlled. To achieve this, an organization should establish, and where appropriate document, arrangements and/or processes to address the:

- allocation of roles, responsibilities and authorities for the origination, generation, capture, maintenance, retention, transmission, access to, assurance, archiving and disposal of items of information;
- definition of the content, meaning, formats and medium for the representation, retention, transmission and retrieval for each information item;
- requirements for information maintenance, including version control and assurance activities;
- requirements for the generation, capture or importing of the identified items of information;

- requirements for the storage of information items according to integrity, security and confidentiality requirements;
 - retrieval and distribution of information to designated parties as required by agreed schedules or defined circumstances;
 - requirements for the archival of designated information, for example for the purpose of retaining audit records and knowledge preservation;
 - requirements for the disposal of obsolete, unreliable or unwanted information in accordance with the organization's requirements and security and privacy requirements;
- e) The organization should also establish, implement and maintain a process(es) and/or a procedure(s) for the retention, management and disposal of records. Records should be stored in a safe place, readily retrievable and protected from deterioration. Critical asset management records should be protected from possible fire and other damage or loss as appropriate, or as required by law. Consideration should also be given to issues surrounding the holding and use of electronic records, e.g. legal constraints, storage media obsolescence, access controls.

4.4.7 Risk management

4.4.7.1 Risk management process(es)

The organization shall establish, implement and maintain documented process(es) and/or procedure(s) for the ongoing identification and assessment of asset related and asset management-related risks, and the identification and implementation of necessary control measures throughout the life cycles of the assets.

Risk management is an important foundation for proactive asset management. Its overall purpose is to understand the cause, effect and likelihood of adverse events occurring, to optimally manage such risks to an acceptable level, and to provide an audit trail for the management of risks. This is achieved by:

- identifying potential risks associated with the assets, and making an estimate of the associated risk levels, in the basis of existing or proposed risk controls;
- determining whether these risks are tolerable;
- determining whether further analysis is required to establish whether the risks are, or are not, tolerable;
- devising risk controls where these are found to be necessary or desirable.

Risk management is integral to all asset management processes. However, there is specific need to have processes in place to identify and monitor risks, linked to control mechanisms for controlling, mitigating or recording them. It is a legal requirement that safety of employees, third parties and the public is managed to the appropriate legislative standard (and there may be specific industry sector regulations). There are further compliance requirements to manage environmental risks, and to comply with the legislation on corporate and financial risk management.

ISO XXXX-Y recognizes the need to integrate the management of risk throughout the asset management system, beyond the requirements of legislation in order to prioritize and optimize activities based on cost, risk and performance. In practice, this extends to the management of business risk and includes long-term sustainability.

4.4.7.2 Risk management methodology

The organization's methodology for risk management shall:

- f) be proportionate to the level of risk under consideration;
- g) be defined with respect to its scope, nature and timing to ensure it is proactive rather than reactive;
- h) include, where appropriate, the assessment of how risks change or can change over time and usage;
- i) provide for the classification of risks and identification of those risks that are to be avoided, eliminated or controlled by asset management objectives and plans (see 4.3.2 and 4.3.3);
- j) be consistent with the organization's operating experience and the capabilities of risk control measures employed;
- k) provide for the monitoring of required actions to ensure both the effectiveness and the timeliness of their implementation (see 4.6.1).

4.4.7.3 Process steps

The methodology requirements of ISO XXXX-Y can be met largely by ensuring that a step by step, systematic approach is adopted to the management of asset risks:

- classify assets and define scope: prepare a list of asset systems and their constituent assets, and gather information about them, including the management and control activities which affect the assets' performance; define the scope and limits of the individual asset risk assessments;
- identify credible risks: create a table of potential events and their causes;
- identify the risk controls that exist (or are proposed for planned assets and planned activities);
- determine level of risk: estimate the likelihood and consequences for each potential event, assuming that planned or existing controls are in place. The effectiveness of any existing risk controls, and the likelihood and consequences of their failure, should also be considered;
- determine the tolerability of the risks: decide whether planned or existing controls (if any) are sufficient to keep the risks under control and to meet any legal, statutory and other asset management requirements.

These principles should be in place and integrated into all activities and procedures throughout the asset management system, together with the necessary governance and assurance to ensure that risk controls are effectively implemented and monitored. It is an important principle embedded in ISO XXXX-Y that a whole life cycle approach is adopted. Therefore, risk management of physical assets should include consideration of risks across the whole asset life cycle. For example, the design process should include the identification and management of risks throughout the life of the asset, taking account of the operating conditions and criticality of the asset utilization. When determining risk controls, or considering changes to existing controls, consideration should be given to reducing the risks according to the following hierarchy:

- 1) elimination;
- 2) substitution;
- 3) physical controls;
- 4) signage/warnings and/or administrative/procedural controls.

4.4.7.4 Risk registers

Risk registers are a common and effective mechanism for recording and managing risks within the organization. At a corporate level this may comprise a list of significant risks defined in terms of likelihood and

consequence, together with existing mitigation, planned actions and responsibilities. These should include significant asset related risks. The type of risk should also be recorded to enable clear classification and auditability of safety and other types of risk. The monitoring and management of this risk register includes senior management review, together with clear processes and accountabilities for supporting processing and delivery of planned mitigation (for further detail on managing risk for corporate governance see PD 6668:2000). The process of maintaining, updating and auditing the risk register is one of the key asset management processes, and should be referenced in the asset management strategy. In order to ensure that appropriate priority is placed on risks of different types, a common assessment methodology should be adopted, enabling risks of a different nature to be considered and managed.

4.4.7.5 Management of asset-related risks

The management of asset risks should be carried out using processes that are consistent with any corporate risk register, enabling asset related risks to be escalated to the corporate risk register where they are of sufficient magnitude. Asset-related risks need to be identified and recorded in a way that is appropriate to the type of asset or asset system, taking into account their utilization and variety of failure consequences.

It is theoretically possible to provide a risk evaluation for every asset and asset system owned by an organization. This is not often a practicable solution, and it is more usual practice to focus primarily on significant risks, with lesser degrees of reporting and control required for lower risk areas. Many small, similar risks, however, can combine to represent significant systemic concerns, so it is necessary for the organization to be able to consider similar risks from across the systems so that the overall impact on the business can be evaluated, and the most appropriate organization-wide controls can be put into place, e.g. programmes of work or common procedures.

The nature of asset-related risks is that they are also likely to vary in time, as a result of many factors including the degradation of assets. Good risk management systems for asset management include recognition of how risks change with time (for example, with age or use), and the control of such changing risks is critical to asset maintenance and renewal decisions. However, the optimization of such decisions is complex and should be undertaken with particular care (for example, taking account of the degree to which the planned activity “resets the clock” of deterioration processes, considering any risks introduced by the planned activity, and calculating the optimal interval for periodic tasks, or renewal timing).

