The Institute of Asset Management

Asset Management – an anatomy

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Asset Management – an Anatomy

Anatomy = the study of the structure or internal workings of something for the purpose of examining and analysing its parts

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About the IAM

The Institute of Asset Management (the IAM) is a not-for-profit, professional body. We are owned and controlled by our Members and committed to remaining independent from commercial and trade associations. We exist to advance the discipline of asset management, not only for people and organisations involved in the acquisition, operation and care of physical assets but also for the benefit of the general public. Our priorities are to promote the generation and application of knowledge, training and good practice and to help individuals become demonstrably competent.

Acknowledgments

This document has been produced through the significant efforts of many individuals. The Institute would like to thank all of them and, especially, the contributors listed (see inside back cover).

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The page header of this document indicates the date of last revision and issue

Amendment Number	Date	Comments

Foreword

About this Document

We know that previous versions of the Anatomy have been read and used by a wide range of individuals across business, government (central and local) and not-for-profit organisations in many countries. The first version was published in 2011 and revised in 2014. Version 3 reflects feedback from many users and we invite further comment.

We developed the Anatomy to provide an appreciation of asset management: what it is; what it can achieve; the scope of the discipline and a description of the underlying concepts and philosophy. It also describes the knowledge, skills and attitudes that support it.

ISO 55001[1] specifies the requirements for those aspects that can be captured and documented in a management system. But the discipline of asset management is broader than this. So the Anatomy also places the management system for asset management in context of the wider discipline.

Using the Anatomy

We encourage you to read the entire document. But, if your time is limited, it is important to understand the key points, returning to read the rest as time permits.

Start with Section 2 'What is Asset Management?' and Section 4 'Why does Asset Management matter?'. This will cover the basic concepts, identify the breadth of asset management activities - and should demonstrate that this is a discipline worth exploring!

Then read Section 5 'Who does Asset Management?' to appreciate the implications for both organisations and people. This outlines the concept of the 'Journey' towards capability for both.

If you want to understand the main building blocks, read Section 3 'Asset Management Models and Management System'. This explains the context of the ISO 55000[2] management system, clarifying why Asset Management is broader than the management system. It also introduces the '39 Subjects (of asset management)'.

You will then be in a position to return later to Section 6 'The Asset Management Subjects' to appreciate the breadth and integration offered by Asset Management. You may initially think that some Subjects are not relevant to you or your business – but you are likely to get more value than you may anticipate! And you can explore Section 6 in any sequence.

Of course, we would not have included the other material unless it had value. We strongly recommend you turn to the Introduction – and we hope you'll read up to Section 6 at least!

1. ISO 55001:2014, Asset management - Management systems – Requirements
2. ISO 55000:2014, Asset management - Overview, principles and terminology

Contents

1 Introduction

Check whether this document is relevant for you by asking:-

Do any of the following statements apply to my organisation?

- It is difficult to demonstrate cost effectiveness to key stakeholders (customers, government bodies, regulators, shareholders etc.).
- Financial / commercial and technical / engineering staff and parts of the organisation do not speak the same language and this results in delays, frustrations and missed opportunities.
- Risk management is patchy and inconsistent, and not a systematic part of normal decision-making processes, or different approaches are used in safety, environmental management, asset reliability performance and enterprise risk management.
- Organisational culture is fragmented – with departments working to their own agendas and performance measures, creating conflict and de-motivation.
- There are operational cost inefficiencies, with too many teams competing and duplicating activities, without alignment of objectives and resources.
- There are too many surprises and too many incidents requiring tactical 'fire-fighting', despite increased levels of asset investment.
- There is no clear strategy to address gaps between what the organisation requires of its assets in the medium and long-term and their current capability.
- There is a lack of, or inconsistency in, long-term investment plans and business justification for which projects should go ahead, and with what urgency.
- The asset portfolio is aging, or subject to technology obsolescence, and needs significant re-investment but funds are constrained and there is no process for evaluating which investments are most important or how urgent.
- There is no single, correct source of information about what assets actually exist, in what condition, providing what function, and where. Data is fragmented, out of date and/or not trusted.

If one or more of the statements above seem familiar, then the discipline of Asset Management and the Anatomy should be a worthwhile investment of your time…..

Purpose of the Anatomy

The Anatomy provides an entry-point for people seeking to understand asset management. There are excellent textbooks and training courses but this is neither! It is an introduction to the overall discipline and the scope of each of the Asset Management Subjects.

It is intended to:

- Help individuals on their asset management journey - to better understand the discipline and where to find more information and what to do next; and
- Help organisations with deciding whether to adopt asset management and/or to improve their asset management capability.

It's NOT just about the Assets!

Modern society is heavily reliant on physical assets in order to function effectively. Managing assets so they can provide products and services now, and into the future, is a core part of the discipline known as asset management. But assets can be made of anything – a brand, a licence, a right of way, a group of companies, opportunities - anything in which you invest to achieve your purpose!

Asset management is about extracting value more than what you do to assets. It is about using assets to deliver value and achieve the organisation's business objectives.

Its underlying concepts have been formed over several decades and in many different countries and cultures. It can be complex and continues to evolve and change. Change may come from assets themselves, the context in which they are operated or the systems used to manage them.

Successful asset management requires the active participation of many individuals within an organisation and its supply chain. It requires the understanding and support of internal and external stakeholders, such as shareholders and regulators, who may wish to exert influence. Asset management is increasingly recognised as being delivered by cross-functional teams at all levels of the organisation. This begins with senior leadership teams and cascades down through levels of business professionals who undertake asset management activities.

Why an 'Anatomy'?

The document name – the Anatomy - was derived from a medical analogy. No doctor should be ignorant of basic anatomy - they are expected to have a working knowledge of the whole body as well as developing deeper knowledge and expertise in a chosen specialty.

This is similar for asset management. It is expected that individuals have an understanding of the Subjects described in this document - but the degree to which they need specialist knowledge and expertise will depend on the role they perform. Many of the Subjects can be learned independently but asset management, like medicine, is a holistic discipline that can only be successfully practiced by considering the scope of the activities described in this document.

The Anatomy helps to provide teams with a common language and understanding of asset management. It will also help them appreciate how they can contribute to the capability of their organisation and where they are in their own professional development journey – and signposts further resources.

Those not familiar with asset management terminology will find the Glossary, towards the end of the document, a helpful resource.

Asset Management – an Anatomy

Anatomy = the study of the structure or internal workings of something
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2 What is Asset Management?

A web search for "asset management" will yield many results related to the management of investment and finance - and a potentially confusing range of apparent variants related to physical assets. For example, strategic asset management, property asset management, facilities asset management, infrastructure asset management, enterprise asset management and others seem to claim a special case or 'difference'. The qualifying descriptors do not change the inherently consistent core, whatever the type or nature of the assets that are to be managed.

It is therefore helpful that the ISO 55000 standard has developed a well-considered definition for asset management (clause 3.3.1): ***"the coordinated activity of an organization to realise value from assets"***, and where:

- an asset (clause 3.2.1) is an ***"item, thing or entity that has potential or actual value to an organization"***;
- and the notes for the definition of asset management state that:
  - *"realization of value will normally involve a balancing of costs, risks, opportunities and performance benefits; and*
  - *the term "activity" has a broad meaning and can include, for example, the approach, the planning, the plans and their implementation."*

Asset management is more than doing things to assets - it is about using assets to deliver value and achieve the organisation's business objectives. It also brings a different approach and way of thinking and a transformation of organisational alignment and culture. Each organisation has to determine what it considers value to be, and choose how to manage its assets to derive best total value.

Asset management is relevant to all types of organisation, whether they are large, small, private, public, government or not-for-profit. There is growing evidence from around the world that effective asset management can improve an organisation's reputation and it its ability to:

- operate safely;
- meet its regulatory and statutory obligations;
- evaluate future business strategies for the delivery of differing performance, cost and tolerable risk profiles; and
- significantly reduce the cost of managing assets over their lives.

2.1 Origins & evolution of Asset Management

Asset management is not new - people and organisations have been managing assets for a very long time. However, it was not until the 1980s that the term 'asset management' started to be used in the private and public sectors in relation to physical assets in various parts of the world:

- In the UK, the North Sea oil & gas industry adopted the term in the era following the Piper Alpha oil platform disaster and the 1980's oil price crash. Radical change was needed, and it was found that the creation of small, dynamic, multi-disciplined teams managing each oil platform (the 'asset') with a full life cycle view led to the stimulation of innovation, which resulted in big improvements in performance, safety and productivity.
- At about the same time, the public sector in Australia and New Zealand was facing falling levels of service, escalating costs and poor planning. This triggered a series of activities to establish much better strategic planning, prioritisation and value-for-money thinking, with the first public sector 'Total Asset Management Manual' being published in 1993.
- In 1988, the US National Council on Public Works issued a landmark publication: 'Fragile Foundations: A Report on America's Public Works'[3], which led to the adoption of federal asset management policies with an emphasis on achieving a desired level of service at the lowest life cycle cost. These policies have guided federal funding programs in transportation, water and wastewater for several decades.

Since then, there has been a significant cumulative development in the understanding and principles of asset management, with a number of approaches, standards and models being developed across the world. The IAM has been one of the bodies that has developed its own conceptual model of asset management to convey the core components and how they integrate. This process of exploring various, differing ways to describe the breadth and interaction of asset management activities has been very healthy for the development of the evolving discipline.
Since the 1980's asset management has also been gradually penetrating a broader range of sectors. The greatest value has been realised by organisations that **recognise that asset management is much more than an extension of maintenance**. The discipline has always provided broader views than those of traditional engineering or systems engineering, with a number of observable systematic trends highlighted in ISO 55000:

- from tactical to strategic;
- from isolated life phases and functional disciplines to a full life cycle view;
- from individual assets to asset systems and systems of systems; and
- from management of discrete activity types to an integrated management system.

Many organisations have recognised that this broader view provides opportunities to realise greater value, in a more joined-up approach to developing and managing their assets.

Since its inception in 1994, and especially since 2002, the IAM has worked in conjunction with many other organisations around the world to develop and refine the discipline of asset management. It has initiated and/or produced many globally accepted documents to explain the discipline. It has also collaborated on the convergence of global thinking on asset management, as it recognised the potential benefits from aligning approaches to form a collective view. This could be especially valuable for organisations that manage assets in multiple countries.

The most notable developments in this global convergence have been publication of:

- the IAM's PAS 55[4] specification in 2004, and its update in 2008;
- the Global Forum's first edition of the 'Asset Management Landscape'[5] in November 2011, and second edition in March 2014; and
- the ISO 55000[6] series of standards published in February 2014.

3. Catalog Record: 'Fragile foundations: a report on America's Public Works' | Hathi Trust Digital Library
4. The IAM created PAS 55 together with a group of interested corporate partners, including BSI and it was issued as a formal 'Publicly Available Specification' (or PAS), latterly BSI PAS 55:2008.
5. The discipline of Asset Management is described in 39 'Subjects', together laid out in the 'Landscape', a document published by the Global Forum on Maintenance and Asset Management (gfmam.org). It was produced by the IAM and other members and adopted by GFMAM in 2011. See Section 4.1.
6. The IAM initiated the project to create an International Standard in 2009. Following the decision to proceed with PC251, the ISO community kindly acknowledged PAS 55 as the 'Base Document' by choosing the designation 55000 for the new series of Standards.

PAS 55 for asset management has been successfully adopted in a number of countries, the development of the ISO 55000 series of asset management standards engaged organisations and individuals from a much wider range of countries and sectors. One outcome of this collaboration was a simple, concise definition for asset management: 'the coordinated activity of an organization to realise value from assets.'

Development of the Asset Management Landscape included an international review of asset management models and assessment methodologies. The core of the Landscape comprises the 'Fundamentals' described in ISO 55000 and the 39 Subjects that are intended collectively to describe the scope of Asset Management.

Since publication of the ISO 55000 standards in February 2014, this widening engagement has continued. The growing global acceptance of the standard increases the recognition of, and support for, asset management. It also increases the likelihood that organisations will embrace and implement asset management.

2.2 The Scope of Asset Management

The Anatomy deals primarily with the asset management of physical assets, for which there is a certain amount of core knowledge required about how assets behave: how they are created, operated, maintained and replaced. This knowledge is, however, challenged by several factors:

- Assets and systems are complex and often interdependent (making it difficult to draw boundary diagrams and failures often cascade);
- Asset system behaviour is dynamic and it may change rapidly;
- Asset lifetimes vary from a few years to hundreds of years, even within one system;
- Assets are voiceless, they must be monitored, analysed, and diagnosed; and
- Assets are technical; requiring an understanding of the material world, and a foundation in science and engineering.

This core knowledge does not describe the integrated discipline of asset management; it is only a support. This becomes more obvious when considering additional unique challenges set by asset management:

- How to understand the nature of value to various stakeholder groups;
- Understanding how value is delivered;
- How to bring together the views and contributions of different activities to maximise value;
- Managing internal competition for resources;
- Developing rules for decisions based on risk tolerability and opportunity enhancement; and
- How to thoroughly integrate assets into the value chain, thus overcoming frequently held views that assets are an overhead, or somehow ancillary, to the enterprise, rather than a core contributor to organisational value.

2.3 Concepts & Principles

Clause 2.4.2 of ISO 55000 states that asset management is based on four fundamentals: Value, Alignment, Leadership and Assurance. In addition to these, two features of asset management, which differentiate it from other disciplines and management systems, are its focus across the whole asset life cycle and its approach to decision making.

2.3.1 Value

Assets have actual or potential value to an organisation.

Each organisation has to determine what constitutes value in relation to achieving its organisational objectives. These objectives will take account of the needs and expectations of its stakeholders such as investors, customers, regulators, employees and local communities. This requires organisations to consider intangible elements of value in their decision making, for example reputation, customer satisfaction or environmental responsibility.

It is important not to confuse an organisation's corporate 'values' with the customer value produced by its activities. An organisation's corporate values are part of its operating context and act as constraints or enablers on its activities. They may contribute to customer value where they make the organisation's products or services more attractive to customers, for example environmental or social values.

Although individual assets can contribute value to an organisation, it is usually when they are connected together as an asset system, or a larger entity, that they generate value for an organisation. Figure 1 illustrates the contributions to value typically made at various levels of an asset hierarchy.

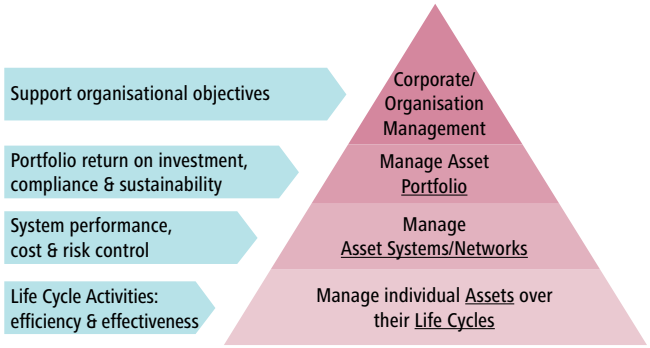


Figure 1: Hierarchy of assets within an integrated management system

Examples of an asset system in a manufacturing organisation would be a production line or, in transportation, a road or rail route. A railroad operating trains from station A to station B, is concerned with the condition of its tracks and rolling stock as contributors to customer satisfaction. On-time performance, comfort, aesthetics and safety may all be influenced by asset condition.

A larger entity would be a transportation system, which is concerned with moving people from area A to area B. The collection system and the transfer system needed to get passengers on the train may be more expensive, time-consuming and complex than the train itself, with ticket purchase and schedule / timetable information also being important parts of the transport system[7].

Two widely used approaches to conceptualising value in an organisation are:

- the Value Stream, which is a 'Lean' operations concept, focusing on customer satisfaction; and
- the Value Chain, which is a strategic concept, focusing on competitive advantage.

A value chain describes how a defined set of activities combine within an organisation to create value. The focus of the value chain is the 'value proposition' to the customer, whilst value to the organisation is measured by: 'profit' in 'for-profit' organisations and 'cost of service' for 'non-profit' organisations. Assets are aligned through the value chain to support the customer value proposition. For example, sports and entertainment venues today focus on the "audience experience," in their marketing campaigns. This experience includes stadium aesthetics as well as access to the stadium and pre/post game activities in the stadium area. The value chain allows capture of all the activities and assigns value to the assets that support each activity. Audience experience can be enhanced without rebuilding the stadium. The asset management standpoint is that having the right assets in the right place at the right time (and working together) supports the organisation's value chain and is critical to success.

7. Smith, Thomas W. "The Impact of ISO 55000," Chapter 2, The New Asset Management Handbook, Reliability Web, Ft Myers, 20147.

2.3.2 Alignment (or 'Line of Sight')

Good asset management has clear connectivity between an organisation's strategic plan (commonly called the business or corporate plan) and the asset management activities delivered by staff. This is known as alignment, or 'line of sight' and enables everybody to understand how they contribute to achieving success.

'Line of Sight' translates organisational objectives into asset management policy, strategy and objectives, which cascade down into more detailed asset management plans and activities. It also requires that senior management decisions, strategies and plans take account of bottom-up, fact-based realities ie asset capabilities, performance, opportunities and constraints. 'Line of sight' is important for giving staff delivering asset management activities direct visibility of the purpose of the work they undertake – so they understand why it is needed, not just when and how to do it. Such alignment brings advantages in prioritisation and coordination of purpose, but it also helps to stimulate creativity and innovation: staff who understand what is important (and why) can often identify new and better ways of achieving their goals.

2.3.3 Leadership

Visible senior level leadership and commitment is crucial in organisations that aspire to deliver effective asset management.

People are likely to judge the importance of asset management to an organisation based on where responsibility for it is placed in senior management. Organisations need to make sure that leadership for asset management is assigned to senior managers with sufficient influence and authority to progress the asset management agenda. This will include:

- ensuring the way the organisation is structured and the culture of the organisation are both conducive to what it is trying to achieve;
- setting the direction and priorities for developing the asset management capabilities required to deliver the organisation's objectives; and
- ensuring that asset management thinking and practices cross traditional boundaries between functions and disciplines.

To successfully establish, operate and improve asset management within an organisation, it is essential that leadership, and commitment, is demonstrated by all levels of management – from senior executives to supervisors.

2.3.4 Assurance

Assurance is the combination of monitoring and auditing (of processes and outcomes) to confirm the assets, systems and processes are operating as intended. Good asset management requires an effective framework for assurance. This is essential to provide assurance that:

- Assets will fulfil their required purpose; and
- Asset management activities will be delivered, and asset management objectives achieved consistently and sustainably over time.

An assurance framework includes policies, plans, business processes and information systems to give assurance that the asset management activities will be delivered, along with competent resources to monitor and demonstrate assurance to the appropriate levels of management.

2.3.5 Life cycle activities

The concept of life cycle activities is easy to understand at the lowest levels of asset granularity, such as physical equipment components. However, as discussed in 2.3.1, assets usually contribute value in a systems context.

There are many variations for the descriptions used for the stages of the life cycle. The naming and number of the stages, and the activities under each stage, can vary in different industry sectors. But a common principle is that the life cycle includes all aspects of managing assets from the initial concept through to disposal. Figure 2 illustrates some examples. Section 3.1.3 identifies the life cycle stages used in the IAM's Asset Management Conceptual Model.

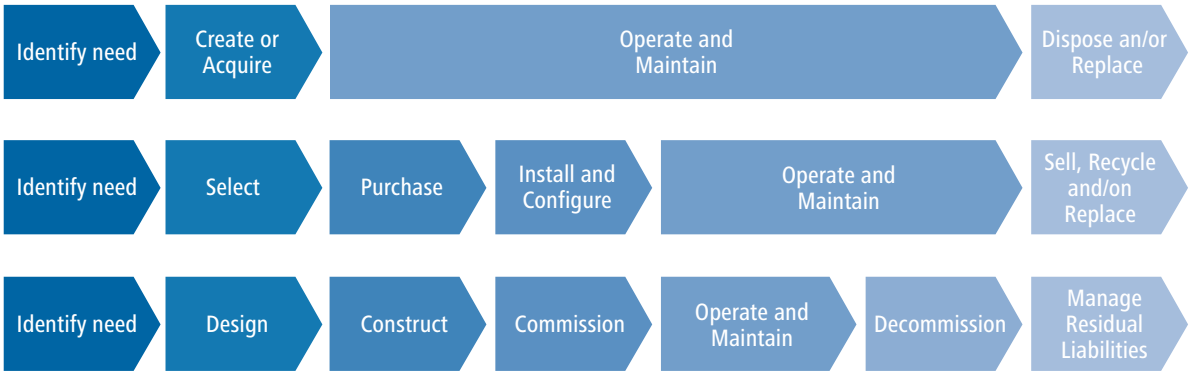


Figure 2: Examples of variations in the description of asset life cycle stages

The concept of the life cycle can become more challenging where:

- more complex asset systems are considered. These can have a finite or infinite 'life', depending on the continuing need for the asset system, and how they are managed. 'Patch and continue' maintenance strategies, component asset replacements, modifications, obsolescence, changing functional demands, recycling and other options need to be considered for managing the asset system.
- an asset has a series of owners during its life, with different objectives, value criteria and planning horizons.