4.4.7.6 Asset criticality

The concept of asset criticality is a particular manifestation of risk management – this is the recognition that assets and asset systems have differing importance (value), or represent different vulnerabilities, to the organization. Criticality will usually include, but is not limited to, the risks of asset failure or non-performance. Criticality may also consider asset capital value, performance or efficiency, flexibility and other characteristics that reflect organizational goals and values. The corresponding asset characteristics should be assessed and weighted or scaled in a consistent manner to determine asset criticality for the purposes of prioritized asset management attention. Some assets of low material value, or indirect business contribution, may still have the potential to cause high impact in the event of failure (for example, safety relief valves).

Care should be taken in the definition and determination of asset criticality that includes risk elements. Some organizations refer to criticality only in terms of the potential failure consequences of the assets or asset systems; this may be suitable for prioritizing repairs or corrective actions for failures that have already occurred, but the true risks (probabilities multiplied by consequences) should normally be used within asset criticalities for the purposes of planning asset management (and risk management) actions. In some cases, where risks represent very low probability, very high consequence events (such as major safety risks), a degree of “disproportionality” should be considered to artificially increase the criticality, in recognition of the greater uncertainties associated with such risk estimations.

4.4.7.7 Risk identification and assessment

The identification and assessment of risks shall consider the probability of credible events and their consequences, and shall as a minimum cover:

- a) physical failure risks, such as functional failure, incidental damage, malicious damage or terrorist action;
- b) operational risks, including the control of the asset, human factors and all other activities which affect its performance, condition or safety;
- c) natural environmental events (storm, floods, etc., including the likely effects of climate change);
- d) factors outside of the organization's control, such as failures in externally supplied materials and services;
- e) stakeholder risks, such as failure to meet regulatory performance requirements or risks to the reputation of the organization;
- f) risks associated with the different life cycle phases of assets (see 4.5).

Risk is defined as the product of probability and consequence (for risk terminology see ISO/IEC Guide 73). Risk identification and assessment needs to recognize and include consideration of both these factors. The complexity of modelling and risk controls should be commensurate with the nature and magnitude of the risks being managed. It is important that risk assessment is applied coherently and consistently throughout the organization. Ideally, risk assessment should be based on a common approach and methodology with a common calibrated scale for quantification, but if this is not practicable, then care should be taken that the way risk is treated for different types or scales of risk is compatible.

Techniques for identifying, quantifying and managing asset-related risks, with varying levels of complexity, exist in different business sectors. Some of these are identified below and references to more general methods and techniques are provided in the AIRM IC, ALARM, IRM.

- a) Risk identification:
 - SWOT analysis (Strengths, Weaknesses, Opportunities, Threats);
 - BPEST analysis (Business, Political, Economic, Social, Technological);
 - PESTLE (Political, Economic, Social, Technical, Legal, Environmental);
 - HAZOP (Hazard and Operability Studies);
 - Risk assessment workshops;
 - Industry benchmarking;
 - Incident investigation;
 - Auditing and inspection.
- b) Risk analysis
 - Threat analysis;
 - Failure Mode and Effect Analysis (FMEA);
 - Failure Mode and Effect Criticality Analysis (FMECA);
 - Root Cause Analysis (RCA);
 - Event Tree Analysis (ETA);

- Fault Tree Analysis (FTA);
 - Deterioration, dependency or system performance modelling.
- c) Selection of controls
- Reliability Centred Maintenance (RCM);
 - Risk Based Inspection (RBI);
 - Instrument Protective Function (IPF).

These are not exhaustive lists, and organizations should consider adopting combinations of techniques as appropriate to the asset criticalities and diversity of risk types. In addition to these general methods and techniques, there are a variety of decision support tools and proprietary database products which can be employed to support risk assessment, auditing and ongoing management. In particular, there are a number of reliability- and risk-based methodologies for determining appropriate inspection and maintenance strategies, and cost/risk optimization of such strategies.

Organizations should consider their individual requirements, including the nature and scale of their business, the availability of information and implementation practicalities, when adopting appropriate methods and techniques. Some techniques require significant training and ongoing commitment of resources to be implemented effectively.

4.4.7.8 Use and maintenance of asset risk information

The organization shall ensure that the results of risk assessments and the effects of risk control measures are considered and, as appropriate, provide input into:

- a) the asset management strategy;
- b) the asset management objectives;
- c) the asset management plan(s);
- d) the identification of adequate resources including staffing levels;
- e) the identification of training and competency needs (see 4.4.3);
- f) the determination of controls for assets' life cycle activities, and the implementation of asset management plan(s) (see 4.5);
- g) the organization's overall risk management framework.

The organization shall keep the results of identification of risks, risk assessments and determined controls up-to-date, and document these where not doing so could affect the delivery of the asset management objectives and the asset management strategy.

In order to manage risks effectively, the consideration of risk should be embedded into all activities and procedures throughout the asset management system and preferably asset related risks should be addressed as part of the organization's corporate risk management framework.

Risks should be identified and managed as part of all asset management activities considering risks throughout the life cycle of assets. For example, the design process should include the identification of risks during the operation and maintenance phase of the asset, including its eventual decommissioning and disposal and taking account of the operating conditions and criticality of the asset.

4.4.8 Legal and other requirements

The organization shall establish, implement and maintain process(es) and/or procedure(s) for identifying and accessing the legal, regulatory, statutory and other applicable asset management requirements.

The organization shall ensure that the applicable legal and other external obligations or requirements are identified and incorporated into the corresponding elements of its asset management system.

The organization shall keep this information up-to date. The organization shall communicate information on legal and other requirements to all relevant stakeholders.

Organizations seeking to implement the requirements of ISO XXXX-Y on compliance with legal and other requirements, should consider the following recommendations and guidance:

- a) The organization should be aware of, and understand, how its activities are, or will be, affected by applicable legal and other requirements, and communicate this information to relevant personnel.

NOTE The requirement of 4.4.8 of ISO XXXX-Y is intended to promote awareness and understanding of legal responsibilities. It is not intended to impose an obligation on the organization to establish libraries of legal or other documents that are rarely referenced or used.

- b) The organization should operate a system through which it can identify the legislation, statutes and regulations applicable to its activities, and through which it can monitor forthcoming changes in such legislation. This should include arrangements to disseminate this information to affected parties and ensure that the necessary action is taken to achieve or maintain legal and regulatory compliance.
- c) Organizations should seek out the most appropriate means for accessing the information, including the media supporting the information (e.g. paper, optical storage disk, intranet, internet). The organization should also evaluate which requirements apply and where they apply, and who needs to receive which kind of information.
- d) Other asset management requirements could, for example, include parent company requirements, guidance from regulatory bodies, guidance from industry and trade associations, manufacturer's requirements, or any other asset management related standards that the organization subscribes to or that are deemed necessary for the effective implementation of the asset management system.

4.4.9 Management of change

Where existing arrangements are revised, or new arrangements are introduced that could have an impact on asset management activities, the organization shall assess the associated risks before the arrangements are implemented. The new or revised arrangements to be considered shall include:

- a) revised organizational structure, roles or responsibilities;
- b) revised asset management policy, strategy, objectives or plans;
- c) revised process(es) or procedure(s) for asset management activities;

- d) the introduction of new assets, asset systems or technology;
- e) the introduction of new contractors or suppliers.

The organization shall ensure that risks are managed in accordance with 4.4.7.

The organization should ensure that risk assessments are performed for any significant changes to elements of the asset management system. This does not necessitate additional risk management processes but ensures that there are existing arrangements in place which provide assurance that risk assessment is carried out when, for example, the following changes occur:

- revised organizational structure, roles or responsibilities;
- revised asset management policy, strategy, objectives or plans;
- revised process(es) and/or procedure(s) for the control activities;
- the introduction of new assets, asset systems or technology;
- the introduction of new contractors or suppliers.

Existing processes relating to the organizational structure, for example, should ensure that changes to that structure are risk assessed.

4.5 Implementation of asset management plan(s)

4.5.1 Life cycle activities

The organization shall establish, implement and maintain process(es) and/or procedure(s) for the implementation of its asset management plan(s) and control of activities across the whole life cycle, including:

- a) creation, acquisition or enhancement of assets;
- b) utilization of assets;
- c) maintenance of assets;
- d) decommissioning and/or disposal of assets.

The requirement for documentation to control these asset life cycle activities shall be in accordance with 4.4.5. The process(es) and/or procedure(s) for the implementation of the asset management plan(s) and for the control of life cycle activities shall:

- a) be sufficient to ensure that operations and activities are carried out under specified conditions;
- b) be consistent with the asset management policy, asset management strategy and asset management objectives;
- c) ensure that costs, risks and asset system performance are controlled across the asset life cycle phases.

The organization shall ensure that the planned arrangements, functional policies, standards, process(es) and procedure(s), asset management enablers and resources are utilized for the efficient and cost effective implementation of the asset management plan(s).

The organization should establish and maintain arrangements to ensure the effective control of all activities required to fulfil the asset management policy, strategy, objectives and plans, the control of its asset-related risks, and the conformity to legal, statutory and other asset management requirements.

Fundamental to the principles of asset management set out in ISO XXXX-Y is the controlled delivery of the asset management plan(s) through the day-to-day activities of the organization. In practice this means that procedures and processes need to be in place, which set out roles and accountabilities for every asset management activity, and introduce the necessary governance and controls for managing unplanned events or variations to the plan.

4.5.1.1 Implementing the asset management plan(s)

Asset management plan(s) should address all of the life cycle phases and all asset types, although the structure and composition of those plans may be varied accordingly. The structure and composition of the plans, and the implementation of those plans, will also vary with organizational and industry requirements. The following guidance should be considered in light of each of the life cycle phases.

- a) The asset management plan(s) should state who is responsible for the effective, efficient and compliant delivery of the plan(s). This responsibility includes ensuring necessary resources are available to deliver the plan(s) on time, within the allocated budget and that the delivery of the plan(s) conforms to all applicable legislative, and statutory requirements, policies, standards, process(es) and/or procedure(s) and any other requirements to which the organization may subscribe. Provision could be made in the plan(s) for the nominated individual to sign as a formal acceptance of this responsibility.
- b) Deliverables, and procedures for managing variations in the delivery of the plan, should be agreed and understood by all parties, with appropriate governance in place. The overall responsibility for the monitoring and management of plan delivery should be unambiguously designated.
- c) In-house delivery departments, supply chain partners and other outsourced suppliers should be incentivized consistently with the delivery of the plan, and the organization's key performance measures. Where practicable, common measures and targets should be shared between contributing parties.
- d) Information systems should provide adequate information to enable the efficient and economic delivery of asset management plan(s), with arrangements in place to ensure that asset information, records and other relevant data is of the necessary quality and accessible in the appropriate format to those responsible for plan delivery.
- e) Quality assurance processes should be aligned to the delivery of the plan, ensuring that all aspects of asset management activities conform to relevant standards, specifications and other requirements (including safety, legal and environmental requirements).
- f) The delivery of the plan should include scheduling and management of resources and ensuring that sufficient materials, suitably qualified staff, tools, access equipment, etc. are available. Scheduling should be designed to optimize the use of resources, consistent with the efficient delivery of the plan, and include due consideration of logistics and contingencies for foreseeable unplanned work and overruns.
- g) Plan delivery should align with constraints and wider business objectives. Specifically, plans and schedules should align with operational objectives, ensuring that work is prioritized, optimally bundled and carried out consistently with shutdown or other access constraints.
- h) Progress monitoring of the plan should be ongoing, with regular exchange of information, including forward predictions of completion dates and performance outcomes, between parties responsible for each asset management activity. Mechanisms should be in place to review and realign plans during the delivery phase, enabling the reprioritizing of work or allocation of resources (including consideration of acceleration options where appropriate) in order to optimize the plan delivery when encountering unanticipated events.

- i) There should be clear escalation procedures to enable the management of variations in plan delivery to be agreed. This should include decision making criteria if additional funds or resources are needed to address exceptional circumstances which cannot be accommodated within normal delivery control mechanisms.
- j) Plan delivery should incorporate the updating of asset information and records, and the recording of condition and actual expenditure against assets to enable continuous improvement.

4.5.1.2 Operational control of asset management processes

In addition to the delivery of the asset management plan(s), ISO XXXX-Y requires organizations to maintain and improve the processes that manage all phases of life of asset systems. This includes all life cycle activities listed in ISO XXXX-Y, 4.5.1 (create/acquire, utilize, maintain, decommissioning/disposal of assets). These activities should be controlled in line with the requirements of the asset management strategy, and should have clear boundaries, effective interfaces and coordination with associated activities. Governance and accountabilities should be unambiguous, effective and should not present any barriers to effective and efficient delivery.

Organizations can have a number of asset management functional policies; examples are shown in 4.4.5 (i). Functional policies provide a framework for the control of specific asset management related activities (such as capital investment, operation, maintenance, materials management or transport logistics). They also provide the workforce with clarity for what is expected of them and the boundaries for any permissible variability. For example, the following policy would require the production of a set of maintenance strategies and plans but it would also prevent a manager from simply employing the manufacturer's recommendations for maintenance activities:

Maintenance strategies will be proactive and risk-based, taking due account of asset criticality and condition.

However, when formulating functional policies, care should be taken not to conflict with other organizational or asset management policies, or restrict managers to the extent that they are unable to take appropriate action for the optimal life cycle management of the assets. For example, a capital investment or purchasing policy should not encourage "cheapest purchase cost" solutions unless there are pre-considered life cycle cost, risk and/or performance reasons for this to be appropriate. Similarly, functional policies and any derived strategies should be appropriate to the operational role, context and criticality, and the value of the assets to which they apply.

In addition to generic considerations and functional policies applicable in the control of asset management activities, there are specific considerations regarding each of the life cycle phases (see 4.5.1).