Asset management requires integration of activities across the whole life cycle not just consideration of individual life cycle stages. This focus on integration particularly affects the design phase, which can determine as much as 80% of the total life cycle costs of an asset, as well as a large portion of its environmental and social impact.

2.3.6 Asset Management Decision Making

Competent, consistent, optimal decision-making is a vital element underpinning successful asset management. In making asset management decisions, it is important to find the right compromise between competing interests, such as asset utilisation/performance versus asset care (maintenance), capital investment cost versus operating expenditures, or short-term benefits versus long-term sustainability.

It is also important that the approach applied is proportionate. Asset management decisions vary greatly in complexity and criticality, so it is inappropriate to apply the same level of sophistication to all decisions. Simple, non-critical decisions can, and should, be made with (educated) common sense, whereas higher impact decisions, with multiple influences, options, timings or inter-dependencies require systematic, multi-disciplined and auditable decision making processes.

Asset management also involves organisations choosing, and using, appropriate combinations of tools and techniques (such as Lean, 6-Sigma, Total Productive Maintenance, Reliability Centred Maintenance) to support decision-making and improve asset management activities. This also includes Operational Excellence, which builds upon continuous improvement methodologies such as Lean and Six Sigma, bringing a workplace focus on problem solving, teamwork and leadership to continually improve activities to meet customer needs.

The term 'optimising' is often used in relation to asset management decision-making. It describes the process of establishing the best value compromise between a set of competing factors, in order to support asset management decision-making. This can range from a subjective, qualitative judgement to more sophisticated techniques that can demonstrate that the best value is being obtained.

2.4 Asset Management as an Integrative Discipline

As indicated in 2.2, engineering or technical knowledge of physical assets does not sufficiently describe the integrated discipline of asset management. To deliver the benefits of asset management requires the development of an integrative discipline and a field of study. Asset management draws on and includes professionals from a range of disciplines (such business risk, finance, design, project management, maintenance and safety) working across the stages of the asset life cycle and all levels of the asset portfolio. It supports an organisation with establishing an overall capability to develop and deliver asset, and non-asset, solutions to achieve its asset management objectives.

In addition to a focus on value, and the need to manage the complexities outlined in 2.2, there are several threads that tie together the various disciplines that contribute to the overall asset management capability:

- a life cycle view, including an understanding of varying life cycles;
- a multifaceted understanding of risk;
- the integration of asset data and financial data; and
- a commitment to continual improvement.

It is a shared understanding of these issues that integrates the discipline of asset management, allowing many specialisms from different functions and disciplines to join in a common view. Knowledge development, including research and debate can occur within or across individual disciplines, to achieve common objectives. For example:

- If an organisation's strategy depends on the quality of products or services, senior managers and quality managers must understand how assets contribute to quality.
- If significant networks and databases are used to support asset maintenance, IT staff and maintenance staff need to develop a shared understanding of the effective development and use of those databases.
- If an organisation is committed to life cycle design: then engineering, procurement, operations and maintenance are all involved in the design process.

Anyone practicing asset management no matter from what background or organisational function needs to understand that the entire integrated discipline contributes to a shared vision of asset management.

2.5 Asset Management as a field of Professional Practice

Along with the discipline, asset management can be viewed as a field of professional practice. This practice includes developing and implementing asset management programmes or systems; working in those systems, evaluating them, and improving them. Individual specialists working in these areas may be designers, operators or maintainers. They may also come from executive positions or supporting positions such as information systems. Irrespective of their primary discipline, they must, align with the organisation's financial and executive management systems and be willing to work towards common outcomes.

The complexity of modern asset management requires a focus on outcomes for professional practice and a truly interdisciplinary approach. This approach is evolving rapidly and many who associate asset management with maintenance will be surprised to find, that in many organisations, it is now being driven by finance and engineering, or operations and quality management. Those who have been in asset management for a while may need to step back and review their assumptions about the field.

Professionals who define their roles in terms of improving asset performance or reducing risk may find that, in some organisations, asset performance is not measured and managed independently, but rather in terms of the asset's contribution to the organisation's value chain for products or services.

This view requires an alignment of the asset register with the financial register. It also requires the concept of a 'line-of-sight', so that those at the top, middle and bottom of the organisation all see the assets in a similar way, and focus on that level of the asset hierarchy that directly interfaces with the organisation's value chain.

The IAM has been a major contributor to the development of asset management as a profession, establishing a Competences Framework and Qualifications that support the professional development of asset managers (see 5.4 The Individual Asset Management Journey).

3 Asset Management Models and Management System

The IAM takes the view that there is no single perfect model to describe asset management and encourages organisations and individuals to explore a range of models to evaluate what works best for them. How well a particular model will work for an organisation will depend on the nature of the organisation and its context. It may be necessary to modify elements of a chosen model to better meet the needs of the organisation.

To explore asset management models, good places to start are the IAM, the IIMM[8] or with models developed by other members of the Global Forum. For example the AMC (Asset Management Council in Australia) has developed a group of related models which work together to cover concepts, management & organisational systems and delivery processes[9]. In the Anatomy, only the IAM's conceptual asset management model is considered. Asset management will continue to evolve - so it to be expected that many of these models will change over time and others will emerge.

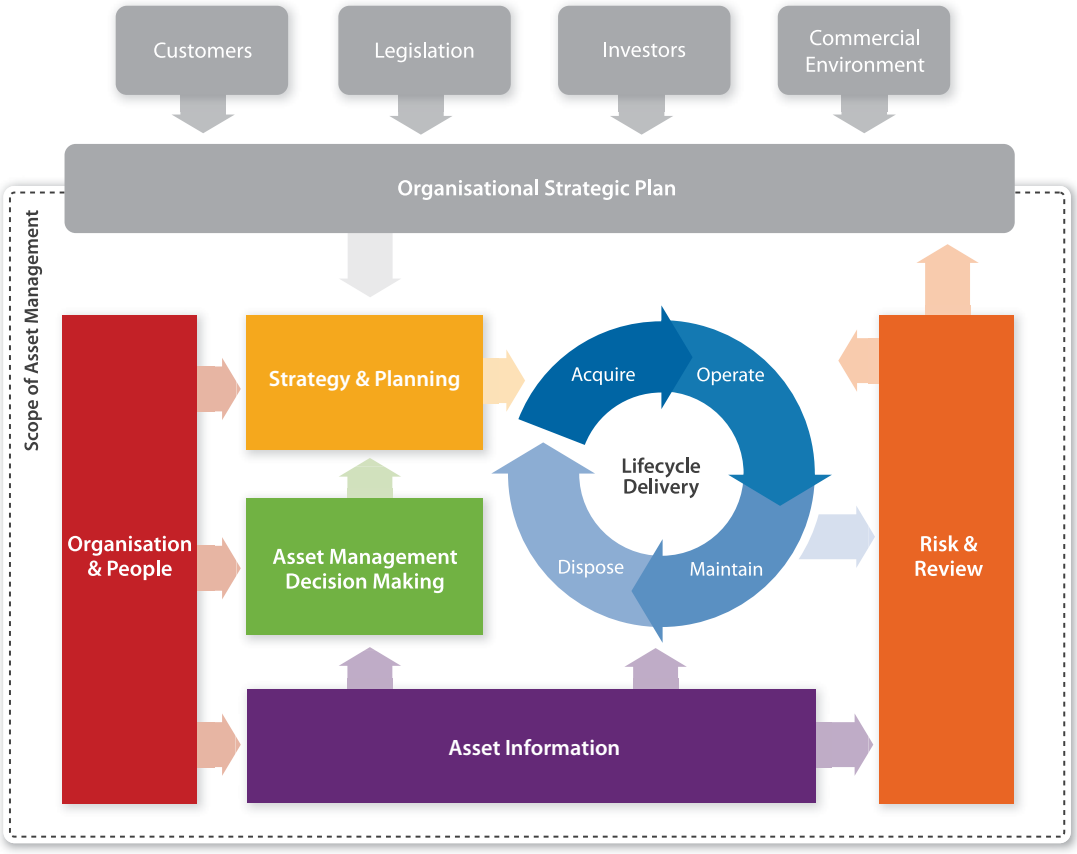


Figure 3: The IAM's Conceptual Asset Management model

8. International Infrastructure Management Manual, produced by NAMS New Zealand Inc. and the Institute of Public Works Engineering Australia (IPWEA)
   http://www.ipwea.org/publications/bookshop/ipweabookshop/iimm
   http://www.nams.org.nz/pages/273/international-infrastructure-management-manual-2011-edition.htm
9. www.amcouncil.com.au/knowledge/asset-management-body-of-knowledge-ambok/ambok-models.html

3.1 The Subject Groups

The IAM's conceptual model for asset management comprises a suite of six Subject Groups (see Figure 3) covering a total of 39 asset management Subjects.

Each subject group contains asset management subjects that align with those of the Global Forum's Asset Management Landscape (see Figure 4). The model was designed to illustrate:

- the breadth of activities within the scope of asset management;
- the interrelationships between activities and need to integrate them; and
- the critical role for asset management to align with and deliver the goals of an organisation's strategic plan.

The IAM's conceptual model and the supporting Subjects were developed in recognition that a management system standard for asset management would identify what is required to be in place for the management system, but would not address how asset management could be implemented. The subjects are intended to support the conceptual model and explain the asset management activities in greater detail.

The Anatomy provides the first stage in expanding the subjects. This section provides a very brief, high-level overview of the six subject groups and the subjects within them, enabling the reader to quickly gain an appreciation of the overall scope of the subjects.

More information on the individual subjects is contained in Section 6 and the IAM's suite of Subject Specific Guidance documents, due for completion by 2017. *www.theIAM.org/SSG*

The importance of individual Subjects to a specific organisation will depend on its organisational purpose and context. For individuals, the depth to which they may need, or wish, to develop specialist knowledge in particular subjects will depend on their career aspirations or their role within an organisation, or the organisation(s) they are supporting. The IAM believes that, even if individuals specialise in a particular area of asset management, it is important that everyone has an understanding of how their activities fit, and interact with, the other subjects and the elements of the asset management system (AMS).

Group 1 - Strategy & Planning

1. Asset Management Policy
2. Asset Management Strategy & Objectives
3. Demand Analysis
4. Strategic Planning
5. Asset Management Planning

Group 2 - Asset Management Decision-Making

6. Capital Investment Decision-Making
7. Operations & Maintenance Decision-Making
8. Lifecycle Value Realisation
9. Resourcing Strategy
10. Shutdowns & Outage Strategy

Group 3 - Life Cycle Delivery

11. Technical Standards & Legislation
12. Asset Creation & Acquisition
13. Systems Engineering
14. Configuration Management
15. Maintenance Delivery
16. Reliability Engineering
17. Asset Operations
18. Resource Management
19. Shutdown & Outage Management
20. Fault & Incident Response
21. Asset Decommissioning & Disposal

Group 4 - Asset Information

22. Asset Information Strategy
23. Asset Information Standards
24. Asset Information Systems
25. Data & Information Management

Group 5 - Organisation & People

26. Procurement & Supply Chain Management
27. Asset Management Leadership
28. Organisational Structure
29. Organisational Culture
30. Competence Management

Group 6 - Risk & Review

31. Risk Assessment & Management
32. Contingency Planning & Resilience Analysis
33. Sustainable Development
34. Management of Change
35. Asset Performance & Health Monitoring
36. Asset Management System Monitoring
37. Management Review, Audit & Assurance
38. Asset Costing & Valuation
39. Stakeholder Engagement

Figure 4: Alignment of the 39 Asset Management Landscape Subjects with the six Subject Groups

3.1.1 Group 1 - Strategy & Planning

Strategy & Planning aligns an organisation's asset management activities, and the outputs from its assets, with its overall organisational objectives. This alignment – or 'line of sight' – enables the individuals carrying out their day-to-day asset management activities to trace the rationale for what they are doing through the asset management plan(s) and asset management objectives to the organisational objectives. These activities include planning to improve an organisation's asset management capabilities, and the management system for asset management.

1. Asset Management Policy	This comprises the principles and mandated requirements derived from and consistent with the organisational plan, to provide a framework for the development and implementation of the strategic asset management plan (SAMP) and the setting of the asset management objectives.
2. Asset Management Strategy & Objectives	The strategic plan for the management of an organisation's assets to achieve the organisational objectives. ISO 55000 refers to this asset management strategy as the Strategic Asset Management Plan (SAMP). The Strategy describes the long-term approach to management of the physical assets, specifies how organisational objectives are to be converted into asset management objectives, the approach for developing asset management plan(s), and the role of the AMS in supporting achievement of the asset management objectives.
3. Demand Analysis	The processes an organisation uses to both assess and influence the demand for, and level of service from, an organisation's assets. It typically includes the analysis of future demand for the product or services being offered and the requirements this demand will place on the asset portfolio.
4. Strategic Planning	The processes an organisation uses to undertake strategic asset management planning, to establish asset management objectives and develop the asset management strategy (SAMP). It includes: how the organisation is to address the outputs from demand analysis; the processes for determining long-term renewal, enhancement and maintenance work volumes; and the associated risks and costs to meet the asset management objectives. Asset management strategic planning is usually undertaken as part of the overall organisational strategic planning process.
5. Asset Management Planning	The activities to develop the asset management plan(s) that specify the detailed activities, resources, responsibilities, timescales and risks for the achievement of the asset management objectives. Asset management planning follows on from the strategic planning process.

3.1.2 Group 2 – Asset Management Decision Making

Effective asset management decision-making is essential for an organisation to maximise the value realised over the lives of its assets. This subject group considers the challenges faced and the approaches to decision-making for the three main stages of an asset's life: acquisition/creation; operation and maintenance; end of life (which includes decommissioning, disposal, and renewal).

Decisions made at each stage have an impact on subsequent stages. The choice of asset acquired influences the performance, risks and maintenance requirements during its operational life and the methods and costs of decommissioning. The way it is operated and maintained influences its useful life and end-of-life complexities and costs.

6. Capital Investment Decision-Making	The processes and decisions to evaluate and analyse scenarios for decisions related to capital investments of an organisation. These processes and decisions may relate to new assets for the organisation (eg Greenfield projects) and/or replacements of assets at end of life (CAPEX sustaining programmes).
7. Operations & Maintenance Decision-Making	The management activities and processes involved in determining the operations and maintenance requirements in support of the asset management objectives and goals.
8. Lifecycle Value Realisation	The activities undertaken by an organisation to balance the costs and benefits of different renewal, maintenance, overhaul and disposal interventions. It includes the methods used to ensure the best total value is obtained, by consideration of the interaction between the life cycle activities, and determination of the optimal combination, including costs, risks, performance and sustainability effects. The total value usually needs to be considered at the level of asset system or asset portfolio.
9. Resourcing Strategy	Determining and documenting the activities and processes to be undertaken by an organisation in order to procure and use people, plant, tools and materials to deliver the asset management objectives and asset management plan(s). The resourcing strategy should consider the costs and risks of out-sourcing the provision of resources, and how to best integrate the available resources across the organisation in order to cost effectively deliver the asset management plan(s).
10. Shutdowns & Outage Strategy	The activities taken by an organisation to develop a strategy for shutdown and outages. It includes consideration of reducing downtime and outages, and the cost to carry out the activities in the asset management plan efficiently and safely during the planned outages.

3.1.3 Group 3 - Life Cycle Delivery

These subjects implement the asset management plan(s) developed in the Strategy & Planning Subject Group. Good control of the activities, and associated risks, to acquire, operate, maintain and dispose of assets is essential for the successful delivery of the asset management plan(s).

Organisations incur the majority of their asset-related expenditure through the activities in Life Cycle Delivery. A focus on integration of activities across the life cycle can enable organisations to reduce avoidable downstream costs. For example, good design, procurement and asset operation practices can reduce the level of corrective maintenance that is needed, and increase the asset reliability and availability, delivering additional value at a lower cost.

11. Technical Standards & Legislation	The processes used by an organisation to ensure its asset management activities are compliant with the relevant technical standards and legislation.
12. Asset Creation & Acquisition	An organisation's processes for the acquisition, creation, installation and commissioning of assets. It also includes elements of approval and releasing of funding, arrangements for hand-over to operations, the monitoring and capture of actual costs and benefits analysis.
13. Systems Engineering	An interdisciplinary, collaborative approach to derive, evolve and verify a life cycle balanced system solution that satisfies customer expectations and meets public acceptability. It describes policies and processes for the requirements analysis, design and evaluation of assets. Verification and validation execution is considered as part of asset creation and acquisition.
14. Configuration Management	A management process for establishing and maintaining consistency of a product's physical and functional attributes with its design and operational information throughout its life. It is closely aligned with the principles and requirements of systems engineering.
15. Maintenance Delivery	The management of maintenance activities including both preventive and corrective maintenance management methodologies. It includes definition of maintenance specifications and schedules, maintenance execution procedures, procedures for missed maintenance and the capture and utilisation of maintenance and inspection measurements and results.
16. Reliability Engineering	The processes for ensuring that an item shall operate to a defined standard for a defined period of time in a defined environment. Reliability engineering starts at the conceptual phase of design and continues through the life cycle. The goal is to identify potential reliability problems as early as possible in the life cycle and ensure that the reliability requirements will be met.
17. Asset Operations	The processes used by an organisation to operate its assets to achieve the business objectives. It includes the processes that provide instructions to operators about how to operate the assets within the appropriate design, maintenance and operational parameters.
18. Resource Management	Implementing the resourcing strategy to manage the use of funds, people, plant, tools and materials in delivering asset management activities. It includes integrating the resource utilisation across the organisation and across all asset management activities.

19. Shutdown & Outage Management	An organisation's processes for identification, planning, scheduling, execution and control of work related to shutdowns or outages. It includes policies and processes for the implementation of the shutdown and outage strategy to ensure the effective management of shutdowns and outages.
20. Fault & Incident Response	Responding to failures and incidents in a systematic manner, including incident detection and identification, fault analysis, use of standard responses, temporary and permanent repairs as well as the taking over and handing back of sites. It includes developing plans to respond to unplanned events and managing the resources required for the response to the events, and escalation criteria.
21. Asset Decommissioning and Disposal	The processes used by an organisation to decommission and dispose of assets due to ageing or changes in performance and capacity requirements.

3.1.4 Group 4 - Asset Information

Organisations involved in the management of assets rely on asset data and information as key enablers across the breadth of asset management activities. Asset information is typically an input to asset management processes, may be modified or created by a process, and will be an output of a process. Data and information requirements, including quality requirements, need to be identified and defined. Typically, organisations do not have perfect, or even adequate, asset information in either the quality or quantity they require. This leads to a requirement to assess and prioritise activities to focus on areas that will provide most benefit.

A fast developing discipline that compliments asset management is Building Information Modelling (BIM). Although some aspects of BIM originated in the building/facilities management disciplines, taking a wide definition of building to include any built asset, the concepts and approaches apply equally to other physical assets.

22. Asset Information Strategy	The strategic approach to the definition, collection, management, reporting and overall governance of asset information necessary to support the implementation of an organisation's asset management strategy and objectives.
23. Asset Information Standards	The specification of a consistent structure and format for collecting and storing asset information and for reporting on the quality and accuracy of asset information.
24. Asset Information Systems	The asset information systems an organisation has in place to support the asset management activities and decision-making processes in accordance with the asset information strategy.
25. Data & Information Management	The data and information held within an organisation's asset information systems and the processes for the management and governance of that data and information.

3.1.5 Group 5 - Organisation & People

Implementing an asset management approach is a change that leads organisations to question traditional ways of thinking and working. This can include reviews of organisational structures, roles and responsibilities and contractual relationships. This can make the introduction of asset management thinking and practices a challenging experience for people, be they in senior management roles, staff delivering asset management activities, or working in the supply chain. Effective leadership is therefore crucial for building an organisation, with the appropriate culture, which supports the delivery good asset management.

The subjects with Organisation & People are highly interdependent and exert strong influences on an organisation's ability to adopt and embed asset management successfully. It is necessary to invest time and effort in them to produce the performance and behaviours that will support successful delivery of the asset management strategy and objectives. They are important for delivering the level of business integration that characterises more mature asset management capability.

26. Procurement & Supply Chain Management	The processes used by an organisation to ensure that all outsourced asset management activities are aligned with the asset management objectives of the organisation and to monitor the outcomes of these activities against these objectives
27. Asset Management Leadership	The leadership of an organisation required to promote a whole life asset management approach to deliver the organisational and asset management objectives of the organisation.
28. Organisational Structure	The structure of an organisation in terms of its ability to deliver the organisational and asset management objectives.
29. Organisational Culture	The culture of an organisation in terms of its ability to deliver the organisational and asset management objectives.
30. Competence Management	The processes used by an organisation to systematically develop and maintain an adequate supply of competent and motivated people to fulfil its asset management objectives including arrangements for managing competence in the boardroom and the workplace.

3.1.6 Group 6 - Risk & Review

This Subject Group contains core activities associated with: the identification, understanding and management of risk; the establishment of effective feedback and review mechanisms to provide assurance that objectives are being achieved, and to support the continual improvement of asset management activities.

It also provides important inputs to the Subject Groups for Strategy & Planning (see 3.1.1) and Asset Management Decision-Making (see 3.1.2).

31. Risk Assessment and Management	The policies and processes for identifying, quantifying and mitigating risk and exploiting opportunities.
32. Contingency Planning & Resilience Analysis	The processes and systems to ensure an organisation is able to continue to either operate its assets to deliver the required level of service in the event of an adverse impact or maintain the safety and integrity of the assets (whether or not they operate).
33. Sustainable Development	The interdisciplinary, collaborative processes used by an organisation to ensure an enduring, balanced approach to economic activity, environmental responsibility and social progress to ensure all activities are sustainable in perpetuity.
34. Management of Change	An organisation's processes for the identification, assessment, implementation and communication of changes to people, processes and assets.
35. Asset Performance & Health Monitoring	The processes and measures used by an organisation to assess the performance and health of its assets using performance indicators. The indicators can be leading or lagging and allow for the prediction of future asset performance and health as well as the assessment of current or historic performance.
36. Asset Management System Monitoring	The processes and measures used by an organisation to assess the performance and health of its AMS. The primary aim is to evaluate the extent to which the AMS is fit for purpose and that the organisation is delivering its asset management objectives.
37. Management Review, Audit & Assurance	An organisation's processes for reviewing and auditing the effectiveness of its asset management processes and AMS.
38. Asset Costing & Valuation	An organisation's processes for defining and capturing 'as built', maintenance and renewal unit costs and the methods used by an organisation for the valuation and depreciation of its assets. This includes ensuring that the quality of financial information is appropriate for the financial reporting framework of the organisation.
39. Stakeholder Engagement	The methods an organisation uses to engage with stakeholders.

3.1.7 Relationships between Subjects

Asset management is, by definition, holistic and integrative, so the number and boundaries of Subjects can be drawn in a number of different ways. Different industry sectors can hold differing views about the respective activities, a bit like the naming and number of the life cycle stages in Figure 2. In fact, there have been several revisions to the titles and scope of some Subjects since their development in 2011.

It is misleading to treat any a Subject as free-standing, as there are complex inter-relationships between most of them. In fact, if these relationships are drawn diagrammatically they can be confusing. To illustrate this, Figure 5 shows one of the simpler examples for some key relationships for the Strategy & Planning subject group. Note:

- The relationship between the organisational objectives and organisational (strategic) plan and the subjects of the Strategy & Planning subject group.
- The strong interaction between the Strategy & Planning subjects and those of Asset Management Decision-Making. This ensures that the most appropriate decisions are made, and their long-term implications are understood.
- The important input to Strategy & Planning from the subjects for Stakeholder Engagement and Risk Management & Assessment in the Risk & Review subject group.

The interactions within and between other Subjects and Subject Groups can be even more challenging to illustrate clearly.

The IAM strongly encourages individuals to develop an appreciation of ALL the asset management Subjects. This is essential to understand how best to obtain maximum value from applying asset management. Gradually this broad understanding also helps understand each Subject at a deeper level.

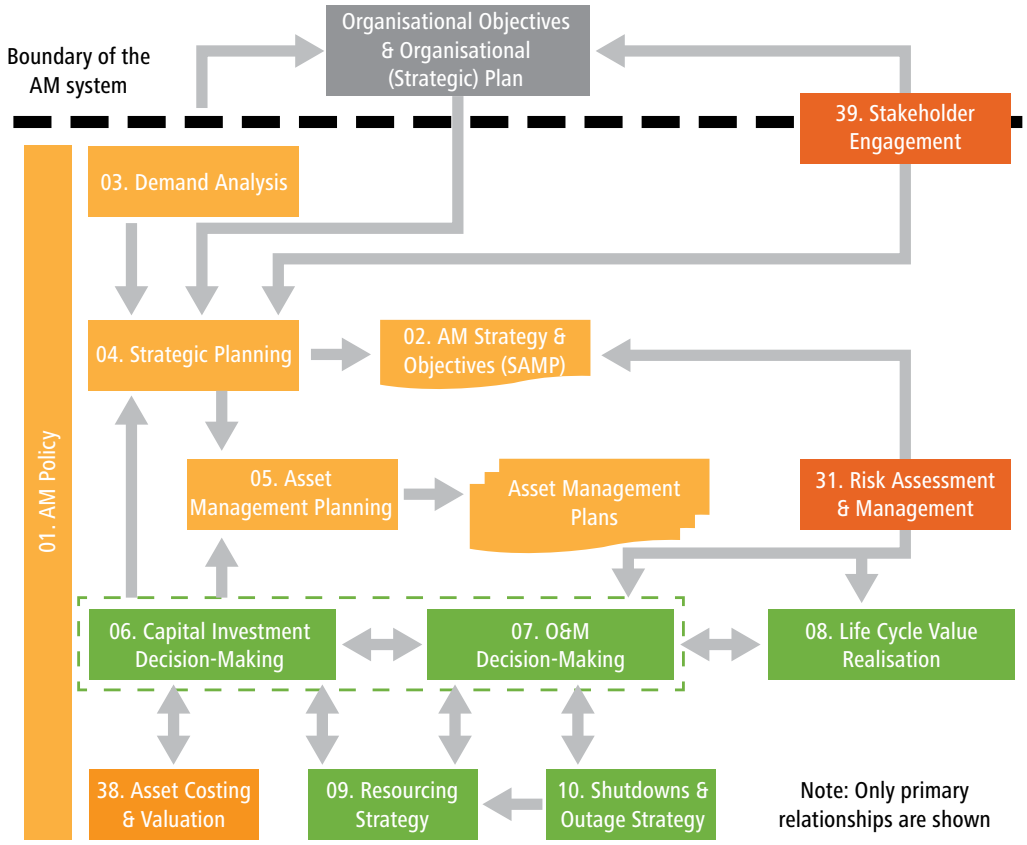


Figure 5: Key relationships for the Strategy & Planning subject group

3.2 The ISO Management System for Asset Management

For most businesses, coordinating the many facets of asset management requires a system of direction and control – a management system.

The ISO 55000 standards describe a management system for asset management. The effectiveness of ISO management systems is often questioned - but when an ISO management system aligns with an organisation's over-arching corporate management system, the results can be very effective. It is also the case that an ISO management system that is not aligned, and is just bolted on, cannot be expected to function effectively.

ISO 55001 defines seven sets of requirements for a management system for asset management, with each supported by between 5 and 20 "shall statements" to provide the detail for each requirement:

1) Defining the Organisational Context;
2) Leadership commitment and direction, and roles and responsibilities;
3) Multi-level Planning for assets and asset management;
4) Support for effective management: resources (including competence), tools and information;
5) Operational control of the management system and dependent asset systems;
6) Evaluation of the performance of the management system and dependent asset systems; and
7) Improvement, including correction and prevention in a quality-process environment.

Many readers will be familiar with the Deming Plan-Do-Check-Act (PDCA) approach for management systems. Figure 6 illustrates how the ISO 55001 clauses align with the PDCA model. It should be

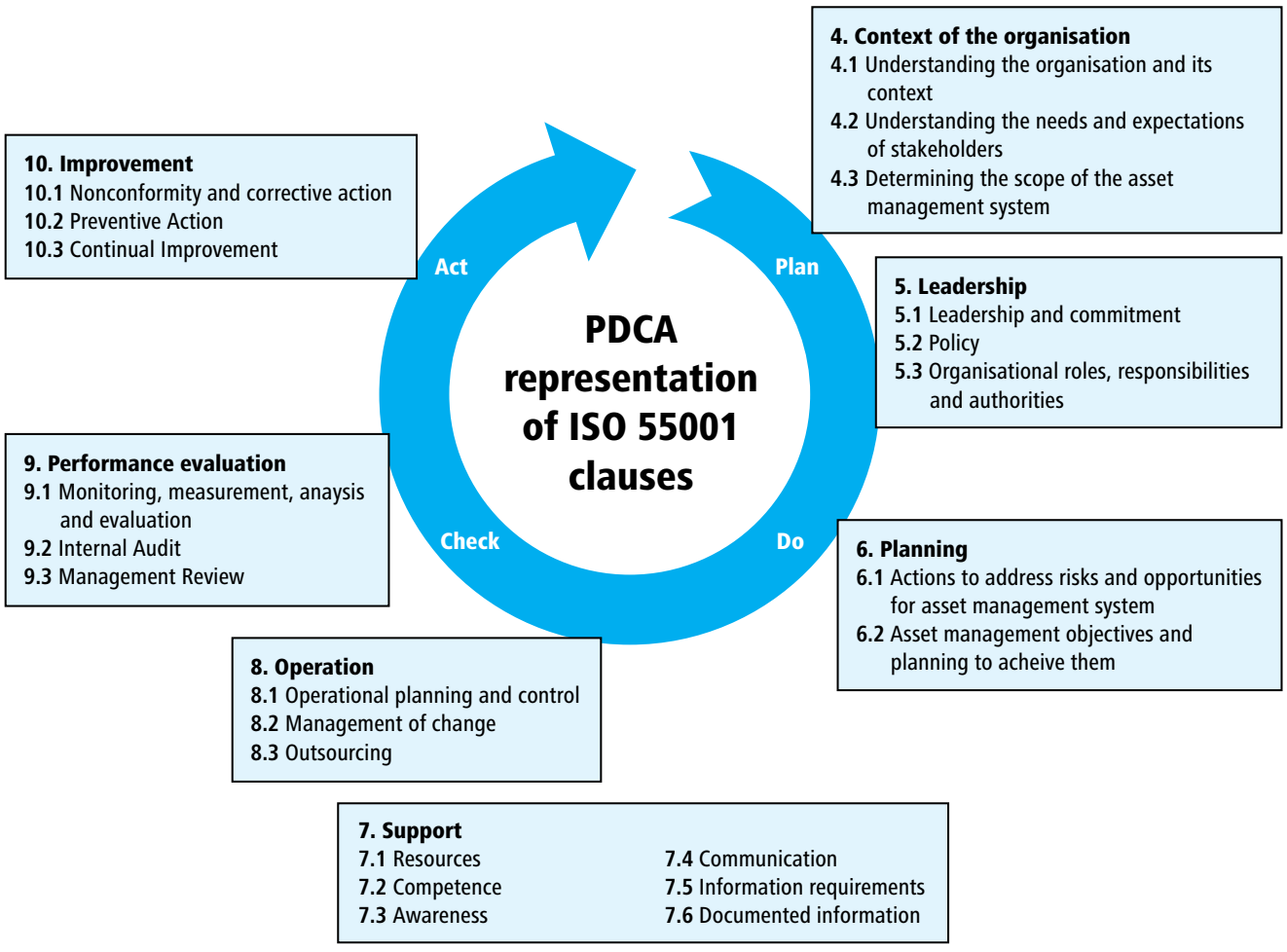


Figure 6: ISO 55001 clauses and the Plan-Do-Check-Act model

noted, however, that organisations can adopt other approaches to management systems, such as Lean and Six Sigma, which do not follow the PDCA model. This is reinforced in the Introduction of ISO 55001, which states: *"The order in which the requirements are presented in this International Standard does not reflect their importance or imply the order in which they are to be implemented."*

The ISO 55001 requirements create a combination of specific interacting elements that provide direction, alignment, coordination, control and continual improvement in the effective management of assets. The combined effect of these elements should deliver performance and assurance of a 'competent' level of asset management.

The ISO 55000 standards do not, however, cover all aspects of the discipline of asset management. They consider the 'shall do' elements but intentionally do not address the 'should do' or 'could do' elements, nor do they address 'how to' implement asset management. They also do not consider whether there could be justification for developing capabilities beyond conformance to the requirements in ISO 55001 - and what this might look like. In fact, clause 4.4 of ISO 55002 states that: *'It should be noted however, that compliance with all the requirements of ISO 55001 represents achieving the minimum standard for an effective asset management system and should not be seen as the final goal.'*

The ISO 55000 management system is considered a subset of the overall discipline of asset management as shown in Figure 7 from clause 2.4.3 of ISO 55000 'The relationship of the asset management system to asset management'.

Clause 2.4.3 of ISO 55000 also states that: *'An asset management system is used by the organization to direct, coordinate and control asset management activities. It can provide improved risk control and gives assurance that the asset management objectives will be achieved on a consistent basis. However, not all asset management activities can be formalized through an asset management system. For example, aspects such as leadership, culture, motivation, behaviour, which can have a significant influence on the achievement of asset management objectives, may be managed by the organization using arrangements outside the asset management system.'*

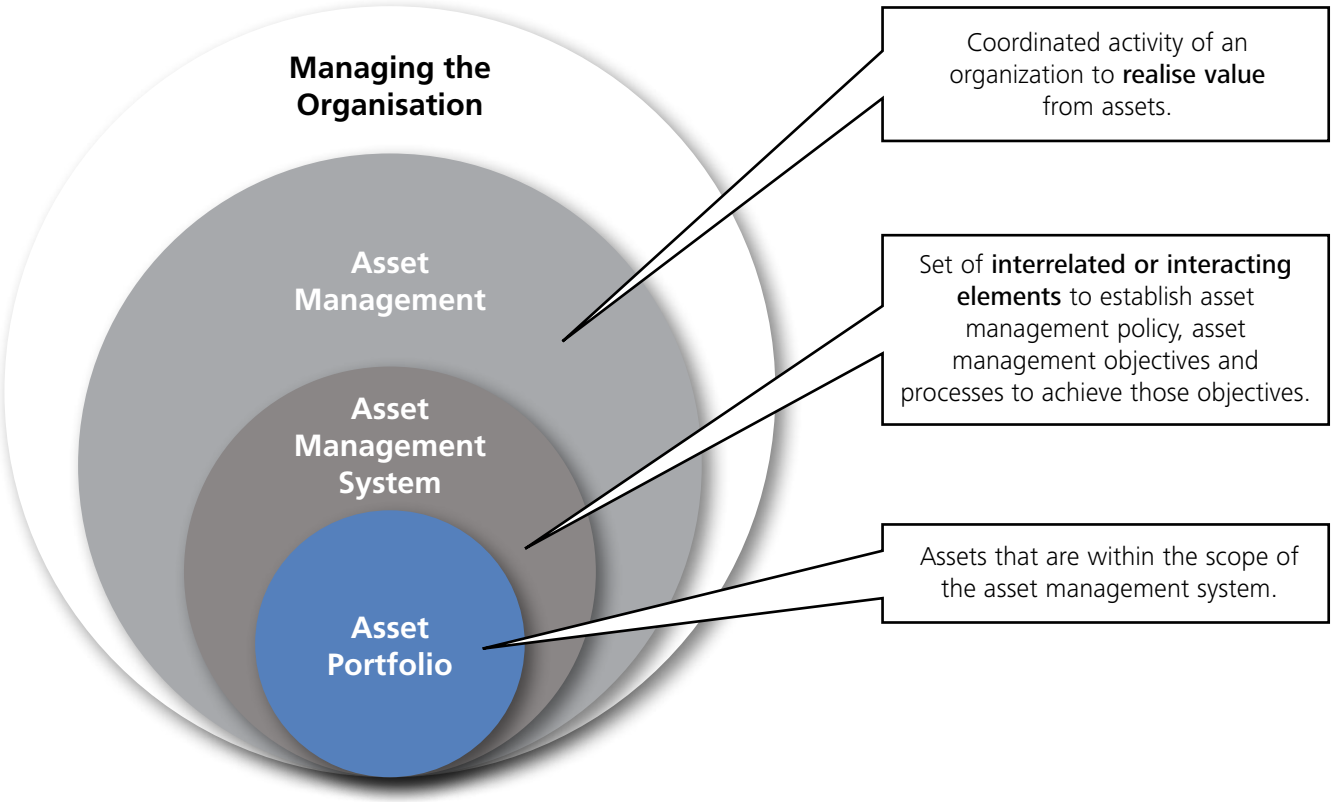


Figure 7: Relationship between asset management and the Asset Management System

4 Why does Asset Management matter?

There are several ways to look at this question and understand the reasons why asset management matters. For many organisations, asset management will be the next frontier in value creation and risk reduction. It also brings its own business case and management imperatives. Any organisation, large or small, will find that one or more of the driving factors identified in this section, applies to them and supports their case for adopting asset management.

4.1 Asset Management Benefits

Clause 2.2 of ISO 55000 states that the benefits can include, but are not limited to, the following:

- Improved financial performance;
- Informed asset investment decisions;
- Managed risk;
- Improved services and outputs;
- Demonstrated social responsibility;
- Demonstrated compliance;
- Enhanced reputation;
- Improved organisational sustainability; and
- Improved efficiency and effectiveness.

Some benefits can be directly assessed and quantified, for example reduced capital and maintenance costs, increased asset availability and reduced risk exposure. Other benefits can be much more difficult to measure but may be equally important in terms of revenue generation or overall business performance (such as improved reputation, and customer/stakeholder satisfaction). Also, although many benefits are realised over the short term, savings in whole-life asset costs may not be delivered for a number of years.

4.2 The Business Case for Asset Management

The traditional business case for asset management has typically focused on cost savings through reduced operations and maintenance costs, along with improved productivity through increased reliability and availability.

These are important benefits, but there are many other potential elements in the business case which may prove equally or more important:

- Effective management of value, risk and liability is also part of the standard business case. Good governance, and a good understanding and control of assets, can improve stakeholder confidence (e.g. customers and regulators acting on behalf of customers) and result in lower insurance premiums;
- Effective asset management improves both personal safety and process safety[10], reducing the risk of injury and catastrophic events;
- Assets contribute to the reputation and image of the organisation, just as they contribute to its operation. Assets are often the front door to the enterprise, such as in hospitality and retail, and improved design contributes directly to increased visits;
- Asset management allows large organisations to standardise and simplify plants and equipment, reducing costs for spares and supplies, as well as training and support;
- Improved understanding of asset performance through improved data and analytics;
- The management of outsourced services is more effective when asset management is in place;
- In many organisations, the need to allocate operational expenditures and capital expenditures (Capex) effectively across units and divisions is also an important driver;
- Asset management moves this allocation into the realm of quantitative management, based on objective evidence from data and information; and
- Safety, health and security programmes require current asset knowledge.

10. Process Safety is a blend of engineering and management skills focused on preventing catastrophic accidents, particularly explosions, fires, and toxic releases, associated with the use of chemicals and petroleum products. (Centre for Chemical Process Safety)

For many stakeholders, including senior executives, the case for asset management being a core activity to mitigate business risk, is established when a large proportion of the total assets on the balance sheet comprises property, plant and equipment. A key role of asset management is to assure the delivery of value, in line with:

- agreed performance / levels of service;
- Return on Investment (ROI) and/or Return on Net Assets (RONA);
- required residual risk profile (safety, asset reliability, reputation etc); and
- the projected profit and loss account and cash flow statement.