4.5.1.3 Creation, acquisition or enhancement of assets

Adding to, or enhancing assets, asset systems or the asset portfolio are critical, often high cost activities, with long-term consequences and uncertainties about their future utilization, performance, costs and risks. Procedures and operational controls for asset acquisition, creation or modification therefore need to match the planning and scheduling processes closely to ensure that required design criteria are met at optimal life cycle cost. Opportunities and options encountered during the acquisition, creation or enhancement of assets should be evaluated for whole life cost, performance and risk impact to determine if the asset management plan(s) should be changed to exploit the opportunities and/or mitigate the risks (see also 4.4.9).

The management of major projects or construction programmes can take on many forms, with some organizations preferring strategies where contracted service providers have responsibility for design, engineering, procurement and construction ("buy and build"), or "buy, build and maintain" or even "buy, build, operate and maintain" (see also 4.4.2). Control and alignment with the organizational strategic plan and asset management policy, strategy, objectives and performance standards should be considered in the choice of

these options, ensuring that life cycle costs, long-term performance and the organizational strategic plan goals are not compromised.

Major projects or construction programmes are often managed by consortia of organizations working together, or by a number of independent contributing organizations supplying specialist services to the asset owner or manager. In such cases it remains critically important for the construction and procurement programme to be optimized (within known constraints) based on whole life cost and value, in line with the asset management policy, strategy and plan. There are legal, health, safety and environmental compliance requirements set down for construction, in addition to any specific asset management requirements. Practical implementation also requires good project management, with clear accountabilities, risk management, mechanisms for addressing nonconformities and change control (see Project Management Body of Knowledge Guide: 2004). The scheme of incentives and alignment of business drivers, including sharing of knowledge and long-term mutual commitment and management of interfaces are important mechanisms for improving the probability of success. Ultimately, however, the asset management organization has accountability for due diligence in appointing competent contractors and delivering investment value for money.

In the early life cycle stage (create/acquire assets) it is of particular importance to ensure that new assets meet quality assurance requirements and are handed over in good operational order to those responsible for future operation (utilization and maintenance) of the assets. This will include consideration of training and knowledge transfer and the provision of necessary design, operations, performance, reliability, maintainability and life cycle assumptions, guidance and data. Effective commissioning procedures, warranty conditions and provision of all records and asset data should normally be tied in to contractual requirements.

4.5.1.4 Utilization of assets

During the utilization of assets, consideration should be given to how operating criteria are defined, documented and communicated, as well as how they are controlled and monitored. Examples include the use of temporary speed restrictions in a railway network, the specification and monitoring of optimal temperature and pressure ranges in a chemical process, or the ambient lighting and temperature conditions for office buildings.

It is important that the operational parameters and controls are considered and managed in conjunction with maintenance arrangements (because of the potential impact of utilization upon asset degradation characteristics, failure risks and asset life cycles). For example, if the landing gear of an aircraft is maintained on a schedule linked to the numbers of landings, then variations in the operational flying regime need to be reflected into the maintenance programme so that relevant maintenance actions and resources can be suitably adjusted.

4.5.1.5 Maintenance of assets

Controls for maintenance of assets should be consistent with ensuring compliance with the asset management policy, asset management strategy and asset management objectives, and take account of asset operating parameters.

Consideration should be given to control mechanisms for ensuring that:

- staff are competent at the point of work;
- operating parameters are understood;
- appropriate records are kept.

Maintenance management systems are often used to coordinate maintenance activities. These systems may be based on simple scheduling tools, such as card/index systems, or more sophisticated work programming and schedule optimization tools. The organization should ensure that such systems are selected, implemented and utilized appropriately and effectively for the coordination and management of different types of maintenance activity (such as condition monitoring, inspection or predictive maintenance, planned preventive maintenance, function testing and corrective maintenance). Work procedures or instructions, standards and systems for supervision, checking or approvals (for example, “permit to work” systems) should

be designed to ensure adequate control of quality, consistency and control of risk in the delivery of maintenance activities. The control of maintenance activities should also reflect the criticality and urgency of the tasks (including timing criticality), the dynamic nature of condition-based work (where the scope of work depends upon the condition of the asset found during inspection), work bundling opportunities and resource constraints.

4.5.1.6 Decommissioning and/or disposal of assets

At decommissioning, the safe management and disposal of any redundant equipment should follow appropriate policies, including environmental management. From an asset management perspective, decommissioning should also include consideration of the long-term management of similar assets, and controlled retention if appropriate (for example, spare parts). It is also essential that records and asset information are correctly updated – it is good practice to write this into decommissioning procedures and include such obligations in contractual requirements. Decommissioning should ensure that equipment is removed as planned, and that remaining equipment is left in the required safe condition and that any relevant signs and notices are updated.

4.5.1.7 Other operational controls

The following list provides examples of the range of operational controls that might be employed by the organization in managing its assets.

- a) Control of imported risks
 - assessment and approval of the design for new plant or equipment;
 - procedures ensuring the availability of documentation for the safe handling, operation and maintenance of new machinery, equipment, materials or substances;
 - evaluation, and periodic re-evaluation, of the competence of contractors;
 - procedures for the review, approval and control of contracts.
- b) Controls on specific tasks
 - pre-determination and approval of working methods;
 - pre-qualification of personnel for hazardous/critical tasks;
 - permit-to-work systems, and procedures controlling the entry and exit of personnel to hazardous areas or those containing critical equipment;
 - procedures for tactical planning, development, project management, scheduling and resource management.
- c) Controls on through-life management of plant and equipment
 - evaluation and approval procedures at the various asset life cycle stages, e.g. creation/acquisition, utilization, maintenance and decommissioning/disposal;
 - procedures for the operation of plant and equipment;
 - procedures for repair, maintenance and inspection activities;
 - procedures for calibration and maintenance of tools and test equipments;
 - procedures for the management of spares;

- isolation of equipment and segregation and control of access;
- maintenance, inspection and testing of protection systems and emergency equipment such as:
 - i) guarding and physical protection;
 - ii) shutdown systems;
 - iii) fire detection and suppression equipment;
 - iv) essential monitoring devices.

4.5.2 Tools, facilities and equipment

The organization shall ensure that tools, facilities and equipment are maintained and, where appropriate, calibrated. The organization shall establish and maintain process(es) and procedure(s) to control these maintenance and calibration activities, where such tools, facilities and equipment are essential for:

- a) the implementation of its asset management plan(s);
- b) achieving the required function(s) and performance from its assets or asset systems;
- c) the monitoring and measurement of performance and/or condition.

As part of the Plan-Do-Check-Act processes, a wide variety of parameters are defined during the development of policies, processes, standards and plans. Some of these require tools, facilities or measuring/test equipment to effect their implementation. It is essential that any tools, facilities or equipment that are required for the delivery and/or control of asset management activities are themselves identified and managed as assets, at a level of detail appropriate to their criticality.

Any monitoring equipment or instrumentation that is built into an asset may require periodic calibration or testing; this should be regarded as an intrinsic need of the asset itself, to be identified, planned and controlled appropriately. It is important to consider how tools, facilities and equipment are identified and tracked through their usage and life cycles.

It is also important to know where and when they have been applied; for example, if a piece of test equipment is found to be significantly out of tolerance, it may be important to be able to trace where and when it has been used so that re-testing can be carried out.

4.6 Performance assessment and improvement

4.6.1 Performance and condition monitoring

The organization shall establish, implement and maintain process(es) and/or procedure(s) to monitor and measure the performance of the asset management system and the performance and/or condition of assets and/or asset systems. The process(es) and/or procedure(s) shall provide for the consideration of:

- a) reactive monitoring to identify past or existing nonconformities in the asset management system, and any asset-related deterioration, failures or incidents;
- b) proactive monitoring to seek assurance that the asset management system and assets and/or asset systems are operating as intended. This shall include monitoring to ascertain that the asset management policy, strategy and objectives are met, the asset management plan(s) are implemented, and that the process(es), procedure(s) or other arrangements to control asset life cycle activities are effective;
- c) leading performance indicators to provide warning of potential non-compliance with the performance

requirements of the asset management system and/or the assets and/or asset systems;

- d) lagging performance indicators to enable detection of, and to provide data about, incidents and failures of the asset management system, and for incidents, failures or deficient performance of assets and/or asset systems;
- e) both qualitative and quantitative measures, appropriate to the needs of the organization;
- f) monitoring the overall effectiveness and efficiency of the asset management system;
- g) recording of monitoring and measurement data and results to facilitate subsequent analysis of problem causes to assist in determining corrective or preventive actions and/or to facilitate continual improvement (in accordance with 4.6.5).

When setting the frequency of condition or performance monitoring and the parameters for measurement the organization shall consider, at a minimum, the costs of monitoring, the risks of failure or nonconformity, and potential deterioration mechanisms and deterioration rates.

Organizations seeking to implement the requirements of ISO XXXX-Y on performance and condition monitoring, should consider the following recommendations and guidance.

- a) The overall purpose of monitoring asset management performance is to evaluate the implementation of asset management objectives, the effectiveness of the arrangements for controlling risk and enable the identification of the need to restore or improve asset management performance.
- b) ISO XXXX-Y identifies the requirement for both reactive monitoring and proactive monitoring.
- c) Reactive monitoring comprises structured responses to an indication of a deficiency or failure of the asset management system, assets or asset systems. This indication could be the failure of an asset, or assets failing to perform as expected, or it could be evidence that the asset management system itself is deficient, for example, as a result of an observation from an external party, such as a regulatory agency.
- d) Proactive monitoring comprises timely routine and periodic checks that plans and planned arrangements have been implemented, to determine the level of conformance with asset management system requirements and to seek evidence of problems with the asset management system that have not otherwise come to the attention of the organization via reactive monitoring.

NOTE 1 Performance and condition measurement and monitoring focuses on the performance of the asset management system (i.e. processes) and the performance and/or condition of the assets or asset systems on a day-to-day basis, whereas auditing is a process for reviewing and evaluating the effectiveness of the asset management system retrospectively (normally based on an annual plan). The two should not be confused.

- e) Proactive monitoring should be carried out to determine whether:
 - the asset management system is being operated as intended, i.e. asset management objectives, targets and plans have been set and are achieved;
 - the assets and/or asset systems are functioning as required, i.e. the output, reliability, availability, condition, etc. from an asset and/or asset system are as planned;
 - asset management plans, operational control criteria and applicable legislation, regulatory, statutory, and other asset management requirements are being complied with. An exclusive reliance on reactive monitoring could lead to complacency, with the organization's asset management system likely to lie dormant until problems occur. Proactive monitoring of asset management performance in many cases (for example where routine checks are carried out) leads to immediate corrective action and the information about the findings might not be formally recorded. Where practicable,

organizations should record the findings of such proactive monitoring (and actions resulting) and should always document the findings of reactive monitoring (and actions resulting).

f) ISO XXX1 also identifies the requirement for both leading and lagging performance indicators.

— Leading performance indicators provide data on compliance or non-compliance with the performance requirements of asset management plan(s) and compliance or non-compliance with the organization's asset management system generally. They provide warning signs of potential problems, either before they occur or before they become significant. Leading indicators should be applied, in particular, to activities or processes that could have the greatest potential beneficial influence on subsequent asset performance. Leading performance indicators should predict the prevalence of lagging indicators in the months and years ahead. Such indicators are useful in that they provide early evidence of success or failure, although their link with long-term performance might not be perfect.

NOTE 2 The data for leading indicators results mainly from proactive monitoring.

— Lagging indicators provide data on performance results, such as the frequencies and severities of undesirable events; for example, incidents or failures of the asset management system, assets or asset systems. Lagging indicators are vital as they are the final check on the effectiveness of an asset management system. However, there are limitations relating to their use in the following circumstances:

- i) monitoring the levels of risk for high impact, low probability events, such as those in the major hazard industries
- ii) there are too few failures to detect changes in the level of risk;
- iii) monitoring sustainability or long lead-time effects – problems are detected too late;
- iv) monitoring intangible or indirect effects such as reputation, employee morale, customer satisfaction – problems are detected too late.

NOTE 3 The data for lagging indicators results mainly from reactive monitoring.

— A combination of leading and lagging indicators should be used, since the two approaches are complementary; lagging indicators (for example asset failures) can reveal weaknesses in a system that is otherwise operating as intended, whereas leading indicators can detect non-conformances which can be corrected before adverse events occur.

g) The organization should identify key performance indicators (KPIs) as the principal indicators to be used by top management to review the organization's asset management performance.

A large number of performance indicators might be required to monitor the implementation and effectiveness of the entire asset management system and the overall asset performance. However, this range of performance indicators should be aggregated into KPIs to enable senior staff to efficiently and effectively monitor the overall performance of the asset management system and assets. KPIs should comprise a small number of both leading and lagging performance indicators. It is essential that the KPIs selected are appropriate in terms of relevance and quantity and that senior staff have sufficient information but are not overloaded with data.

The top management of some organizations employ a "Balanced Scorecard". This comprises a relatively small number of KPIs, yet covers a broad range of organization objectives and performance criteria (note that a "balancing" mechanism is often missing – so that performance in one area may be at the expense of another). A corresponding "Asset Management Scorecard" should be considered to monitor the organization's overall asset management performance, provided that a clear understanding of individual goals is complemented by understanding of the trade-offs involved. An optimization method is needed to ensure that improvements in one KPI are not achieved at the disproportionate expense of another, e.g. an asset performance target is achieved but at excessive costs or risks.