4.3 The Organisational Effectiveness Case for Asset Management

Within any organisation, there will be supporters of asset management at all levels, as it provides a means to improve aspects of organisational effectiveness that they value, for example:

- Boards of Directors will use it as a tool for assurance;
- CEOs (Chief Executive Officers) find it to be a powerful tool in resolving conflicts among divisions over resource allocation;
- CFOs (Chief Financial Officers) will use it as a source of data to improve integration and performance;
- Public Relations officers expect to use it as a way to improve image and reduce or deflect exposure from incidents;
- Asset related managers see it as way to improve their influence and budget;
- Operations and maintenance workers expect it to help them improve working conditions and job satisfaction; and
- The majority of all employees favour sound environmental policies and practices related to assets.

4.4 Improved Management of Risk

The activities of all types and sizes of organisation involve risk. The ISO 55000 standards use the widely adopted definition of risk - *'effect of uncertainty on objectives'*. This definition, which is also used in ISO 31000:2009[11], originates from ISO Guide 73:2009[12]. The uncertainty can come from external and internal factors and influences.

An organisation's approach to risk management will be determined by its risk appetite and tolerance. These will be influenced by its organisational context: its sector, stakeholders, culture and objectives.

An organisation's assets are often the leading edge of its exposure to external risk, for example: buildings and other structures are exposed to environmental risks from weather and climate change; transportation and utility infrastructure is exposed to increasing safety and security risk; all organisations are exposed to resource depletion or constraints, and changing economic conditions. Risk also arises from internal circumstances, including the construction, operation, maintenance and disposal of assets.

Asset management's risk based approach supports organisations in strengthening their resilience to external risks, enabling better control and mitigation of risks that can arise from the management and operation of their assets. For example, where assets that have been under-utilised or neglected, these can often be more appropriately managed by systematically assessing and taking account of their potential risk to the organisation. This approach can be particularly useful for assets nearing the end of their useful life, where traditional practices for managing assets may increase risk through a short-term driver to achieve least-cost maintenance.

4.5 Finding Value in Overlooked Resources

In an organisation's goal to realise increased value from its assets, they may be repurposed or expanded to meet a changing context. In a manufacturing plant, making minor modifications to assets can allow production of products in higher demand. The warehouse turned into apartments is a common example. Or the airport waiting area, which used to be a cost of doing business, is now a profit-centre featuring dining, shopping and entertainment. In the infrastructure sector, corridor assets (e.g. for transport or energy) are particularly valuable, since once they are lost, it can be impossible to recreate them. These rights of way have always had external revenue potential and this is increasing with population density.

11. ISO 31000:2009, Risk management – Principles and guidelines
12. ISO Guide 73:2009 'Risk management - Vocabulary'

4.6 Supporting Compliance with Financial Reporting Obligations

A technically and financially integrated asset management system allows compliance with the general features of local Generally Accepted Accounting Principles (GAAP) or the International Accounting Standards Board (IASB). This enables organisations to meet their financial reporting objectives.

In the International Financial Reporting Standards (IFRS), established by the IASB, some of the IFRS general features are relevant, and important, for asset management. These include:

- **Fair presentation and compliance with IFRS:** This requires the faithful representation of the effects of transactions, other events and conditions, in accordance with the definitions and recognition criteria for assets set out in the IFRS framework. Events or transactions through the asset life cycle can include (but are not limited to): initial recognition[13]; obligation to dismantle, decommission or restore; change in useful life; major inspection or overhaul; held for sale or disposal.
- **Accrual accounting**: The accrual accounting methodology requires organisations to understand the relationship between their operational and capital expenditures (related to physical assets) and the delivery of the required value to that organisation. It requires transactions to be recorded at the time they are agreed, rather than at the time that cash or cash equivalents change hands.
- **Materiality and aggregation**: Every material class of similar items has to be presented separately. Items that are of a dissimilar nature or function have to be presented separately unless they are immaterial. In the case of plant, property and equipment the principle of component accounting is mandatory. This means that where a tangible fixed asset comprises two or more major components with substantially different useful economic lives, each component should be accounted for separately for depreciation purposes.

4.7 A Framework to integrate Other Standards

A large organisation may need to use and apply thousands of technical standards, codes, and industry guidelines. These standards address the performance requirements and issues related to asset management. The potential for asset management to provide an overall framework for technical standards was recognised during the development of ISO 55000, with Section 0.2 of the standard *('Relationship with other standards')* stating: *'ISO 55001, ISO 55002 and this International Standard can be used in combination with any relevant sector or asset type-specific asset management standards and technical specifications. ISO 55001 specifies requirements for an asset management system, while the other standards detail sector-specific, asset-specific or activity-specific technical requirements or give guidance on how ISO 55001 should be interpreted and applied within a specific sector or to particular asset types.'*

Asset management is not seeking to replace other existing disciplines. There are very effective standards and guides for risk management, systems engineering, quality management, reliability engineering and so forth. Asset management seeks to provide a framework where these can be used more effectively to deliver value by helping to describe and communicate the context in which those other disciplines can be applied and integrated.

13. An asset is recognised in an organisation's financial statements when: it is probable that any future economic benefit associated with the item will flow to the entity; and the item has a cost or value that can be measured with reliability.

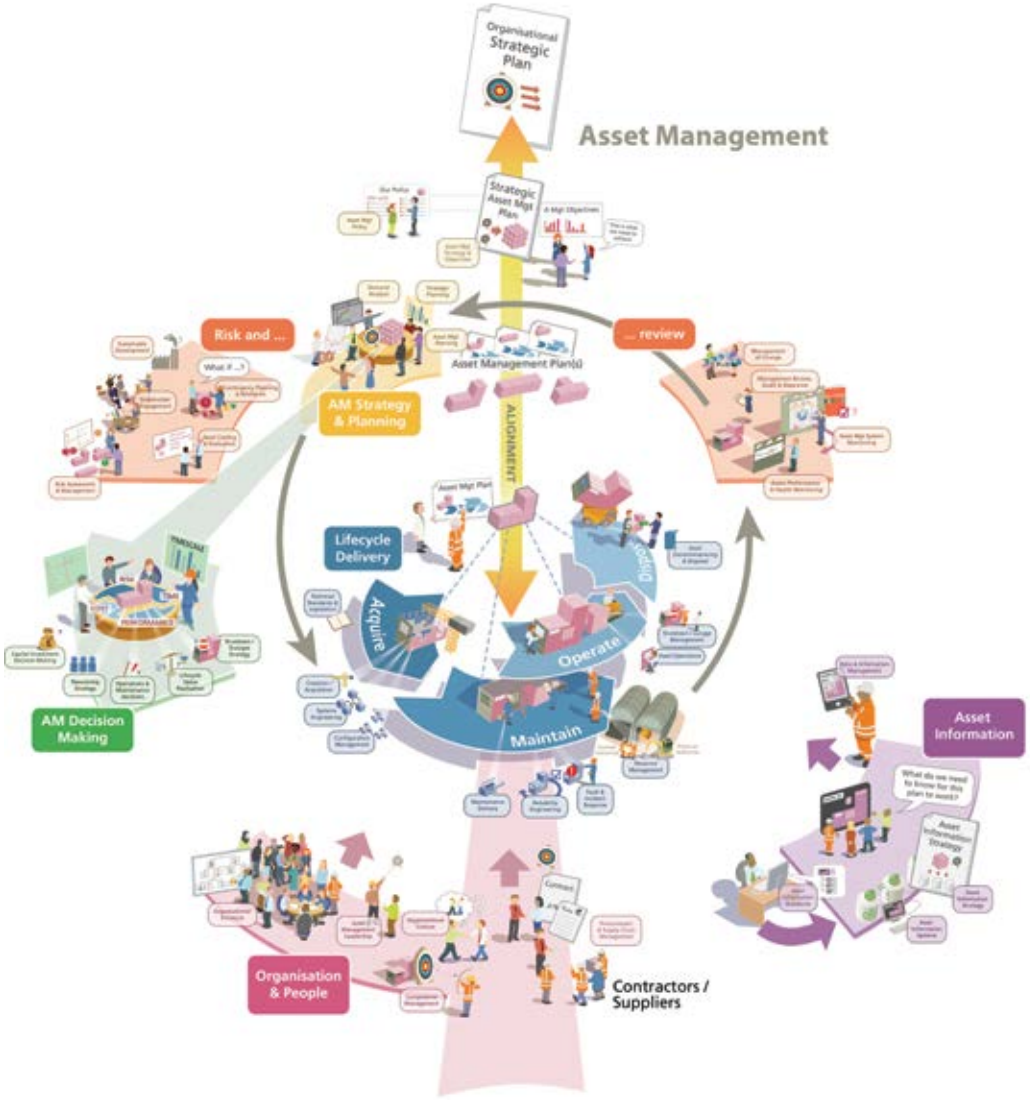
5 Who does Asset Management?

It is vital to remember that ***people*** do asset management and therefore people, and their knowledge, competence, motivation and teamwork have a huge influence on the asset management outcomes.

Tools and technologies are important: but engagement of the workforce, clarity of leadership, and collaboration between different departments and functions are the real differentiators of a leading asset management organisation.

People do asset management

Knowledge, competence, motivation and teamwork have a huge influence on asset management outcomes



Extract from the IAM's 'Big Picture'.
For more information about the IAM's 'Big Picture', go to www.theIAM.org/BigPicture

Figure 8: People do Asset Management

Asset management engages at multiple levels within organisations (for example enterprise, division, manufacturing plant, and production line) and their supply chains. It requires people from different functions and disciplines to work more closely than they may have done. It also includes contributors from across the organisation, such as: business strategy, risk & insurance, finance, operations, maintenance, security, analytics, information systems, environmental awareness, quality, engineering, design, construction, safety and security. Each level and contributing group brings its own expertise, expectations and activities.

As the inter-dependence between activities increases, teamwork and collaboration become increasingly critical for organisational effectiveness. Asset management is a team effort. This will be very apparent with cross-functional teams at the enterprise or division level. The asset management team at this level requires executive sponsorship. At the enterprise or division level, the team concept provides a broad base of knowledge and skill to support asset management; and it also allows representation across the asset life cycle and across the organisation.

For some organisations, there can reasons for teams not being fully cross-functional. These can include, for example: logistics, geographical separation, or legal / regulatory issues. In smaller organisations the structure may be pared down with multiple levels, or contributing groups, being combined. No matter the size of the organisation, the team should be representative of the organisation and have executive sponsorship.

The concept of 'line of sight' means that everyone who touches or influences what happens to an asset is involved in asset management. This brings into scope functional teams at the plant or production line level and the concept of operator care (integrating operations and maintenance responsibilities at the equipment level). It also means that teams often include members from outside the core of the organisation, including suppliers, consultants and in some cases customers.

An asset management system (AMS) can enable all of those involved in asset management activities to understand how their roles relate to those from other functions and/or levels that are covered by the management system.

5.1 Asset Management Culture

One of the most important elements of asset management is the role of organisational culture. It is a foundation of good asset management, and a key ingredient of its success – or failure.
Culture refers to a long-lived set of values, beliefs, attitudes and assumptions which are thought to affect behaviour and performance over the longer term. A popular and simple definition is: *'the way things are done around here'*.

A management system, no matter how detailed and well implemented cannot specify, command or monitor all employee activities and actions. There is much that falls between the cracks, for which culture is the critical reference point.

Building an organisation with a healthy culture is a significant part of effective leadership. The organisational structure created by senior management can have a major influence on the culture of the organisation and vice versa. Culture is less tangible than organisational structure and more complex in that there are many more variables at play. Creating an appropriate organisational culture is integral to achieving the level of integration between functions that good asset management requires. There is no single correct organisational structure or culture for asset management - an organisation's senior management need to ensure that the structure and culture are conducive to what they want to achieve. Sustaining cultural change requires consistent behaviours, especially from management (at all levels from the boardroom to line managers and supervisors), continuous communication and reinforcement.

This analogy from *'Living Asset Management'*[14] illustrates the interactions required to achieve the desired outcomes.

'Asset Management is an evolving discipline that is dynamic and complex; involves life cycle considerations and relationships among various disciplines. Physical assets and management systems are visible and tangible like the trunk and branches of a tree. Leadership, emotions, culture and behaviors are invisible and intangible. Yet they are essential to an organization. Just as a tree is

14. Lafria, J. and Hardwick, J. Living Asset Management. Engineers Media, 2013

not merely a collection of trunks, branches and leaves, neither is an organization merely collection of assets and their plans and processes. Without the right leadership, culture and behaviors, an organization cannot produce its desired outcomes, just as without the right soil, nutrients, environment and gardeners a tree cannot produce its fruit.'

5.2 The Organisational Asset Management Journey

Well-implemented asset management has the potential to transform an organisation's culture, integrate its management systems and provide greater value in delivering the goals of the business. The development and initial implementation of asset management is a multi-year journey. In a large organisation, it will often take five or ten years to become embedded as a 'business-as-usual' activity for continual improvement. The journey can also be complex and difficult. Those involved need to be clear on why they are making it, and not settle for the status quo or simply pursuing tactical improvements in managing the assets themselves. For some, the perception may have been created that asset management is about software systems and it will be necessary to begin with completing an asset inventory. The ISO 55000 standards have helped reinforce that asset management is much more than this. Most organisations know enough about their assets to begin implementing asset management without completing an inventory. In fact, developing an AMS will help an organisation to define its requirements for asset knowledge, including the breadth and depth of information in the asset register.

Organisations often begin their asset management journey as a time-bound project (e.g. to implement an IT system), or programme of work (a group of related projects, e.g. implementing an IT system along with changes to processes to improve asset reliability). These typical journeys usually result in a realisation that successfully implementing asset management is not quick and requires an integrated approach across a broader range of activities. Resources, such as those identified in Section 7, can help organisations starting their asset management journey.

If an organisation wishes to implement an AMS based on ISO 55000, this may be achieved by combining it with its other ISO management systems, such as ISO 9000 (quality management,) ISO 14000 (environmental management), or the PAS 1192 series of standards (BIM or building information management). This approach can aid a quick start where these systems are in place and working well, and reduce the effort and expense involved in creating an AMS. It will also improve integration across management systems and with the organisation's dominant management system. This approach can also access a broad base of support from within the organisation as it is seen as extending the scope of an existing integrated management system.

This integration of management systems is supported by ISO/IEC Directives[15], which expand and rename certain of the required elements of a management system. They also support a wide variety of approaches to quality management, such as Lean and Six Sigma, in addition to the traditional PDCA (plan-do-check-act) model. ISO 55001, ISO 9001 and ISO 14001 management system standards all now follow these directives.

Section 2.6 of ISO 55000, *'Integrated Management Systems Approach'*, recognises and supports the integration of management systems.

'Using an integrated management systems approach allows an organization's asset management system to be built on elements of its other management systems, such as for quality, environment, health and safety, and risk management. Building on existing systems can reduce the effort and expense involved in creating and maintaining an asset management system. It can also improve integration across different disciplines and improve cross-functional coordination.

Organizations that have implemented an integrated systems approach have demonstrated the benefits of the integrated approach and shortened the time to implementation of each new system. The integrated approach, in addition to reducing cost, reduces risks and improves acceptance of each new system.

Asset management, because it touches so many parts of the organization, is a natural candidate for an integrated systems approach.'

At some point, the AMS will need to be integrated with the organisation's dominant management system and other organisational management systems, such as: financial management, human resources management, legal and intellectual property management, and marketing and sales. Addressing this integration at an early stage is likely to be more efficient than trying to merge management systems at a later date.

Similarly, an organisation will want to develop an asset management capability tailored to best suit its own circumstances. This can be accelerated by, and benefit greatly from, consideration of available asset management models and the capabilities which support them. These can provide information beyond that which is available within the ISO 55000 documents, and where desired by organisations, help with developing higher levels of asset management maturity.

As asset management becomes established, one of the challenges for organisations can be maintaining alignment across departments. This risk can increase once asset management becomes business-as-usual and there have been significant changes over time of management or staff in the contributing departments and/or supply chain. Good change management and strong leadership with an understanding of, and focus on, maintaining alignment will be crucial to ensure the asset management journey stays on track.

15. ISO/IEC Directives Part 1 and Consolidated ISO Supplement, Annex SL, Appendix 2. (2013, Fourth Edition).

5.3 Asset Management Maturity

As identified earlier in 2.1, there is now convergence of opinion on what 'good' asset management looks like; and it is surprising how consistent this can be across different industries / sectors and for different asset types and environments.

Many organisations choose to have their AMS assessed for conformance to the ISO 55001 standard by independent third party assessors. Achieving a certificate of conformance demonstrates a level of competence and good practice in asset management. To get most value from the assessment and certification process, it is advisable to use assessors that are recognised through a formal scheme, such as those managed by National Accreditation Bodies, or the IAM's Endorsed Assessor Scheme.
Such assessors will be able to demonstrate that their individual auditors have knowledge and understanding of asset management as well as the management system standard. This can be achieved by testing compliance with the Global Forum's Specification[16], *currently* through examination for one of the following qualifications:

- The IAM's 'Certificate in Asset Management'; or
- The 'Certified Asset Management Assessor' examination[17].

Asset management maturity goes beyond conformance with ISO 55001. There will be organisations that want to develop their capability beyond conformance in order to achieve their business objectives. The discipline of asset management is continually evolving through process innovations, new technology and learning. This constantly challenges the understanding of 'best' practice. Organisations also have widely different operational environments, constraints, cultures and opportunities. This means that what should be recognised as 'competent' or 'excellent' depends on the context of the organisation. The features that would be regarded as 'Excellent' in one sector, or set of circumstances, may not be the same as those that are applicable, or desirable, in another.

The IAM has developed a maturity scale and terminology to define asset management capability / maturity. The maturity scale and associated guidance considers the maturity of:

- the management system (conformance with ISO 55001, representing a 'competent' level of maturity); and
- an organisation's asset management (the wider discipline, as defined by the 39 subjects of the Asset Management Landscape)

The definitions and characteristics of the higher levels of maturity (that is, beyond 'Competent') are context-dependent and temporary (as the leading edge attributes of 'Excellence' continually move). A specific differentiator for the higher levels of maturity is organisational culture. For this, indicators of how well asset management is established include the level of embedded behaviours for learning and continual improvement.

Characteristics of organisational context that affect what is achievable and worthwhile in asset management fall into three categories:

- Asset systems criticality (the importance of managing the assets optimally);
- Scale and complexity of the asset portfolio (the difficulty of managing assets optimally); and
- Volatility of the business environment (the constraints / opportunities to manage assets optimally over their whole life cycle).

To explore these issues, please visit *www.theIAM.org/Maturity*

16. GFMAM Competency Specification for an ISO 55001 Asset Management System Auditor/Assessor, First Edition, Version 2, ISBN 978-0-9871799-5-1 http://www.gfmam.org/files/ISBN978_0_9871799_5_1_GFMAM_ISO55001_Auditor_Assessor_Specification_Edition_1_v2_English.pdf
17. The CAMA exam is offered by World Partners in Asset Management, a sub-set of the Global Forum's members.

5.4 The Individual Asset Management Journey

Given the relative youth and breadth of asset management, it is inevitable that people coming to the discipline have already demonstrated competence in another profession, such as engineering or finance - and may have significant specialist expertise in a field such as maintenance or auditing.
Particular challenges for individuals considering their own asset management journey include determining what competences they need to develop, and/or want to develop, and finding the training and learning materials they require to achieve this.
The IAM's Competences Framework *(www.theIAM.org/CF)* provides a good starting point to understand the competences required for generic asset management roles. One of the drivers for its development was to help individuals plan their training and professional development.

Once individuals have established the competences they wish to develop, there are many options to begin to acquire the associated knowledge, including:

- Asset management training courses, such as those delivered by IAM Endorsed Training Providers *(www.theIAM.org/ET)*;
- Publications and on-line resources, such as ISO 55000, the IAM's Subject Specific Guidance (SSG) documents, the IIMM, and published textbooks on asset management (see sections 7 'IAM Resources', and 8 'References and Further Reading');
- Asset management conferences;
- Working on projects / initiatives which will enable development of asset management knowledge in specific areas - for example, participating in IAM projects with other asset management professionals from across a range of industry sectors.

Individuals can also test their asset management knowledge by examination and, if successful, gain an asset management qualification such as the Certificate or Diploma developed by the IAM *(www.theIAM.org/Quals)*.

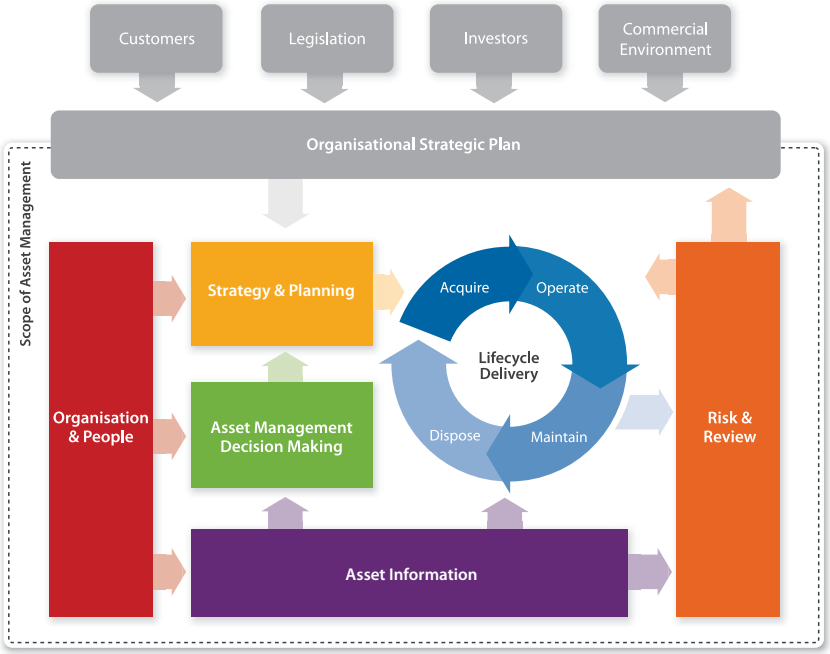
6 The Asset Management Subjects

This section expands on the 39 Subjects, presented in the 6 Subject Groups of the IAM's Conceptual Model (Figure 9).

The Subjects Groups align with the Global Forum's Asset Management Landscape (Figure 10).

The IAM's models was designed to illustrate:

- the breadth of activities within the scope of asset management;
- the interrelationships between activities and need to integrate them; and
- the critical role for asset management to align with and deliver the goals of an organisation's strategic plan.



Group 1 - Strategy & Planning

1. Asset Management Policy
2. Asset Management Strategy & Objectives
3. Demand Analysis
4. Strategic Planning
5. Asset Management Planning

Group 2 - Asset Management Decision-Making

6. Capital Investment Decision-Making
7. Operations & Maintenance Decision-Making
8. Lifecycle Value Realisation
9. Resourcing Strategy
10. Shutdowns & Outage Strategy

Group 3 - Life Cycle Delivery

11. Technical Standards & Legislation
12. Asset Creation & Acquisition
13. Systems Engineering
14. Configuration Management
15. Maintenance Delivery
16. Reliability Engineering
17. Asset Operations
18. Resource Management
19. Shutdown & Outage Management
20. Fault & Incident Response
21. Asset Decommissioning & Disposal

Group 4 - Asset Information

22. Asset Information Strategy
23. Asset Information Standards
24. Asset Information Systems
25. Data & Information Management

Group 5 - Organisation & People

26. Procurement & Supply Chain Management
27. Asset Management Leadership
28. Organisational Structure
29. Organisational Culture
30. Competence Management

Group 6 - Risk & Review

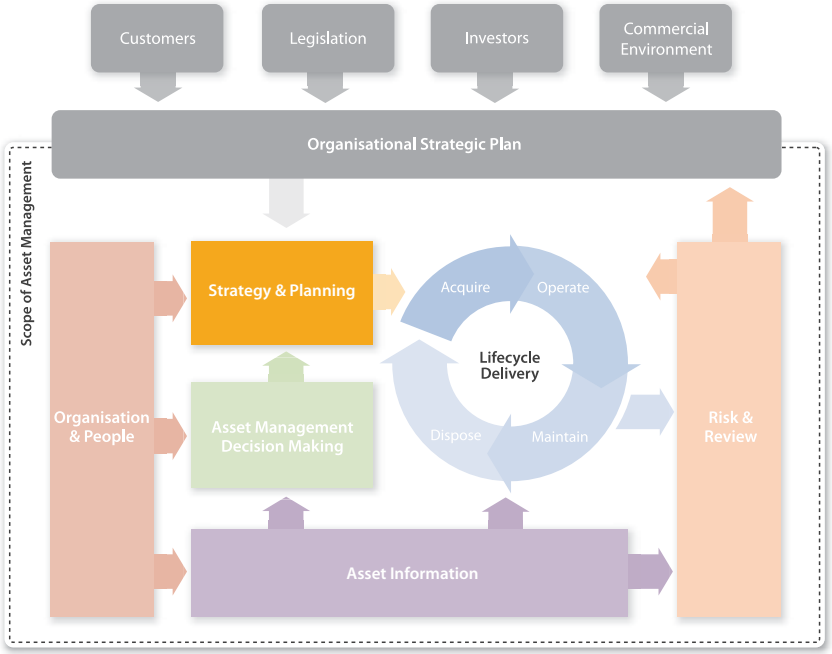
31. Risk Assessment & Management
32. Contingency Planning & Resilience Analysis
33. Sustainable Development
34. Management of Change
35. Asset Performance & Health Monitoring
36. Asset Management System Monitoring
37. Management Review, Audit & Assurance
38. Asset Costing & Valuation
39. Stakeholder Engagement

Figure 10: The 39 Subjects and the 6 Subject Groups in the IAM's Conceptual Model

The importance of individual Subjects to a specific organisation will depend on its organisational purpose and context. For individuals, the depth to which they may need, or wish, to develop specialist knowledge in particular subjects will depend on their career aspirations or their role within an organisation, or the organisation(s) they are supporting. The IAM believes that, even if individuals specialise in a particular area of asset management, it is important that everyone has an understanding of how their activities fit, and interact with, the other subjects and the elements of the asset management system (AMS).

The IAM Subject Specific Guidance (SSG) series of documents is being developed to provide a further level of detail for individual subjects. These are designed to expand and enrich subject content summarised in this Anatomy and identify what should be considered when creating, maintaining and improving an AMS in relation to that subject. They cover a range of industry sectors and, where relevant, recognise the differences in levels of maturity and operating contexts of those sectors and organisations within them. Where appropriate, SSGs provide case studies from different areas to support the key points of guidance. Where Subjects are very closely interrelated a single document may include more than one Subject. *www.theIAM.org/SSG*

6.1 Group 1 - Strategy & Planning



Group 1 - Strategy & Planning

1. Asset Management Policy
2. Asset Management Strategy & Objectives
3. Demand Analysis
4. Strategic Planning
5. Asset Management Planning

6.1.1 Asset Management Policy

An asset management policy states the high-level principles and mandated requirements by which the organisation manages its assets. It is formally authorised by a member of top management, to demonstrate the organisation's commitment to asset management.

An asset management policy is the foundation of an organisation's approach to asset management. A key component of the 'line of sight', it provides a framework for translating the organisation's strategic objectives into asset management objectives, and principles which guide development of the asset management strategy.

ISO 55001 sets out requirements for an asset management policy which fall into five categories:

- Consistency – with the organisational strategic plan and other organisational policies;
- Appropriateness – for the purpose of the organisation and the nature and scale of the organisation's assets and operations;
- Commitment – for the organisation to satisfy all applicable requirements (eg legal and regulatory) and to continual improvement of the asset management system (AMS);
- A framework – for setting asset management objectives; and
- Communication – to managers and staff within the organisation, key supply chain partners and made available to stakeholders as appropriate.

It can be challenging to draft an asset management policy with the right balance for an organisation's circumstances. The structure, length and content of the asset management policy will vary from organisation to organisation, from a single document to a structured group of documents, possibly with a single page 'Asset Management Policy Statement' suitable for notice boards. No matter which format is used, it is essential that it clearly states: how the organisation intends to manage its assets, the principles it will adhere to in making decisions and that top management is committed to the policy.

6.1.2 Asset Management Strategy & Objectives

An asset management strategy and the associated asset management objectives can be considered to be the second stage of an organisation's 'line of sight'.

An asset management strategy - ISO 55000 uses the term 'Strategic Asset Management Plan' (SAMP) - describes an organisation's long-term approach to managing its assets. This specifies how organisational objectives are to be converted into asset management objectives, the approach for developing the asset management plan(s), and the role of the AMS in supporting achievement of the asset management objectives.

The objectives define what the organisation aims to achieve from its asset management activities, including the future capability and performance requirements of assets, asset systems and the asset portfolio as a whole. Where possible, objectives should be Specific, Measurable, Achievable, Realistic and Time-bound (SMART), and established at all relevant levels for all functions within the organisation.

The asset management strategy also describes how the organisation will develop and improve its asset management capabilities and the AMS (i.e. its processes, information, systems, people, tools, resources etc.).

The asset management strategy may include a number of functional strategies to address specific activities (e.g. capital projects, operations, maintenance) and asset classes. These functional strategies are typically an output from the Asset Management Decision-Making Subject Group (see 6.2).

The development of an asset management strategy typically considers the following:

- Consistency – with the asset management policy, the organisational strategic plan and other organisational policies and strategies;
- Risk-based approach - it defines risk tolerability criteria and prioritises activities according to the criticality of the asset or activity and the level of risk associated with it;
- Life cycle approach – it explicitly considers the life cycle of the assets and the interdependencies between each of the life cycle stages;
- Framework – it sets out a framework, including decision-making criteria, to support the development of asset management objectives and plan(s);
- Stakeholder needs – it addresses the requirements and expectations of stakeholders;
- Asset requirements – it identifies functional, performance and condition requirements for the assets (both present and future), taking account of changes in demand and/or service levels;
- Uncertainty – the objectives are based on scenario analyses that consider potential future changes and, if appropriate, the outputs from a sustainable development assessment; and
- Continual improvement – it incorporates relevant feedback, including outputs from management review, to improve the organisation's asset management capability and to ensure that it is still fit for purpose.

The asset management strategy and asset management objectives must be communicated to relevant internal and external parties as appropriate. The cascade of asset management objectives through an organisation has a significant impact on maintaining alignment across the organisation. To counter the tendency to create organisational silos, it can be advantageous for people to have performance objectives which are complementary to, and encourage collaboration with, other departments.

6.1.3 Demand Analysis

When developing the asset management objectives and asset management strategy (SAMP), it is important to consider the current and forecast demand for the organisation's product or service and how this demand translates into the outputs required from the assets. This requires that structured demand analysis be undertaken before fully developing the asset management strategy (SAMP) and objectives and asset management plan(s).
In conducting a demand analysis there are several elements to consider:

- Historical demand,
- Drivers for demand and the change in demand over time,
- For commercial organisations, the changes in price over time (e.g. market prices or resulting from regulatory price controls),
- Changes in required levels of service and/or products.

Quantitative tools can be used for forecasting demand and required levels of service based on a range of information sources including direct research, historical trends, and political, legal, socio-economic, technological and environmental factors. Forecasting and uncertainty go hand in hand and a range of scenarios should be considered with demand projections made for each scenario to provide a range of possible future requirements.

6.1.4 Strategic Planning

Strategic planning is the process for establishing asset management objectives and developing the asset management strategy (SAMP). This provides the platform for more detailed asset management plan(s). Strategic planning is usually undertaken as part of the overall organisational strategic planning process.

The organisational objectives are first translated into asset management objectives, taking into account stakeholder requirements, applicable legal, regulatory and standards requirements and the projected demand for the organisation's products and services. The asset management strategy (SAMP) is then developed to provide the long-term approach, setting out how the asset management objectives will be achieved. The development of the asset management strategy (SAMP) considers:

- the current condition, performance, utilisation and capability of the asset portfolio and how this is likely to change with time and usage based on projected demand;
- the organisational objectives and organisational (strategic plan) for meeting the forecast future demand;
- the constraints on the organisation's resources, such as availability of funding, key skills, plant and equipment;
- the capability and capacity of the supply chain - see also Resourcing Strategy (see 6.2.4) and Procurement & Supply Chain Management (see 6.5);
- the accessibility of the assets or planned outages required to undertake works - see Shutdowns & Outage Strategy (see 6.2.5);
- the need to acquire new assets or enhance existing assets to meet increased demand, or alternatively consider non-asset solutions to regulate demand through restrictions, pricing, or measures to change behaviours of those consuming the product or service;
- opportunities that new technology may provide to enhance utilisation of existing assets or undertake works more quickly and/or efficiently; and
- the business case for any investment required, considering whole life value and whole life cost considerations in line with the organisation's decision criteria and asset management decision-making methods.

The asset management strategy (SAMP) provides the basis and framework for developing a detailed asset management plan or plans. These can be at different levels and functions within the organisation (such as different business units, asset portfolios and asset classes) and for different activity types (such as capital projects for procuring, creating, renewing or enhancing assets, and the operation, maintenance or disposal of existing assets). It is essential that asset management plans are fully aligned with the asset management strategy (SAMP). Strategic planning and asset management planning (see 6.1.5) require an iterative approach, combining top-down strategic direction with bottom up requirements for assets and the capabilities of the AMS.

6.1.5 Asset Management Planning

Asset management planning follows on from strategic planning (see 6.1.4), and is the process of developing the detailed asset management plan(s) from the asset management strategy (SAMP) and asset management objectives.

Asset management plan(s) specify the activities that an organisation intends to undertake to deliver its asset management objectives, along with the resources required, timescales and costs for completion, and responsibilities for their delivery. The scope of the plan(s) encompasses:

- all activities directly related to assets to achieve the asset management objectives; and
- the actions required to address the identified asset related, and asset management related, risks and actions arising from previous failures and incidents.

The information in the asset management plan(s) includes:

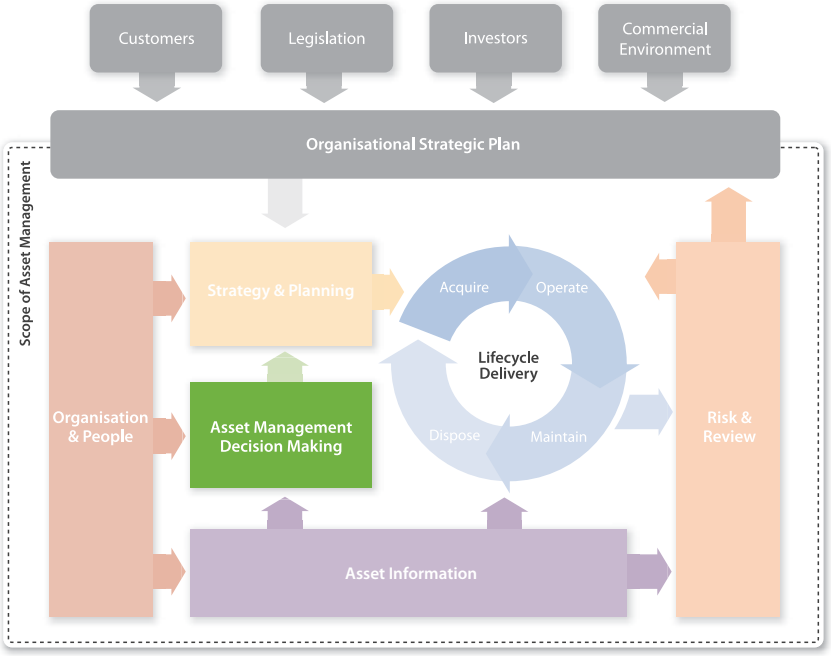
- the responsibilities for leading and delivery of each activity;
- the resources needed to deliver each activity, including financial, human (numbers and specialist skills / knowledge) and equipment;
- the timescales to complete activities, including access and outage requirements;
- when the expected outputs, or benefits, will be achieved; and
- the threats / risks to delivery, and mitigations required.

The planning activities and methods are often specified in procedures or a planning manual and would typically include:

- how activities within the plan(s) are to be prioritised, decisions are to be made, and who is responsible for asset management decision-making;
- the process to determine the optimum combination of activities necessary to deliver an objective, by applying appropriate asset management decision-making techniques;
- the description of the criteria which are to be considered in order to justify the plan(s); and
- how the plan(s) will be approved, monitored, reviewed and updated.

Successful delivery of the asset management plan(s) relies on integration with other organisational plans in both the development and delivery phases, e.g. Finance, Health & Safety, Human Resources, Legal, Procurement.

6.2 Group 2 - Asset Management Decision-Making



Group 2 - Asset Management Decision-Making

6. Capital Investment Decision-Making
7. Operations & Maintenance Decision-Making
8. Lifecycle Value Realisation
9. Resourcing Strategy
10. Shutdowns & Outage Strategy

6.2.1 Capital Investment Decision-Making

Capital Investment Decision-Making comprises the processes to evaluate and analyse options for the creation of new assets, increasing the capability of assets, or the replacement of assets at the end of their useful life.

Capital investment adds equity value to an organisation – it increases its financial worth, and the timing and costs of the investments can have a significant impact on an organisation's success.

An organisation may have mandatory investments to comply with legal or regulatory conditions. Other investments are considered discretionary. Discretionary expenditure has to be justified taking into account how the organisation funds capital, and the range of alternative investment requirements or opportunities available. Consequently capital investment decision methods consider the time value of money (discounting), and follow strict accounting practices / financial rules and internal criteria used by the organisation. The most common method used for evaluating capital investment decisions is Cost Benefit Analysis (CBA) using discounted cash flows.

A range of criteria may be used to evaluate whether an investment is worthwhile, or to compare alternative investments. The most commonly used are Net Present Value (NPV), Internal Rate of Return (IRR) and Payback Period (The value in today's money, the discount rate at which the investment is value neutral and the time taken for it to recover its costs). An organisation also needs to evaluate its ability to fund investments.

CBA calculations must consider the required period of the asset's function, and include all expenditure and benefits. This is known as Life Cycle Costing (LCC), which is discussed further in Life Cycle Value Realisation (see 6.2.3).

Capital investment proposals are usually categorised to align with the delivery of strategic objectives or particular types of investment (such as environmental improvement). This allows an organisation to ensure that investment is aligned and prioritised to achieve asset management objectives making best use of the available funds.

Organisations should have guidance in place to support consistent development, evaluation and comparison of investment proposals.

Strategic planning (see 6.1.4) generates potential long-term investment requirements. At this early stage they may be outline proposals with limited detail, on the understanding that the detailed design will follow. The initial planning stages usually create unconstrained to consider against the organisation's constraints (including funding, resources, supplier capacity and shutdown availability). Prioritising discretionary capital expenditure should be done to agreed criteria taking into account the value of the decision to the business and the urgency of the requirement. This process, known as Value Optimisation, which aims to deliver the best combination of benefits aligned to the organisational strategic goals and life cycle costs, is discussed further in Life Cycle Value Realisation (see 6.2.3).

Once an investment proposal is in the plan, it is normal to develop more detailed proposals and evaluate alternatives. This requires a more detailed CBA, supported by relevant information, including of planned and unplanned maintenance and operating costs for each year of the analysis.

Proposals should be supported with risk assessments, identifying the risks associated with each alternative. These can range from simple subjective approaches, where proposals are assigned to different categories and levels of risk, through to quantified risk assessments based on detailed studies. The risk assessment process determines requirements for controls and mitigations.

It is good practice to develop strategies for managing assets that are critical to the organisation due to their financial value or the consequence of their failure. These strategies support long-term capital forecasts for asset replacement, and the prioritisation and the grouping of investments in the planning process. Ageing assets present a particular challenge where new failure modes emerge after a long period of stable operation. While the physical failure of an asset may be obvious, an organisation may not realise that an asset has reached its economic end-of-life. This is generally characterised by declining performance, increasing operating and maintenance costs, declining reliability, or an unacceptable increase in the probability of failure. While an asset may be kept functioning at an acceptable output level, a full analysis may reveal that it is uneconomic to keep it in service. The development of a strategy, or strategies, to deal with ageing assets can help an organisation to recognise conditions for economic end-of-life, and plan appropriate mitigations in good time.
There is a range of options to manage the end-of-life of an asset or asset system. The simplest is to react to functional failures, sometimes referred to as 'fix (replace)-on-fail'. This can be appropriate and effective for low value, low criticality assets or even for high-value assets, where redundancy is built in to the system, the fix is quick and the failure rate is tolerably low. Where the cost of planned replacement is less than unplanned replacement (due to additional consequential losses such as lost production and penalty payments) it would normally be desirable to plan to replace assets prior to their functional failure.

A planned approach can become more important when there are large numbers of critical assets approaching their end of life. It may be necessary to develop long-term plans in order to justify and secure resources. Decision-making during strategic planning to develop long-term replacement plans is usually based on families of assets, and may include guidance for prioritising (within the families) the assets for replacement. Leading practice asset replacement decision-making utilises decision support tools and modelling.