- h) The organization should identify parameters for its asset management performance across the whole organization. These should include, but not be limited to, parameters that determine whether:
- asset management policy, strategy, objectives, targets and plans will be or are being achieved;
 - risk controls have been implemented and are effective;
 - the assets are achieving the performance and being maintained in the condition required of them and that lessons are being learnt from asset management system failures, including incidents, and potential nonconformities (near misses);
 - awareness, training, communication and consultation programmes for employees and interested parties are effective;
 - information that can be used to review and/or improve aspects of the asset management system is being produced and being used.
- i) Organizations should base their performance measurement on a well-formulated combination of objective, subjective, quantitative and qualitative data types:
- objective data: data which is detached from an assessor's personal judgement;
 - subjective data: data which could have been influenced by those doing the measuring. These measures can be very useful but need to be treated with care;
 - quantitative data: data which describes numbers and recorded on a scale. Where possible, it is desirable to quantify performance measures so that comparisons can be made over time. However, such data might give an unjustified impression of precision;
 - qualitative data: data which describes conditions or situations that cannot be recorded numerically. While qualitative data is very important it might be difficult to relate to other performance measures.
- j) The use of a combination of these various data types will provide a better overall assessment of the asset management system and asset performance than reliance on only one type of measure. In general, however, objective and quantitative measures should be the preferred choice if critical business processes or assets are being monitored.
- k) Attention should be given to the level of competence required of those responsible for planning, collecting and analysing data from performance measures.
- l) The scope, level of scrutiny, frequency of measurement and condition or performance alarm levels (at which point remedial action is initiated) should be optimized and risk-based. These criteria may be adjusted over time as information accumulates, the stability of the system is established, and confidence in the asset management system increases. The minimum frequency of inspection for some assets may be determined by legislation.
- m) Evidence of internal/external benchmarking exercises and acting on the results obtained can be helpful in demonstrating that the organization is committed to performance measurement and improvement.
- n) It may be appropriate periodically to commission the independent gathering of physical condition data for the assets to verify the accuracy of asset data records and to validate the results from any predictive tools used to estimate asset condition.

NOTE 4 The word "independent" here does not necessarily mean external to the organization.

4.6.2 Investigation of asset-related failures, incidents and nonconformities

The organization shall establish, implement and maintain process(es) and/or procedure(s) for the handling

and investigation of failures, incidents and nonconformities associated with assets, asset systems and the asset management system. These process(es) and/or procedure(s) shall define responsibility and authority for:

- a) taking action to mitigate consequences arising from a failure, incident or nonconformity;
- b) investigating failures, incidents and nonconformities to determine their root cause(s);
- c) evaluating the need for preventive action(s) to avoid failures, incidents and nonconformities occurring;
- d) communicating, as appropriate to relevant stakeholders, the results of investigations and identified corrective action(s) and/or preventive action(s).

Investigations shall be performed within a timescale commensurate with the actual and/or potential consequences of the failure, incident or nonconformity.

4.6.2.1 General

Organizations should have effective procedures for reporting, evaluating and investigating incidents and non-conformances. The prime purpose of the procedure(s) is to prevent further occurrence or escalation of such situations by identifying and dealing with the root cause(s). Furthermore, the procedures should enable the detection, analysis and elimination of potential causes of non-conformities.

The organization should prepare procedures to ensure that incidents and non-conformances are investigated, and corrective and/or preventive actions initiated. Progress in the completion of corrective and preventive actions should be monitored, and the effectiveness of such actions reviewed. Immediate action to be taken upon observation of non-conformances, incidents or cases of imminent risk should be known to all parties and should be reflective of the risk associated with the non-conformance or incident.

Root cause analysis should be used to investigate critical asset-related failures or incidents, repetitive failures or incidents and significant non-conformances (including near misses). Where solutions or improvements related to critical assets are identified, systematic identification, selection and cost/risk/performance evaluation of these solutions or improvements should be carried out. It might not be appropriate to investigate each and every non-critical asset failure and it therefore might be more efficient to classify such failures into categories of similar events, which are then subjected to a generic assessment and course of action that could facilitate trend analysis.

4.6.2.2 Procedures

4.6.2.2.1 General

Any procedures should:

- define the responsibilities and authorities of the individuals involved in implementing, reporting, investigating, follow-up and monitoring of corrective and preventive actions;
- require that all non-conformances, incidents, and cases of imminent risk are reported;
- clearly define the course of action to be taken following non-conformances identified in the asset management system;
- where an incident has legal or regulatory implications (for example health, safety or environmental) then the procedures should ensure compliance with any legal or regulatory requirements.

4.6.2.2.2 Immediate action

Immediate action to be taken upon observation of non-conformances, incidents or cases of imminent risk should be known to all parties. The procedures should:

- define the process for notification;
- where appropriate, include co-ordination with emergency plans and procedures;
- define the scale of investigative effort in relation to the potential or actual harm, e.g. include top management in the investigation of serious incidents.

4.6.2.2.3 Recording

Appropriate means should be used to record the factual information and the results of the immediate investigation and the subsequent detailed investigation. The organization should ensure that the procedures are followed for:

- recording the details of the non-conformance, incident or cases of imminent risk;
- defining where the records are to be stored, and responsibility for the storage.

4.6.2.2.4 Investigation

The procedures should define how the investigation process should be handled. The procedures should identify:

- the type of events to be investigated, e.g. service interruption incidents above a defined threshold (such as duration and number of customers affected);
- whether the involvement of external agencies and authorities is required;
- the purpose of investigations;
- who is to investigate, the authority of the investigators, required qualifications (including line management when appropriate);
- the process for establishing the root cause of the non-conformance;
- arrangements for witness interviews;
- practical issues such as availability of cameras and storage of evidence;
- investigation reporting arrangements including statutory reporting requirements.

Investigatory personnel should begin their preliminary analysis of the facts while further information is collected. Data collection and analysis should continue until an adequate and sufficiently comprehensive explanation is obtained.

4.6.3 Evaluation of compliance

The organization shall establish, implement and maintain process(es) and/or procedure(s) for evaluation of its compliance with applicable legal and other regulatory or absolute requirements, and shall determine the frequency of such evaluations.

The organization shall keep records of the results of these evaluations.

An organization should establish, implement and maintain a procedure for periodically evaluating its compliance with the legal or other requirements that are applicable to its asset management, as part of its commitment to compliance.

Evaluation of the organization's compliance should be performed by competent persons either from within the organization and/or using external resources.

A variety of inputs can be used to assess compliance, including:

- audits;
- the results of regulatory inspections;
- analysis of legal and other requirements;
- reviews of documents and /or records of incidents and risk assessments;
- interviews;
- facility, equipment and area inspections;
- project or work reviews;
- analysis of test results from monitoring and testing;
- facility tours and/or direct observations.

The organization's processes for the evaluation of compliance can depend on its nature (size, structure and complexity). A compliance evaluation can encompass multiple legal requirements or a single requirement. The frequency of evaluations can be affected by factors such as past compliance performance or specific legal requirements. The organization can choose to evaluate compliance with individual requirements at different times or at different frequencies, or as appropriate. A compliance evaluation programme can be integrated with other assessment activities. These can include management system audits, environmental audits or quality assurance checks.