For many types of assets there are interventions available to slow the onset of end-of-life, ranging from changes to maintenance regimes to extensive refurbishment. The most efficient strategy may be determined by evaluating the costs and benefits of the available life extension options and the future needs for the asset.

It is generally more straightforward to justify changing an asset because of the need for increased capacity (augmentation or reinforcement) than it is because of unacceptable probability of failure. This is because demand forecasting tends to be more definitive than probability of failure. It is essential that an organisation's decision-making processes acknowledge the uncertainties in this area.

6.2.2 Operations & Maintenance Decision-Making

The goal for maintenance is to prevent or mitigate the deterioration of performance of assets in service, and manage the risk of failures. It is good asset management practice to have a maintenance strategy to ensure a predictable and acceptable level of performance through the useful life of the asset. This includes inspections, testing & monitoring, and preventative maintenance regimes (time-based, condition-based, usage/duty-based).
Normally, maintenance activities are funded from operational expenditure (OPEX) rather than CAPEX. Most operational decisions do not consider the time value of money as they are funded from the current year's budget and are usually of a recurring nature. In some organisations, this financial distinction is built into the definition of maintenance while others have a category of capitalised maintenance.

In some industries, assets and asset systems have their maintenance regimes determined at the time of asset creation, using reliability engineering techniques (see 6.3.6). Normally, Original Equipment Manufacturers (OEM) and suppliers provide a list of maintenance and inspection tasks to be carried out at recommended intervals. These recommendations are often generic with little or no account taken of the operating environment, usage or the consequences of a specific asset's failure. The resultant maintenance regimes can be overly risk averse, and so there may be opportunities to reduce maintenance tasks with no impact on asset condition or performance. The converse may also apply but it is more common to find OEM recommendations to be conservative.

In industrial plants many defects that result in equipment failure originate in poor design, procurement or operating practices. It is essential that the functions responsible for these activities work together to minimise the risk of these defects, to reduce the avoidable corrective maintenance workload and improve operating performance.

There are well-established techniques and methodologies for developing maintenance strategies and tasks, including Failure Mode and Effects Analysis (FMEA), Reliability-Centred Maintenance (RCM) and Risk Based Inspection (RBI). RCM systematically identifies failure modes and effective mitigations, including design and operating modifications, and condition- based and time-based (interval and runtime) maintenance tasks. It is supported by FMEA, which enables the capture and analysis of failure modes. In addition, Risk-Based Maintenance (RBM) techniques can enhance the RCM process to optimise maintenance intervals for a cost-effective level of reliability and risk.

Decisions related to maintenance must consider the cost of planned interventions, the risk and cost of failures and other impacts. The modelling of maintenance for decision-making requires predictions of future performance including risk profiles, whether failures are random or change with time. For large programmes, it is often impractical to perform CBA using a spreadsheet, and more sophisticated decision support tools should be considered. For lower value decisions, with robust manufacturer's recommendations, and well-established industry standards, it is usually practical to use templates, guidance or standards for supporting maintenance decisions.

The most sophisticated techniques use complex models. Figure 11 illustrates the optimisation of an asset level decision regarding an interval based maintenance task to mitigate a failure mode where the risk of failure increases from the time of maintenance (such as the routine replacement of motor brushes) eventually leading to failure. The more frequently the task is carried out the higher the annual cost of planned maintenance, and the lower the risk of a failure. The optimal point is where the total business impact is lowest (the sum of both planned and unplanned costs) which is different to the point at which planned and unplanned costs are equal.

These techniques can be valuable in developing robust maintenance regimes, with standards or specifications that can be justified from the perspective of cost and risk.

Good operation and maintenance decision-making practice enables activities to be evaluated and combined into practical planned work tasks, usually through Computerised Maintenance Management Systems (CMMS). This supports the alignment and 'bundling' of work, for example, maintenance and other activities to minimise the operational impact of shutdowns and outages.

The implementation of many of these techniques can be costly in terms of the initial purchase, staff training and information requirements and are usually treated as major projects in themselves. It is important for an organisation to carefully evaluate whether or not a particular technique is appropriate before deciding to implement.

6.2.3 Life Cycle Value Realisation

Life cycle value realisation covers the activities undertaken to balance the costs and benefits of different renewal, maintenance and disposal interventions. It requires the optimisation of life cycle costs and the value obtained from assets over the period for which an organisation is responsible for managing them. To achieve this, it is necessary to apply both Life Cycle Costing (LCC) and Value Optimisation (VO) techniques, where:

- **Life Cycle Costing** (LCC) is the analysis of costs implications for an asset or asset system over the organisation's period of responsibility. If a required asset performance is met, then the lowest life cycle cost corresponds to the best value way of delivering this requirement for the organisation. Sometimes LCC is called the "Total Cost of Ownership".

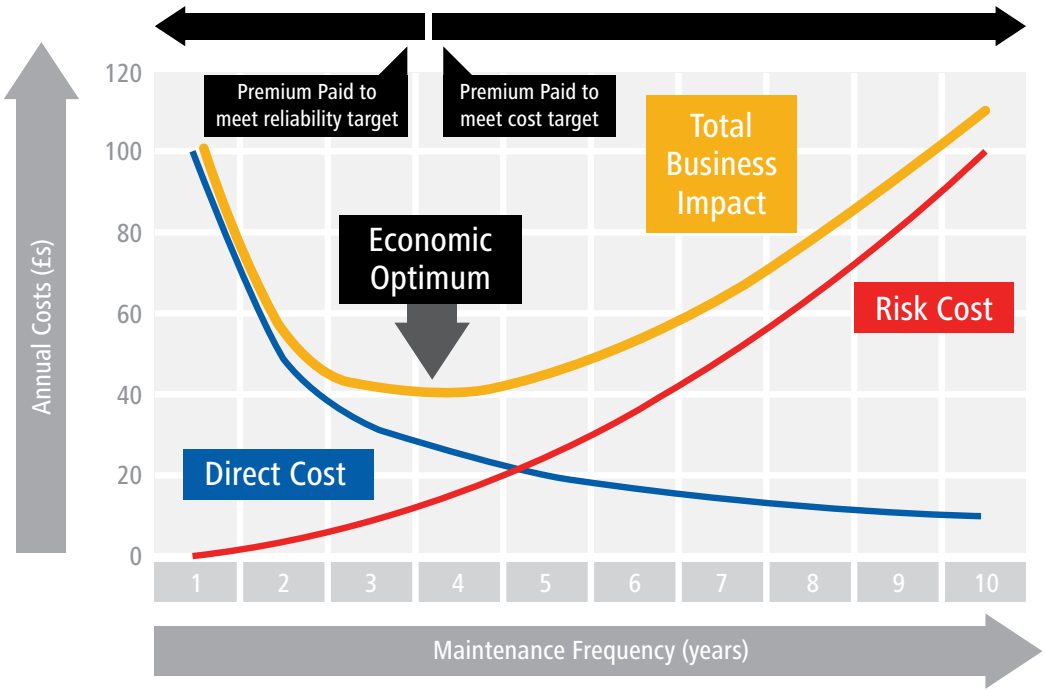


Figure 11: Optimising the frequency of planned maintenance

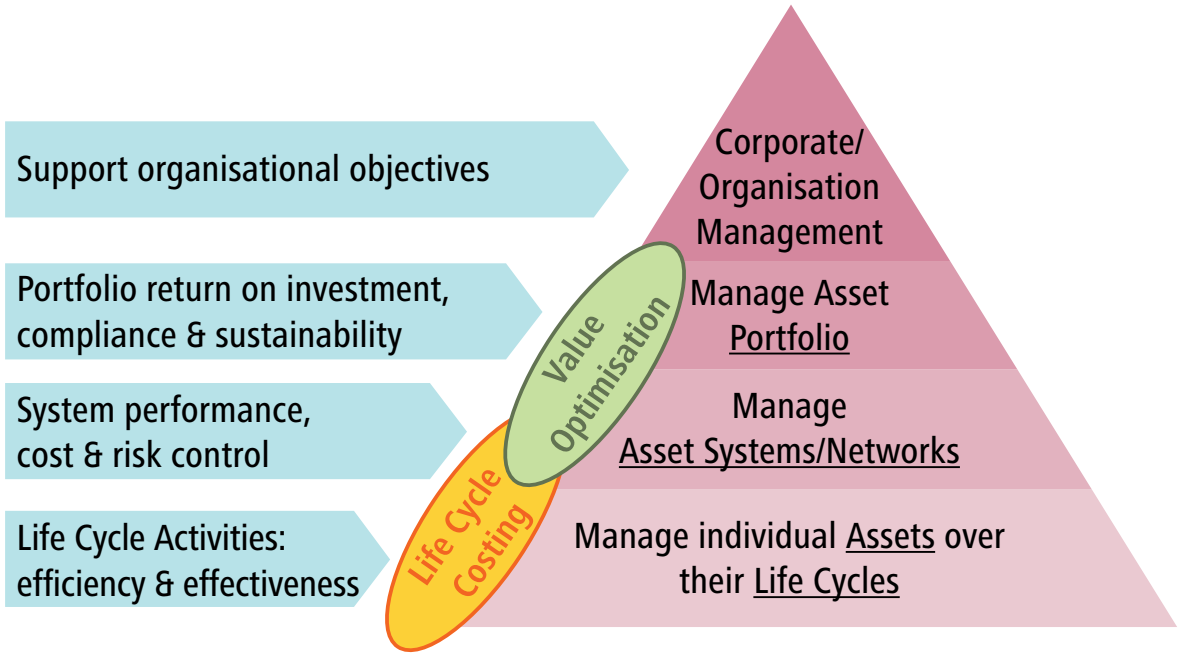


Figure 12: Use of Life Cycle Costing and Value Optimisation for an asset portfolio

- **Value Optimisation** (VO) considers the value of the asset system in addition to the asset costs. It aims to deliver the best ratio of benefits (in terms of delivering organisational objectives) and life cycle costs - in other words, the best value-for-money.
- **LCC & VO** can be applied at different levels for an asset portfolio. This is illustrated in Figure **12**

1. **At the portfolio level** - Asset intensive organisations have a large portfolio of assets and asset systems within their control, all of which put demands on finite resources. The costs, capabilities, and risks within an entire portfolio of assets must be analysed to produce a refined suite of plans and deliverables.

2. **At the system level** - When value is being created at a system level, performance, delivery, cost and risk across the assets in a system must be evaluated and optimised from the top down. System-wide, whole life costs, risks and performance are estimated by aggregating the impact of all assets and modelling the capability of the system as a whole.

3. **At the asset level** - Where capital investment decision-making and operations & maintenance decision-making are optimised for an individual asset, the asset-level decisions must take into account the asset's contribution at the system level.

LCC & VO combine capital investment decision-making with operations and maintenance decision-making processes to support asset management decisions in relation to costs, risks and value opportunities, taking account of both the immediate/short term impacts and any longer term consequences. The correct application of LCC & VO can lead to increased financial and economic benefits, improved decision making effectiveness, better communication with stakeholders as well as driving improved cross-disciplinary governance and consistency. LCC & VO help to ensure that the right decisions are made about what to do, and how much to spend, on what assets, and when.

Life cycle value realisation can deliver a number of important and tangible benefits. However, the degree to which these benefits can be realised will depend on the nature of the organisation and its business context, for example contractual or regulatory constraints, market conditions, risk appetite and stakeholder expectations. The benefits are likely to be particularly significant when decisions are being made in:

- highly critical situations, that involve relatively substantial investment, or for which there are potentially high risk and/or performance consequences; or
- highly complex situations, which involve many factors with complex interactions, or for which there is great uncertainty in assumptions and secondary consequences.

Decision-making in these circumstances may be inadequately served by simple cash flow or payback analysis. Other techniques, such as Internal Rate of Return (IRR) or Net Present Value (NPV), may bias decisions towards short-term approaches, or be unable to evaluate options with different time horizons. It is essential to select the right combination of techniques for the relevant decision types in order to correctly evaluate the benefits.

Further details on the application of these techniques, and the benefits that can be realised are contained in the IAM's Subject Specific Guidance (SSG) document 'Life Cycle Value Realisation'.

6.2.4 Resourcing Strategy

The development of a resourcing strategy is closely integrated with the processes for strategic planning (see 6.1.4) and asset management planning (see 6.1.5). It typically includes analysis, for the relevant planning horizon, to determine the best ways to establish and/or procure the resources required to deliver the asset management plan(s). The resources considered include labour, (and specific competence requirements), spares & inventory, plant & equipment and specialist tools.

The appropriate mix of internal and external resources can be influenced or constrained by external factors (such as supply chain capability and/or capacity), working practices and political or labour union considerations. Organisations normally identify the 'core' resource capabilities to be developed or retained 'in-house', and the 'non-core' capabilities that may be more appropriate to buy in or outsource. This decision will be influenced by a number of factors, including internal resource capability and market availability of suitable suppliers. Organisations should consider the value of being an informed customer with capability to specify, manage and monitor outsourced services. The level of 'in-source' versus 'outsource' should be set out clearly in the resourcing strategy.

The resourcing strategy will directly influence the general procurement strategy supporting the procurement of services established through procurement & supply chain management (see 6.5).

The resourcing strategy will be influenced by a number of factors including changes in business requirements, adoption of new asset and asset management technologies, and workforce demographics. The resourcing strategy should be developed in conjunction with the organisation's human resources strategy to ensure that there is suitable provision for the recruitment and/or development of the required human resources. Developing the required workforce skills is addressed through competence management (see 6.5.5).

For many organisations, production or service availability may be strongly affected by the failure of critical assets. In this case, important risk mitigation is the selection and management of an appropriate spares holding. Factors to consider for spares holdings include procurement lead times, obsolescence and shelf life, and costs for managing, storing and scheduling spares. Opportunities to use modular and standardised spares to cover a variety of assets should also be considered and may influence the cost of ownership and hence acquisition decisions. As with maintenance decision-making, there are well-established tools and techniques for optimising spares that consider the cost of acquiring and managing spares versus the risk of spares not being available when needed, such as lost production.

Efficient and effective delivery of the asset management plan(s) requires material scheduling to be matched with the relevant activities in Life Cycle Delivery (see 6.3) and adequately controlled, particularly where lead times are long or uncertain. The availability of shutdowns or outages within

which to undertake work will affect the profile of resources an organisation requires to deliver its asset management plan(s). An organisation therefore needs to closely coordinate the development of its resourcing strategy with its shutdowns & outage strategy.

6.2.5 Shutdowns & Outage Strategy

The terms 'shutdown' and 'outage' are used interchangeably across many industry sectors and countries. What is always common is that both involve taking assets out of service to execute work that could not be performed whilst the assets are operating. A shutdown would normally involve shutting down the production process, or the service to customers. In some industries, due to redundancy or additional capacity designed into asset systems, assets can be taken out of service (an outage) without completely shutting down the production process or service to customers (it would require one or more further planned, or unplanned, outages for this to occur). Whilst shutdowns and outages may be required to ensure asset performance can be maintained at acceptable levels, they can disrupt output or reduce service levels and are undesirable from a production viewpoint. For the purposes of this Anatomy, the terms shutdown and outage are used interchangeably and denoted as shutdown/outage.

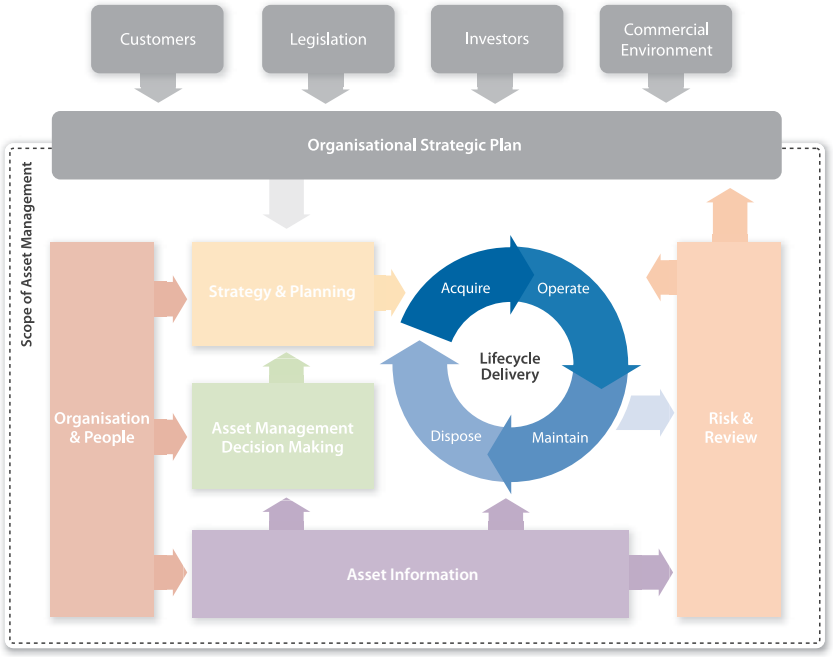
Shutdowns/outages can be expensive to execute requiring large numbers of skilled (and possibly scarce) labour to be set to work within a tight time window and often within limited physical space. A shutdown & outage strategy explores the options available to complete the work activities efficiently and safely within the available shutdown/outage windows. This includes evaluating the efficiency of undertaking fewer, but longer shutdowns/outages (with a large impact on production) compared to more, shorter shutdowns/outages (with less impact on production, but increased delivery costs).

The scope of each shutdown/outage, and the work packages to be completed within it, should be determined using robust, auditable processes. Large shutdowns/outages, such as those involving asset systems, usually require the collaboration of many parties, including operations, maintenance, engineering, projects, production planning, contractors and service providers.

The application of operations & maintenance decision-making identifies the optimum intervals to execute maintenance tasks and/or time windows within which to replace ageing assets. This information, along with other project work, is used to create schedules or scopes of work to be undertaken during shutdowns/outages. It is normal for some activities to be moved from their individual optimal timing to fit within the available shutdown/outage windows in order to achieve the lowest total business impact for the overall programme. Due to the number of possible permutations, evaluating the scheduling of work into shutdowns/outages is often done using specific IT tools for planning and decision support.

The start-up following a shutdown is a higher risk period due to the potential for early life failure of new assets or errors in the execution of complex sequences for re-commissioning and starting up existing assets. These potential risks can be mitigated and managed through agreed and documented processes for commissioning and start-up.

6.3 Group 3 - Life Cycle Delivery



Group 3 - Life Cycle Delivery

11. Technical Standards & Legislation
12. Asset Creation & Acquisition
13. Systems Engineering
14. Configuration Management
15. Maintenance Delivery
16. Reliability Engineering
17. Asset Operations
18. Resource Management
19. Shutdown & Outage Management
20. Fault & Incident Response
21. Asset Decommissioning & Disposal

6.3.1 Technical Standards & Legislation

All organisations have to comply with legislation applicable to their assets and asset management activities. Most organisations will also have internal and external technical standards, such as industry or sector regulations, to which they must conform. These must be considered when developing the asset management strategy, objectives and plan(s) and in the delivery of life cycle activities.

Organisations must have processes to identify the relevant technical standards and legislation and incorporate the requirements into their own policies and processes. In order to demonstrate compliance with the requirements, it is good practice for this to be audited by individuals that are independent of the associated processes, and the results reported to an independent compliance committee within the organisation (see 6.6.7 Management Review, Audit & Assurance).

6.3.2 Asset Creation & Acquisition

Having determined through the development of its asset management strategy (SAMP) and asset management plan(s) that additional or different assets are required to achieve an asset management objective, the organisation must select a method to acquire these assets. Capital Investment Decision-Making (see 6.2.1) includes an outline of the typical stages of decision-making in the investment planning processes to create or replace assets.

Additional assets can be acquired in various ways from other organisations. This includes purchase of assets that are already operational, or accepting the hand-over of assets constructed by others. This can either be as the owner, or contracted to manage the assets for a defined period.

This subject considers the creation, installation and commissioning of assets, including elements of approval and release of funding, arrangements for hand-over to operations, and the monitoring and capture of 'as-built' costs. The development of requirements, analysis, design, and developing the strategies for verification and validation are part of systems engineering (see 6.3.3).

The creation phase is often managed as a project, or programmes of work consisting of multiple projects. Each project has its own set of deliverables and project success criteria (such as time, cost and quality) aligned with the asset management plan(s).