Similarly, an organization should periodically evaluate its compliance with other requirements to which it subscribes (see 4.4.8). An organization can choose to establish a separate process for conducting such evaluations or it may choose to combine these evaluations with its evaluations of compliance with legal requirements (see above) and/or its management review process (see 4.7) or other evaluation processes.

The results of the periodic evaluations of compliance with legal or other requirements should be recorded.

4.6.4 Audit

The organization shall ensure that audits of the asset management system are conducted to:

- a) determine whether the asset management system:
 - 1) conforms to planned arrangements for asset management, including the requirements of Clause 4;
 - 2) has been implemented and is maintained;
 - 3) is effective in meeting the organization's asset management policy, asset management strategy and asset management objectives.
- b) provide information to management.

Audit programme(s) for elements of the asset management system shall be planned, established, implemented and maintained by the organization, based on the results of risk assessments of the organization's activities, and the results of previous audits.

Audit process(es) and/or procedure(s) shall be established, implemented and maintained to address:

- a) the responsibilities, competencies and requirements for planning and conducting audits, reporting results and retaining associated records;
- b) the determination of audit criteria, scope and methods that are commensurate with the business significance and risks being managed.

The selection of auditors and the conduct of audits shall ensure objectivity and the impartiality of the audit process. Audits shall be conducted by personnel independent of those having direct responsibility for the activity being examined.

NOTE 1 The term "independent" here does not necessarily mean external to the organization.

NOTE 2 It is recommended that the selection of auditors considers their level of understanding of good practice in asset management and familiarity with the requirements of Clause 4 of this PAS.

Auditing is a process whereby organizations can review and continuously evaluate the effectiveness of their asset management system. Organizations seeking to implement the requirements of ISO XXXX-Y on audit, should consider the following recommendations and guidance.

- a) An audit should:
 - confirm whether the system meets the requirements of ISO XXXX-Y;
 - establish the degree of compliance with the documented asset management procedures;
 - assess whether or not the system is effective in meeting the asset management policy, strategy and objectives of the organization;
 - identify any corrective actions required to achieve compliance with the requirements.
- b) The audit should include assessing and determining the viability and suitability of the asset management policy, strategy, objectives and plans, particularly in relation to critical assets and asset systems, to ensure that they are:
 - consistent with each other;

- adequate;
- achievable.

Establishing whether they are adequate and achievable also requires assessment of the organization's:

- asset management related assumptions;
 - process(es) and/or procedure(s), methods, tools and techniques;
 - availability/allocation of funds;
 - availability/allocation of resources (including competencies);
 - availability/allocation of time (including timing interdependencies).
- c) The results of the asset management system audits should be recorded and reported to management in a timely manner. A review of the results should be carried out by management and effective corrective action taken where necessary.
- d) Audits should be carried out by personnel from within the organization and/or by external personnel selected by the organization. In either case, the personnel conducting the asset management system audits should be in a position to do so impartially and objectively.
- e) Asset management system audits should be conducted according to planned arrangements that are commensurate with the business significance and risks being managed. Additional audits can be performed as circumstances require.

NOTE The general principles and methodology described in ISO 19011 are appropriate for asset management system auditing.

- f) The audit should provide comprehensive coverage of the whole asset management system. This may organization, and may require auditors with different expertise to contribute to the different elements. It may be appropriate to use a combination of audits to get the necessary depth and coverage, taking either:
- a “horizontal slice”: for example, an audit of asset management plan(s) across the organization to verify that the plans conform to the relevant requirements in ISO XXXX-Y; or
 - a “vertical slice”: for example, the arrangements to manage a specific asset over its life cycle, or a specific asset-related risk, are audited in terms of the asset management policy and asset management strategy, asset management plan(s), the enabling and control processes (including risk management), implementation of asset management plan(s), performance monitoring and management review.
- g) The audit process should establish the effectiveness of the system in managing the assets in accordance with the organization's policy and objectives (validation audit) and also that the organization is following its own procedures (compliance audit). Where the asset management system is additionally required to conform to an external specification this should also be verified.
- h) The audit process should also look for changes in business and asset operating context that renders stated procedures and processes invalid, thereby introducing risk.
- i) The auditor should be aware that the existence of an asset management policy, strategy, objectives, targets and plans alone are no guarantee that they are (or will be) effective in the optimal management of the assets. Therefore, the auditor should seek further evidence to validate the effectiveness of the asset management system.

- j) The audit process should also encourage auditors to identify opportunities for continual improvement. Active participation, understanding and support of the organization's employees are important in achieving this.

4.6.5 Improvement actions

4.6.5.1 Corrective and preventive action

The organization shall establish, implement and maintain process(es) and/or procedure(s) for instigating:

- a) corrective action(s) for eliminating the causes of observed poor performance and nonconformities identified from investigations, evaluations of compliance and audits to avoid their recurrence;
- b) preventive action(s) for eliminating the potential causes of nonconformities or poor performance.

Any corrective or preventive actions taken and their timings shall be commensurate with the risk(s) encountered.

Where a corrective or preventive action identifies new or changed risks, or the need for new or changed process(es), procedure(s) or other arrangements to control asset life cycle activities, the proposed actions shall be risk assessed prior to implementation (see 4.4.7).

The organization shall keep records of the corrective and preventive actions (see 4.6.6) taken and communicate these to relevant stakeholders.

The organization shall ensure that any necessary changes arising from corrective and/or preventive actions are made to the asset management system.

4.6.5.1.1 Corrective action

Corrective actions are actions taken to address the root cause(s) of identified non-conformances, or incidents, in order to prevent, or reduce the likelihood of recurrence. Aspects to be considered in establishing and maintaining corrective action procedures include:

- identification and implementation of corrective measures both for the short-term as well as longterm (this can also include the use of appropriate sources of information, such as advice from employees with asset management expertise);
- evaluation of any impact on risk identification, and assessment results (and any need to update risk identification, assessment and control report(s));
- initiation and implementation of corrective action;
- recording any required changes in procedures resulting from the corrective action or risk identification, assessment and control, and implementation of these changes.

4.6.5.1.2 Preventive action

Preventive actions are those taken to address the root cause(s) of potential non-conformances or incidents, as a proactive measure, before such incidents occur. Examples of elements to be considered in establishing and maintaining preventive action procedures include:

- use of appropriate sources of information, e.g. trends in asset performance indicating imminent risk of failure, failure rates across a population of assets, revised risk assessments, data on environmental changes;

- identification of any potential problems requiring preventive action;
- use of an appropriate methodology to select a suitable and sufficient preventive action;
- initiation and implementation of preventive action;
- recording of any changes in procedures resulting from the preventive action.

4.6.5.1.3 Follow up

Corrective or preventive action taken should be as permanent and effective as practicable. Checks should be made on the effectiveness of corrective/preventive action taken. Checks should also be made to ensure that any temporary containment measures have been removed.