18. Association for project management, Body of Knowledge, 6th Edition. https://www.apm.org.uk/BOK6

Project management is a recognised discipline with different certifiable approaches to control activities to ensure delivery and governance. A typical set of processes for capital projects can be found in the Association of Project Management (APM) approach and Body of Knowledge[18]. Other well-established methodologies include PRINCE and PMI. In all of these frameworks, projects are managed through a project cycle divided into discrete phases, separated by governance gateways that approve, or halt, progress to the next phase. One simple example is:

- **Concept phase** – establishment of a project team with a project sponsor and representatives that can consider whole life aspects of the assets. Where part of an organisation has overall responsibility for asset management, this often performs the role of project sponsor. The project team confirms deliverables/benefits and success criteria.
- **Definition phase** – exploration of one or more options and selection of the one that will best meet the project deliverables within the constraints of the project success criteria. Investment appraisal models are generally used to support the decision-making process where there is more than one option (see 6.2.1 Capital Investment Decision-Making).
- **Implementation phase** – procurement and delivery of the solution to time, cost and quality targets.
- **Handover and closeout phase** – hand over of the asset to the end user - generally the operator/maintainer. The sponsor determines whether the expected benefits have been realised and the project team reviews how the project was delivered and identifies lessons to be learned.

It is widely accepted that involvement, from the concept phase, of personnel with experience of operating and maintaining similar assets / asset systems to those to be created / acquired by a project can improve the likelihood of achieving the project success criteria.

IT tools are often used to develop and monitor the project schedule and plan, capturing costs including manpower, plant and materials. Where multiple projects or resources are managed within a programme, various techniques are available to maximise the opportunity to deliver the overall programme as efficiently as possible.

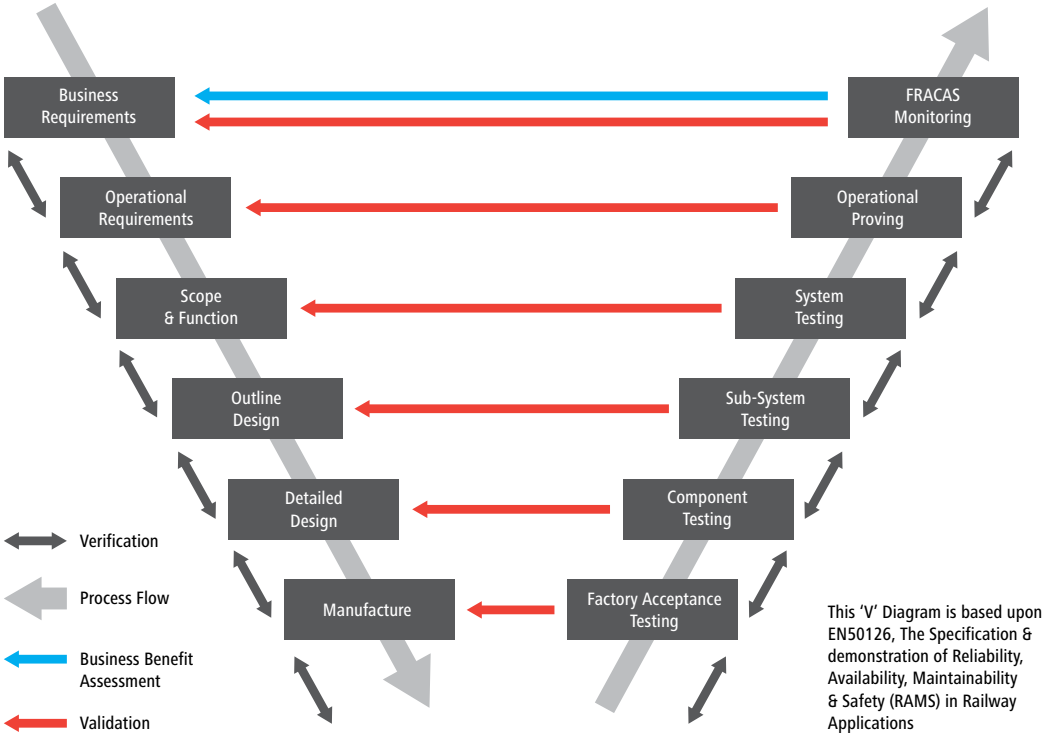


Figure 13: Systems Engineering V diagram

6.3.3 Systems Engineering

Systems engineering focuses on how to design and manage complex engineering systems over their life cycles. It is an interdisciplinary field of engineering more commonly practiced in industries with complex assets or systems. It establishes policies and managerial and technical processes for the requirements analysis, design and evaluation of asset systems and their sub-components.
Systems engineering addresses Reliability, Availability, Maintainability and Safety (RAMS) requirements and considers interfaces between new assets and existing assets or systems. A consideration that is important for many sectors, such as industrial and manufacturing plants, is operability - due to the impact that operating practices can have on asset reliability and availability.

Systems engineering also includes the development of functional and technical specifications, safety approval of equipment, installation processes and acceptance processes including the review, verification and validation of the assets delivered against the RAMS requirements.

Figure 13 shows a typical systems engineering approach, the so-called 'V diagram'. On the left side of the V, requirements are established and cascaded through the design process. On the right side, components are integrated and validated into an overall system to meet these requirements.

A good practice approach to Systems Engineering can be found in ISO 15288, 'Systems and Software Engineering, System Life Cycle Processes'

6.3.4 Configuration Management

Configuration management identifies, records and manages the functional and physical attributes of assets (see 6.4.2 Asset Information Standards), software and related documentation including the links between the components of a system. It provides a process for systematic control of changes to the identified attributes of items for the purpose of maintaining integrity and traceability throughout the life cycle. Configuration management is integral to asset creation and acquisition and closely aligned with the principles and requirements of systems engineering. It is a significant part of the wider management of change process (see 6.6.4).

Configuration management typically comprises the following 5 elements:

- **Configuration management and planning** - establishing documented controls and mechanisms for configuration management, and the production of configuration management plans.
- **Configuration identification** – identification of an item (a hardware and/or software/data product) and its defining attributes. These are recorded and base-lined then subject to formal configuration change control to manage changes to the defining attributes of the item.
- **Configuration control** - processing and approval to manage changes to an item's defining attributes and to re-baseline them as necessary.
- **Configuration status accountin**g - process of recording and reporting on items, their defining attributes, associated configuration baselines and changes to these attributes through time.
- **Configuration verification & audits** – functional and physical audits to ensure that defined functional and performance attributes of items have been implemented / achieved and items are installed in accordance with the requirements of its approved supporting documentation.

Further information on configuration management can be found in:

- AS/ISO 10007:2003 Quality Management Systems – Configuration Management
- EIA-649-A 2004 National Consensus Standard for Configuration Management

6.3.5 Maintenance Delivery

As identified in 6.2.2 (Operations & Maintenance Decision-Making), the goal for maintenance is to prevent or mitigate the deterioration of performance of assets in service, and manage the risk of failures. This ensures that assets continue to meet their service and performance requirements - including safety, environmental and output performance. Operations & maintenance decision-making (see 6.2.2) addresses the selection of appropriate maintenance and inspection regimes to achieve this objective. Maintenance delivery addresses the effective and efficient management of the processes and resources to deliver the chosen regime. This requires cross-functional coordination and integration of activities across Operations, Engineering, Finance, HR, IT and specialist support functions.

Maintenance delivery plans are an output of asset management planning (see 6.1.5). These plans are built using:

- maintenance specifications and standards (see 6.2.2 Operations & Maintenance Decision-Making),
- asset inventorial information (see 6.4.4 Data & Information Management),
- condition and performance information (see 6.6.5 Asset Performance & Health Monitoring), and
- techniques to determine the most appropriate bundling and scheduling of maintenance tasks (see 6.2.2 Operations & Maintenance Decision-Making, and 6.2.5 Shutdown & Outage Strategy).

Maintenance plan tasks can generally be divided into three categories:

- **Inspection, testing & monitoring** – activities to confirm the safety and integrity of assets and to provide information for determining maintenance and renewal needs. This encompasses periodic visual inspections, sophisticated diagnostic testing and remote condition monitoring systems.
- **Preventative maintenance** - planned activities to prevent or reduce the impact of faults, failures or excessive deterioration. Preventative maintenance is based on risk, and related to the maintenance regime being applied to an asset (time-based, condition-based, usage/duty-based).
- **Corrective maintenance** - activities performed to repair defects, damage or address a shortfall in performance in order to restore the asset to a defined standard and keep it operational.

Maintenance delivery can generate large volumes of data & information, such as the results from measurements and monitoring, 'as found' condition reports and records of activities completed. This information is an essential input to develop future maintenance plans, and needs to be well managed via the asset information processes.

It is important that the root causes of corrective maintenance are understood, to evaluate if these can be eliminated, thus reducing excess maintenance requirements. This usually requires collaboration between maintenance other functions such as operations and engineering.
The planning, coordination and scheduling of maintenance activities, the labour resources to deliver them, and other essential supporting resources can be a major undertaking. It requires close coordination with Resource Management (see 6.3.8) and Shutdown & Outage Management (6.3.9). For many organisations, the volume and complexity of this planning and coordination necessitates the use of a Computerised Maintenance Management System (CMMS).

6.3.6 Reliability Engineering

Reliability engineering is the systematic application of engineering principles and techniques throughout a product life cycle to ensure that a system or device has the ability to perform a required function under given conditions for a given time interval. Reliability engineering starts at the conceptual phase of a product design (including defining system requirements) and continues through the life cycle. The goal is to identify potential reliability problems as early as possible in the life cycle and ensure that the reliability requirements will be met. The financial impact of changes to a design are orders of magnitude less expensive in the early stages of a design compared to changes once an asset is manufactured, or assembled, or in service.
Reliability engineering is based on the following:

- Reliability deals with potential events - Reliability engineering is concerned with delivering a specified probability of not failing, at a specified statistical confidence level.
- Reliability is generally taken to mean operation without failure. However, even if no individual part of the system fails, but the system as a whole does not do what was intended, then there is still a loss of system reliability.
- Reliability applies to a specified period and seeks to ensure that components and materials will meet the requirements during the specified period. The period may be expressed in units other than time may be used, for example km travelled or number of operating cycles.
- Reliability activities are restricted to operation under stated conditions. This constraint is necessary because it is impossible to design a system for all conditions.

Reliability engineering activities undertaken during the acquisition & creation of assets include:

- Calculating the allowable system failures for each system component;
- Conducting a Failure Modes, Effects and Criticality Analysis (FMECA);
- Evaluating the reliability potential of alternative designs;
- Ensuring all components in a design will actually behave as the designer anticipates;
- Providing information to designers on how to improve the life of a system and its ease of operation and maintenance;
- Providing information to maintainers by defining the maintenance requirements;
- Formulating and running tests on components, subsystems, and the system itself; and
- Investigating user complaints and field failures.

Assessing the reliability of a system requires a model that represents the time-to-failure of the entire system based on its components. Once a system is operational, the model can be refined by: incorporating failure data; recording as-found conditions and the root causes of failures. This can be used as an input to operations & maintenance decision-making (see 6.2.2) to determine the appropriate maintenance or inspection regime.

6.3.7 Asset Operations

Asset operations comprises the processes used to operate assets to achieve business objectives. Operators require information, and usually training, about how to operate the assets within their appropriate design, maintenance and operational parameters.

Asset operations may include the development of an asset operations strategy, to define the approach and resources required to manage and implement operations, and a plan deliver to the strategy and ensure that the assets or assets systems:

- meet their functional requirements;
- are operated to deliver the required service level, and within the operating parameters specified for the equipment;
- meet all statutory and technical requirements for health, safety, security and reliability;
- achieve and sustain defined levels of physical, functional and financial performance;
- provide a basis for modifying operating parameters based on actual experience.

In developing an asset operations strategy, it is important to consider the risks associated with inappropriate operation of the assets including:

- asset loss or systems failure, including consequential financial loss;
- reduced asset life;
- breach of statutory obligations;
- creating an unhealthy or unsafe environment and consequential liabilities;
- risk of harm to the environment;
- inefficient operational performance, resulting in higher operating costs; and
- adverse customer and/or stakeholder perception.

A contributory factor to these risks is operational error. Systems can be designed and/or configured to reduce the potential for such errors through:

- greater automation of system control;
- better equipment and assets;
- in-built protection in equipment; and
- inherent fail safe designs.

These approaches are developed using system engineering (see 6.3.3) and reliability engineering (see 6.3.6) as part of asset management decision-making. Human factors and ergonomic studies are often incorporated into the design stage of assets and asset systems, to improve the ease of, and discipline in, asset operation - which will further reduce the potential for operational error.

6.3.8 Resource Management

Development of a resourcing strategy (see 6.2.4) includes analysis to determine the best way to create or procure the resources needed to deliver the asset management objectives and asset management plan(s). Resources include labour (with specific competences), spares & inventory, plant & equipment and specialist tools.

Resource management implements the resource strategy by planning and allocating resources to enable the asset management plan(s) to be carried out efficiently and safely. It includes the evaluation of work priorities and risks where there are insufficient resources to deliver planned activities. Project management tools and techniques are normally used to support the efficient planning and scheduling of resources.

Effective resource management needs close integration with a number of other subjects including Shutdown & Outage Management (see 6.3.9), Procurement & Supply Chain Management (see 6.5) and Competence Management (see 6.5.5).

6.3.9 Shutdown & Outage Management

Shutdown & Outage Strategy (see 6.2.5) identifies:

- why planned plant or system shutdowns or outages can be an essential part of asset management for many organisations;
- the typical issues considered in developing the strategy; and
- outputs from the strategy to be implemented via Shutdown & Outage Management

As identified in Shutdown & Outage Strategy the terms ‘shutdown’ and ‘outage’ are used interchangeably in this document.

A shutdown & outage strategy identifies the shutdown/outage duration, along with the required material, manpower, contractors and other critical

resources to deliver the scope of work. Shutdown & outage management encompasses the processes for identification, detailed planning, scheduling, execution and control of work related to shutdowns/outages. It is important that the overall shutdown/outage programme is managed in the most efficient and effective way to minimise direct costs and avoid lost opportunities to undertake work within available shutdown/outage windows.

The complexity of work to be completed within shutdowns can vary from simple inspections to major overhauls of asset systems or process plants. For many organisations the overall shutdown/outage programme can be complex with interactions between shutdowns/outages on the same or related asset systems. This is particularly true where renewal and upgrading or extension is required for parts of integrated infrastructure networks or large process plant. This usually requires shutdowns/outages to be completed in a specific sequence, with little or no scope to vary the duration of individual shutdowns/outages within the overall programme.

Shutdowns/outages often require a large increase in manpower, usually contractors, with the logistical challenges of ensuring that the correct materials, parts, specialist tools and equipment are available at the correct time, before or during, the shutdown/outage. Close integration with resource management (see 6.3.8) is necessary to resolve resource conflicts, ensuring the shutdown/outage objectives are achieved within budget and the approved shutdown/outage duration.

A proportion of shutdown/outage maintenance work will be inspection, testing or monitoring. This can reveal defects requiring further work to maintain asset integrity and performance. To manage these, and other unforeseen events that can arise within a shutdown/outage, requires effective processes for risk management and change control. Constrained resources or shutdown/outage windows can require complex decisions to be made to balance technical risks, change shutdown/outage scopes, extend shutdown/outage durations (with possible consequential impacts on the shutdown/outage programme), or defer work until another shutdown/outage can be planned. All this must be done while ensuring that appropriate arrangements are in place to manage identified asset risks during the intervening period.

Because of the potential business impact, many organisations have resources dedicated to planning and coordinating shutdown/outage work.

6.3.10 Fault & Incident Response

Fault & incident response encompasses responding to failures and incidents, in an organisation's assets or its asset management system, in a systematic manner. The process includes incident detection and identification, fault analysis, use of standard responses, temporary and permanent repair procedures, site access and hand-back, reporting and updating of asset information systems.

Failures and incidents can have a wide range of consequences for an organisation and its stakeholders. The response arrangements an organisation employs to handle failures and incidents should be commensurate with the consequences of the failures, and include mechanisms to escalate control of the response to the appropriate level of management. Following the detection or identification of an asset related failure or incident, the initial response is geared towards mitigating the consequences and evaluating whether the production or service can be safely restored. It is common to have resources on a 24/7 rota to provide the initial response.

An organisation's ability to respond to, and time within which it can restore service, following a failure or incident will be dependent on the availability of competent labour, specialist tools and equipment necessary to effect temporary or permanent repairs, and spares (which can range from sub-components to complete assets).

The development of plans to respond to major unplanned events would normally be addressed through contingency planning and resilience analysis (see 6.6.2).

As with maintenance delivery (see 6.3.5), fault & incident response includes the capture of all relevant information for investigation of failures and incidents to ascertain their root causes. Reviewing the response to faults & incidents, lessons can yield learning to improve processes and practices.

6.3.11 Asset Decommissioning and Disposal

Although assets can have long lives well beyond normal business cycles, there almost invariably comes a point where they are removed from service, decommissioned and disposed.

There are many factors that can drive the decommissioning of assets, including:

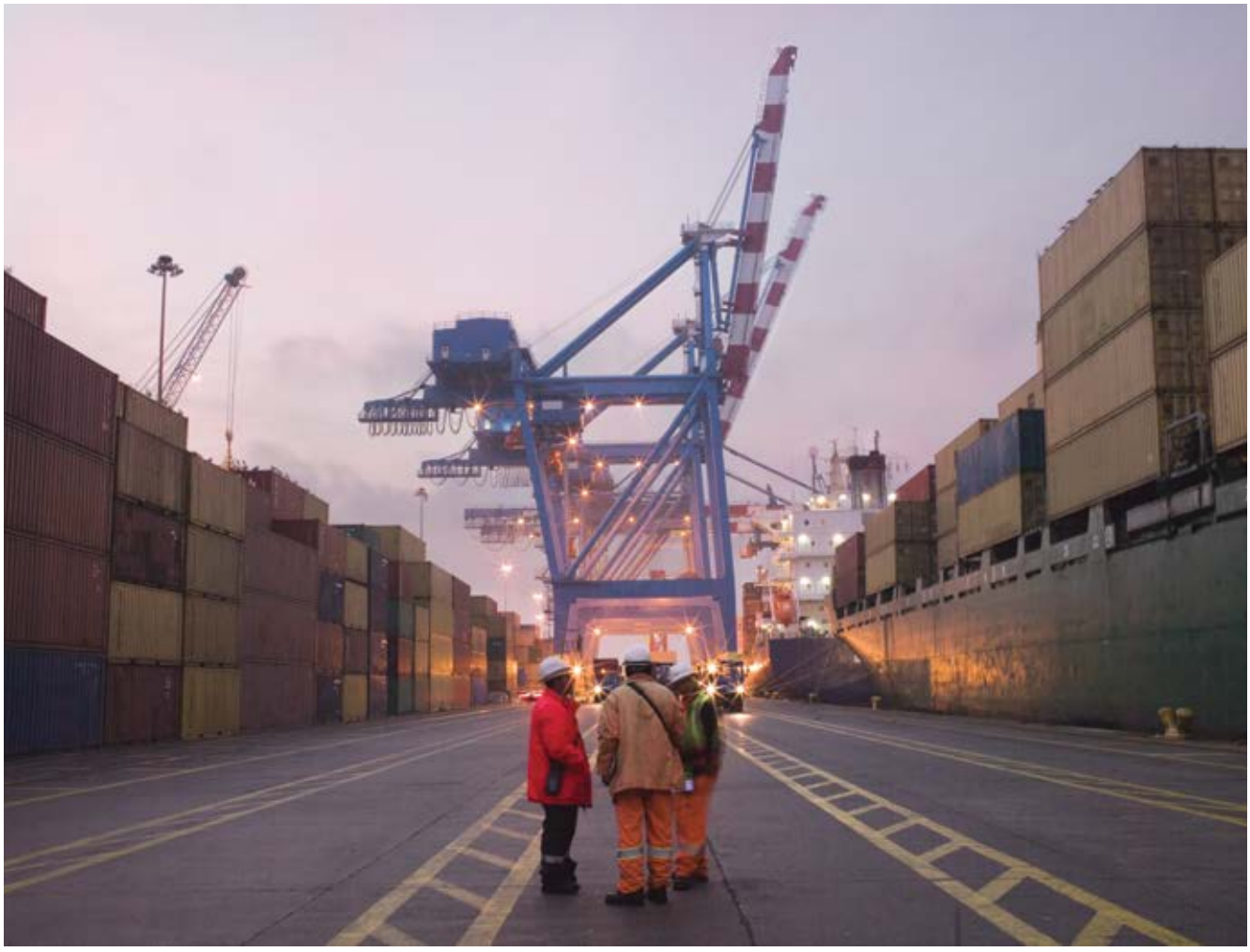
- non-compliance with changes in legislation;
- inability to deliver revised levels of service;
- obsolete technology;
- cost of retaining in service; and
- excess of service capacity.