Outstanding/overdue actions should be escalated as appropriate via management.

4.6.5.1.4 Non-conformance, and incident analysis

Identified causes of non-conformances and incidents should be classified and analysed on a regular basis.

Frequency and severity ratings should be calculated in accordance with accepted industry practice for comparison purposes.

Valid conclusions should be drawn and corrective action taken. At least annually, this analysis should be circulated to top management and included in the management review (see 4.7).

4.6.5.1.5 Monitoring and communicating results

The effectiveness of asset management investigations and reporting should be assessed. The assessment should be objective, and should yield a quantitative result if possible.

The organization, having learnt from the investigation, should:

- identify the root causes of deficiencies in the asset management system and general management of the organization, where applicable;
- communicate findings and recommendations to management and relevant interested parties (see 4.4.4);
- include relevant findings and recommendations from investigations in the continuing asset management review process;
- monitor the timely implementation of remedial controls, and their subsequent effectiveness over time;
- apply the lessons learnt from the investigation of non-conformances across the whole organization, focussing on the broad principles involved, rather than being restricted to specific action designed to avoid repetition of a precisely similar event in the same area of the organization;
- provide a standardized reporting system so as to efficiently analyse the amount and type of asset related failures, incidents and non-conformances occurring and how effectively they are being dealt with.

4.6.5.2 Continual improvement

The organization shall establish, implement and maintain process(es) and/or procedure(s) for identifying opportunities and assessing, prioritizing and implementing actions to achieve continual improvement in:

- a) the optimal combination of costs, asset related risks and the performance and condition of assets and

asset systems across the whole life cycle;

b) the performance of the asset management system.

The organization shall actively seek and acquire knowledge about new asset management-related technology and practices, including new tools and techniques, and these shall be evaluated to establish their potential benefit to the organization.

Opportunities to improve should be identified, assessed and implemented across the organization as appropriate, through a combination of monitoring and corrective actions for the assets and/or asset systems and/or the asset management system. Continual improvement should be regarded as an iterative activity with the ultimate aim to be to deliver organizational objectives. It should not be interpreted as cyclic (e.g. annual) improvements in asset performance parameters just because they can be achieved.

Often organizations are not aware of new technology, tools or methods that have been proven to be of measurable benefit to other organizations. Active research is required to identify, investigate, trial and evaluate such opportunities. Examples of how organizations acquire such knowledge include:

- employing specialist organizations and personnel;
- professional bodies and trade associations;
- conferences, forums, seminars, journals, publications and other media;
- benchmarking and cross-industry technology transfer;
- alliances, contractors and service providers;
- existing suppliers and alternative technology or service vendors;
- research and development activities, results of academic research;
- tracking competitors.

4.6.6 Records

The organization shall establish and maintain records as necessary to demonstrate conformance to the requirements of its asset management system and Clause 4 of this Part of ISO XXXX.

Records shall be legible, identifiable and traceable.

Records shall be maintained in accordance with the requirements of 4.4.6.

Organizations seeking to implement the requirements of ISO XXXX-Y on records, should consider the following recommendations and guidance.

- a) Keeping records and managing them effectively gives the organization a reliable source of information on the operation and results of the asset management system. Records should be kept to demonstrate that the asset management system operates effectively, and that processes have been carried out under prescribed conditions. Records that demonstrate the organization's conformance with the requirements of the asset management system should remain legible, readily identifiable, traceable and retrievable.
- b) ISO XXXX-Y requires that records are kept:

- for essential information generated whilst responding to and managing incidents and emergencies;
 - for training provided;
 - for maintenance, and where appropriate, calibration of specified tools, equipment and facilities;
 - for monitoring and measurement of the performance of the asset management system, and the performance and/or condition of assets and/or asset systems;
 - for evaluations of compliance with legal or other requirements;
 - on the results of audits;
 - on details of corrective and preventive actions;
 - for management review.
- c) An organization should determine which records are required to manage its asset management activities effectively. In addition to those identified in b) above, asset management records could include:
- asset management related complaints records, e.g. from customers, regulators, employees;
 - the results of identification of risks or risk assessments;
 - inspection, maintenance and calibration records;
 - pertinent contractor and supplier information;
 - incident and non-conformance reports/registers;
 - evidence of emergency preparedness and response, including the results of testing contingency plans.
- d) Acceptable records can take many forms. For example, records of management review can include copies of meeting agenda items, lists of attendees, presentation materials or handouts, and management decisions recorded in a memo to file, reports, minutes or tracking system.
- e) Asset management records should be controlled in the same way as other important asset management information.

4.7 Management review

Top management shall review at intervals that it determines appropriate the organization's asset management system to ensure its continuing suitability, adequacy and effectiveness. Reviews shall include assessing the need for changes to the asset management system, including asset management policy, asset management strategy and asset management objectives.

Input to management reviews shall include:

- a) results of internal audits and evaluations of compliance with applicable legal requirements and with other requirements to which the organization subscribes;
- b) the results of communication, participation and consultation with employees and other stakeholders (see 4.4.4);
- c) relevant communication(s) from external stakeholders, including complaints;

- d) records or reports on the asset management performance of the organization;
- e) the extent to which objectives have been met;
- f) performance in addressing incident investigations, corrective actions and preventive actions;
- g) follow-up actions from previous management reviews;
- h) changing circumstances, including developments in legal and other requirements related to asset management and changes in technology.

The management review shall also cover aspects of the asset management system, if any, that are outsourced to a contracted service provider.

The outputs from management reviews, consistent with the organization's commitment to continual improvement, shall include decisions and actions for possible changes to:

- 1) asset management policy, strategy and objectives;
- 2) asset management performance requirements;
- 3) resources;
- 4) other elements of the asset management system.

Outputs from management reviews, which are relevant to the organizational strategic plan, shall be made available to top management for consideration in reviews of the organizational strategic plan.

Records of management reviews shall be retained and information relevant to specific employees, contracted service providers or other stakeholders made available for communication purposes (see 4.4.4).

Organizations seeking to implement the requirements of ISO XXXX-Y on management review, should consider the following recommendations and guidance.

- a) Top management should review the operation of the asset management system to assess whether it is being fully implemented and remains suitable for achieving the organization's stated asset management policy, strategy, objectives, targets and plans.
- b) The review should also consider whether the asset management policy continues to be appropriate. It should establish new or updated asset management objectives for continual improvement, appropriate to the coming period, and consider whether changes are needed to any elements of the asset management system.
- c) Reviews should be carried out by top management on a regular basis, e.g. annually. The review should focus on the overall performance of the asset management system and not on specific details, since these should be handled by the normal means within the asset management system.
- d) It is essential that any deficiencies and/or opportunities for improvement identified as a result of the management review are addressed and the asset management system amended accordingly.
- e) The results of the management review including any recommendations for changes to the asset management system should be communicated to appropriate stakeholders.
- f) The results of the management review should be documented and will form part of the asset management system documentation (see 4.4.5).

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