The processes for deciding and planning which assets are to be decommissioned and disposed form part of Strategy & Planning (see 6.1.4) with the decisions informed by the approaches and techniques identified in Capital Investment Decision-Making (see 6.2).

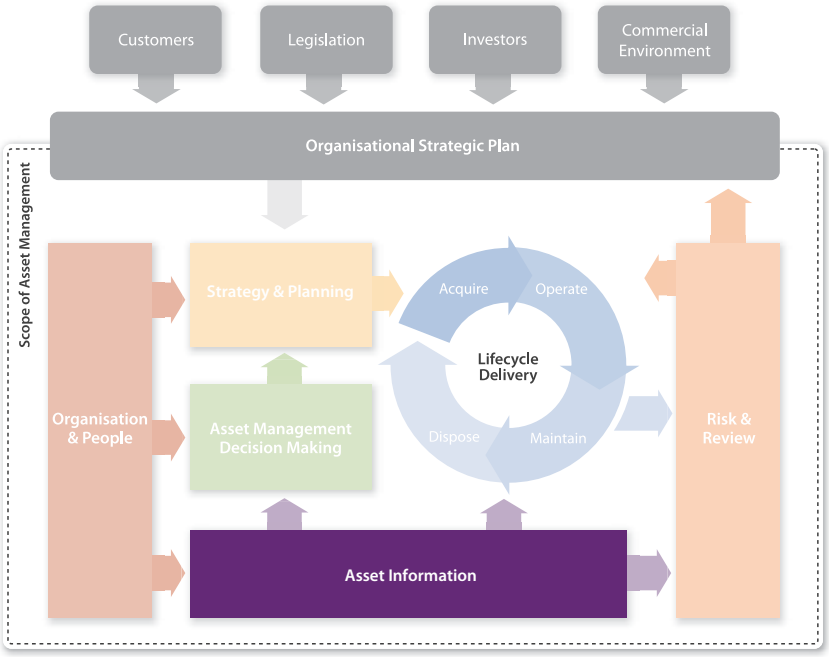
Asset decommissioning and disposal has several aspects to consider including:

- the environmental impact of disposal, including hazardous waste;
- the residual value of assets;
- alternative uses for decommissioned assets; and
- the rehabilitation of land, including decontamination.

The costs of decommissioning and disposal can be significant for some sectors, and decommissioning methods can attract significant stakeholder attention - especially if it is perceived that there is potential for adverse environmental impacts. It is important that the potential costs and impacts are considered in an organisation's capital investment decision-making processes.



6.4 Group 4 - Asset Information



Group 4 - Asset Information

22. Asset Information Strategy
23. Asset Information Standards
24. Asset Information Systems
25. Data & Information Management

6.4.1 Asset Information Strategy

Asset information is a combination of data about physical assets that is used to inform decisions about how they are managed. Good asset information enables better decisions to be made, such as those for asset maintenance or replacement outlined in the subject group Asset Management Decision-Making (see 6.2). The decision may be based on information regarding the asset's location, condition, probability and consequence of failure, work specifications and costs, constraints such as resource availability, and other business priorities, such as compliance with regulatory requirements.

An asset information strategy assesses the current position and clearly articulates an "end state" or intent, in terms of business capability. The strategy should define how an organisation intends to acquire, store, utilise, assess, improve, archive and delete asset information to sustain levels of data quality required to support asset management activities. The asset information strategy should take into account the life cycle costs of the provision of asset information and the value the information adds to the organisation (in terms of improved decision-making and support the day-to-day delivery of asset management activities). The asset information strategy should be demonstrably aligned with an organisation's asset management objectives and strategy (SAMP).

An asset information strategy should include consideration of:

- Asset management decisions and the information required to support these;
- The relationship with the business processes for asset management including business ownership, roles and responsibilities;
- The proposed approach to defining information requirements taking into account the costs of providing asset information and the value of the information;
- The technology and software to be used to deliver the asset information strategy, information flows, system interfaces and the overall logical data model;
- Data management and governance arrangements;
- The costs, benefits and timescales for delivery of improvements to asset information;
- The main outcomes and functionality required from asset information systems (see 6.4.3);
- The core asset information systems required;
- A description of how different asset information systems (both existing and proposed) will integrate;
- A strategy for migrating both data and users from existing systems to new systems; and
- The management of unstructured content.

The asset information strategy should contain objectives relating to the proposed improvements in asset information that are Specific, Measurable, Achievable, Realistic and Time bound (SMART).

Internal and external stakeholder consultation should be undertaken via stakeholder engagement (see 6.6.9) to ensure that the asset information strategy captures their information and access requirements. The asset information strategy should be been signed-off by the appropriate stakeholders within the organisation.

6.4.2 Asset Information Standards

Organisations involved in the management of assets rely on asset data, information and asset knowledge as key enablers for activities in the subject groups for Strategy & Planning (see 6.1) and Life Cycle Delivery (see 6.3).

Asset information standards are required to ensure that asset information is collected, categorised and provided to agreed levels and to agreed timescales. Standards for the measurement process also define the meaning of the data (for example "height" is height above ground, "condition" is tested by standard methods).

Asset information standards typically include:

- Classification of assets to an agreed hierarchy in order to allow an overall asset inventory to be created and managed;
- Definition of the required attributes that should be gathered and managed for each asset type and what these attributes represent;
- Common approaches to the definition and allocation of the criticality of an asset and asset systems to support asset management decision-making;
- Common approaches to the assessment and recording of the condition of an asset in order to support activities within Strategy & Planning (see 6.1);
- Common methods for categorising asset defects and failures for use in planning remedial actions to improve service and reliability;
- Defined approaches to the assessment and recording of the performance or serviceability of an asset to support long and short term planning activities; and
- Agreed methods for assessing and recording the utilisation of an asset to help determine overall asset lives and intervals between intervention activities.

Asset information standards should also define the quality standard appropriate for the different types of information, taking into account the criticality of the assets and the criticality of the decisions made using the asset information.

6.4.3 Asset Information Systems

Although asset information systems can be paper based, they are normally software applications and systems to collect, store, process and analyse the asset information that an organisation requires to manage its assets over their life cycle. These systems ideally store, or are integrated with, a register of all of the company assets. This allows integrated planning and operational activities to be effectively undertaken.

Asset systems can range from sophisticated integrated Enterprise Asset Management (EAM) suites to mixed environments of "Best of Breed" software, bespoke applications and spreadsheet-based analytics. The optimum mix of applications will depend on the size and complexity of the organisation and its regulatory environment. Typical asset information systems include:

- An asset register to detail the assets of interest to an organisation;
- A Geographical Information System (GIS) and / or topological systems to record the location and spatial details of assets;
- Work management systems to plan and record work activities related to an asset;
- Logistics systems to manage the storage, issuing and use of materials and spares;
- Shutdown / outage management systems to plan access to assets for work activities;
- Demand management systems to forecast how demand on assets will change over time;
- Decision support tools such as investment modelling systems to support strategic planning activities;
- Process, telemetry and SCADA systems to record how well assets have performed and are meeting their service requirements;
- Common data environments, to collect, manage and disseminate model data and documents between multi-disciplinary teams to provide a collaborative working environment;

- Condition monitoring systems to monitor key condition indicators of assets, such as temperature and vibration, to help predict possible future failures;
- Mobile working devices to collect data and information from, and disseminate it to, front line operations and maintenance staff.

Across the asset management life cycle, different functions of an organisation have an interest in the asset and require asset information presented and manipulated in differing formats. It is therefore important to have a robust reporting system as part of the asset information system.

There is no clear dividing line between asset information systems and other enterprise/corporate systems - information in asset information systems may be used for wider organisational purposes and information in enterprise/corporate systems may support asset management objectives. For example training and competency records in enterprise human resource systems may support decisions about who can/should respond to defects with specific types of asset, or change detailed costing data to be used in investment or operating cost models.

6.4.4 Data & Information Management

Organisations rely on data and information as key enablers in undertaking activities in the subject groups for Strategy & Planning (see 6.1) and Life Cycle Delivery (see 6.3).

The business need for asset data & information can be strategic, tactical or operational and may not be restricted to asset management practitioners. There may be other users across and sometimes outside the organisation. Once the needs of these stakeholders are understood, more detailed data requirements should be defined. These requirements should not only define the data that is required but also the quality requirements.

Asset data quality encompasses a number of specific data quality measures. These include:

- Accuracy – the data is a true reflection of the physical entity it represents;
- Completeness - a complete set of data is available for each asset data record and all assets are recorded;
- Consistency – data is consistent in its definition, rules, format & value;
- Validity - all data held complies with data storage rules;
- Timeliness – Data reflects the current state of an asset and complies with organisational standards for data update timescales;
- Uniqueness - all keys should be unique with no duplication of data – all assets should be recorded once only.

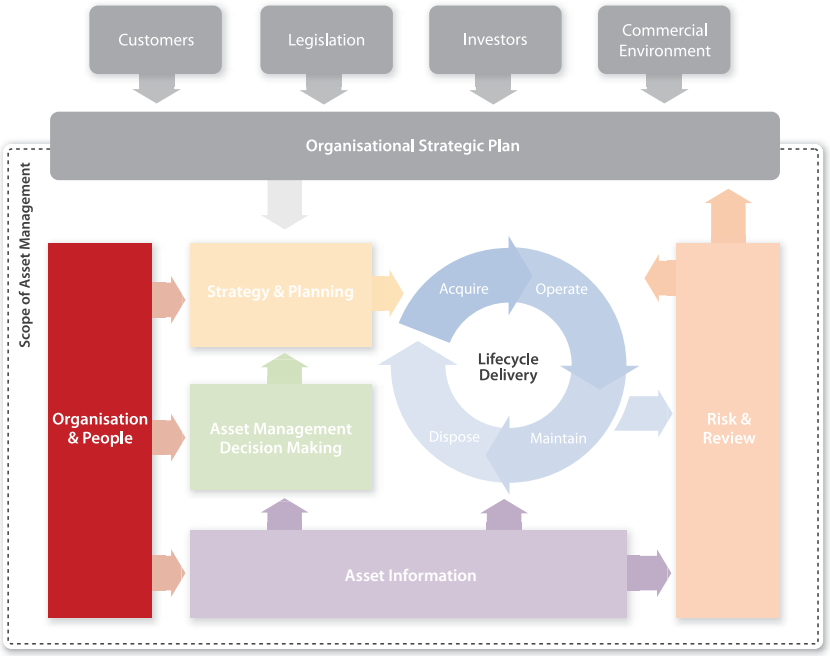
Organisations should assess the quality of their data, and develop a data improvement plan to ensure that missing, or sub-standard data can be acquired within acceptable timescales. Data gathering has a cost and it can be acceptable for an organisation to decide not to gather missing data if the costs outweigh the benefits. As with other decision-making processes, this decision should be based on risk and taken at a suitable level in the organisation. Processes for the provision of asset information resulting from asset interventions (e.g. asset replacements) should be specified. Business decisions must incorporate suitable controls based upon actual data quality. In the context of asset management, information typically includes:

- Records of the existence of a physical asset, collectively known as an asset inventory or asset register;
- Attributes of these assets. An attribute is a quality or feature as a characteristic or inherent part of an asset e.g. make, model, serial number, age, rated capacity;
- Attributes of the asset systems, e.g. capability;
- Location, spatial information, dependencies, and connectivity information – especially in Geographical Information Systems (GIS);
- Logical groupings e.g. systems, equipment types, zones;
- Access requirements e.g. permits, right of way requests, safety related information
- Performance information about the asset. This can be subjective (from experience & knowledge) or objective (from measurements and data). It covers information such as asset reliability, condition and serviceability assessments;
- Historical records of past events and work carried out on the asset - either during short, medium, or long term planned activities or as the consequence of unplanned tasks (e.g. breakdown repairs);
- Documents, design models and drawings, and photographs of the asset;
- Asset types: an understanding of the types of asset within the asset management system and how they are represented in data is critical, for example: point assets, linear assets, area/ polygon assets, volume assets, system level assets;
- Meta-data: This is data that describes data including its structures, data types, business rules, data locations and data qualities;
- Intervention data: This is data that records the history of work done on the asset;
- Workbank – maintenance, renewal, enhancements & failures;
- Unstructured data – user manuals, drawings; and
- Cost data – how much it costs to procure and operate an asset.

Asset knowledge is a more subjective topic and can be influenced in many different ways. Knowledge is derived from the combination of experience, values, information in context, and insight and can be reliant on key individuals to recall specific events or to know where key information is stored. The quality of this understanding will affect the consistency and quality of decision-making. For example, forecasts of future asset performance require good knowledge and not just good data. A key challenge for organisations is to ensure that such personal knowledge and insights are secured and made more widely available for future decision-making and to counteract the potential loss of knowledge when staff leave an organisation or when control of an asset passes from one organisation to another. Concepts like BIM (Building Information Modelling) are increasingly being used to prevent loss of knowledge (and information) at key stages in the life cycle of an asset.

The ISO 8000 series of standards provide guidance on data quality and the importance of linking asset data and information to the organisational goals of the business.

6.5 Group 5 - Organisation & People



Group 5 - Organisation & People

26. Procurement & Supply Chain Management
27. Asset Management Leadership
28. Organisational Structure
29. Organisational Culture
30. Competence Management

6.5.1 Procurement & Supply Chain Management

Research indicates that organisations benefit from using their supply chains strategically, encouraging their key suppliers to participate in their whole life value approach. This can involve moving from short cycle contracts to long-term relationships and changing long established, familiar practices and behaviours.

Organisations with more mature asset management cultures fully align their procurement and supply chain management with their asset management objectives and strategy (SAMP) and the resourcing strategy developed from it. The most mature organisations approach managing their supply chains as they would any other critical asset. They apply the same principles and are focused on the same issues, such as having a clear understanding of how supplier performance contributes to the value realised from assets, and maintaining a focus on continual improvement. This approach is often characterised by closer, and relatively open, working relationships with suppliers.

Organisations that have adopted an asset management approach consider the outputs from their resourcing strategy, including the criticality of the work required relative to their asset management objectives, their volumes of work, management overheads and the availability of competent staff.

They are clear on what activities can, and should, be outsourced and what needs to be kept in house. In reaching these decisions, they:

- Identify and set objectives for their suppliers, and consider how best to deploy contracted staff and integrate them into their own workforce;
- Specify procurement requirements and service level agreements and assess the criticality of individual supplier relationships to the asset management objectives, strategy (SAMP) and plan(s);
- Engage in effective supplier selection activities, developing clear criteria and processes for negotiating with and choosing suppliers, and designing effective contracts that fit their asset management policy;
- Consider how best to incentivise suppliers and build sustainable relationships with their suppliers that ensure their capabilities meet service level needs;
- Use appropriate performance indicators to monitor and manage supplier contracts that minimise the introduction of risk into the business;

- Monitor their suppliers' commercial circumstances and ownership to ensure that relationships continue to be viable;
- Decide how best to make the transition from one supplier management approach to another, and
- Consider the attributes they seek from suppliers in terms of their approach to collaborative working.

Designing contracts that deliver these requirements is vital to aligning supplier expectations, obligations and rights with the asset management strategy (SAMP). It is important for an organisation to carefully consider the types of contracts, supplier relationships, and contract durations, and supplier liabilities that would be most appropriate for the different services it requires to generate enduring value.

6.5.2 Asset Management Leadership

Asset management leadership is crucial in an organisation aspiring to deliver effective asset management. This leadership sets the direction and priorities for the development of the asset management capabilities necessary to deliver the organisation's overall objectives.

To understand asset management leadership, it is necessary to understand the distinction between good management and effective leadership. Managers and supervisors plan, organise, control and make sure that work gets done. Leaders set direction, challenge the status quo, innovate and drive the definition, development and implementation of improved procedures and systems.

There are many different ways to be an effective leader and people with quite different personalities, styles and approaches can be successful. However, all leaders must do the following things well:

- Give direction to the relevant part, or parts of the organisation. In the context of asset management this means that leaders must promote a whole life approach to asset management so the organisation can realise maximum value from its assets, consistent with business risk and performance;
- Articulate their vision clearly and communicate it in a persuasive and practical way, using a variety of approaches, whilst being simultaneously demanding and supportive;
- Make the 'difficult' decisions in the face of ambiguity - difficult is not the same as complex. Difficult asset management decisions are those where the problem cannot be clearly defined or where it is non-routine, or where the decision requires tough choices to be made which affect both individuals and the organisation as a whole;
- Inspire staff to contribute to achieving the organisation's goals; and
- Give confidence to stakeholders of the direction being taken and the benefits that will be achieved.

An organisation needs its staff to be motivated, and leaders make a significant contribution to this through their own behaviour and the arrangements they put in place. The best leaders have an array of techniques that they use to suit a specific situation. It is essential that staff trust their leaders. To be trusted, leaders need to be consistently fair and just, and show that they are prepared to take responsibility when problems arise.

6.5.3 Organisational Structure

Organisational structure refers to the way in which people within an organisation are organised and the groupings within which they have to work. It is inextricably linked with organisational culture.

Managers and executives that are new to asset management often ask *'Where should we place asset management in our organisation?'*

There is no one correct structure that would be applicable for every type of organisation. However, where asset management roles and responsibilities sit in an organisational chart gives a clear indication of how seriously it is taken within the organisation, and will have a big influence on how people perceive it. For example, in a traditional, hierarchical organisation, if there is no one near the top with responsibility for asset management, it is unlikely that the asset management agenda will be taken seriously across the organisation. This would make it very challenging for asset management practices to be driven across an organisation's functions and departments or into the supply chain.

Effective asset management needs organisations to achieve their asset management policies, strategies, objectives and plan(s). The structure of organisations is therefore a crucial concern, because:

- the way people are organised affects how well they work together;
- it is a key enabler of 'line of sight';
- it affects the effectiveness of communications, information flows and feedback in all directions with internal and external staff, and stakeholders; and
- it can have a major influence on the development of organisational culture.

Every organisation needs to decide what type of structure best suits its needs. The structure of an organisation will be influenced by a number of factors, such as:

- size;
- industry sector, and products or services;
- diversity – single site /single country / large multinational;
- ownership structure – private, / government / listed company;
- maturity – a new start-up / an established business;
- cultural background; and
- the appropriate span of control for its services, products and processes.

Asset management requires people from different functions and disciplines to work more closely than many are used to. Because asset management is concerned with the integration of different functions and disciplines, roles and responsibilities need to be allocated at a senior level to make this possible. Maintaining a rigid hierarchy of roles and responsibilities is unlikely to foster multidisciplinary problem solving of the kind that is required for asset management.

Senior management must ensure that the organisational structure and culture are both conducive to what it is trying to achieve. The 'right' structure for an organisation is the one that best suits its requirements, and enables it to meet its goals quickest and most efficiently. In considering the structure, there are three main aspects to consider:

- internal work units e.g. teams, departments, international divisions;
- external work units, e.g. suppliers, contractors, outsourced work; and
- reporting and management lines e.g. committee structures, responsibility hierarchies.

Organisational Culture (see 6.5.4) identifies a number of leading practice principles to apply when deciding on the appropriate organisation structure and culture for asset management activities.

The most appropriate structure for an organisation is also likely to change over time. What is needed to introduce asset management thinking and practices to the organisation may be very different to what is needed as capabilities mature.

Further information and guidance on organisational structure can be found in the published SSG 'Organisational Structure and Culture', which includes a framework to support senior managers when determining what sort of structure best suits their organisation:

- Understanding the purpose of the organisation;
- Understanding the need for change;
- Identifying the necessary structural changes;
- Managing the structural changes; and
- Sustaining benefits of change.

6.5.4 Organisational Culture

The culture of an organisation affects everything it does and all aspects of its performance. Asset management is no exception to this, any more than safety, security, financial management, customer service or corporate reputation. This is why a proactive approach to culture management is important to organisations that seek to benefit from asset management.

There is no one single correct culture for an organisation. Culture is often described as 'the way things are done around here' and each organisation needs to decide what type of culture it needs to be successful and seek to establish this. If the current culture of an organisation is short-term, closed to outside ideas, output driven and risk averse, it will need a bigger change to benefit from asset management thinking and practices than an

organisation that plans for the long term, values processes as well as outputs, benchmarks itself to external best practice, and encourages and exploits innovation and continual improvement.

The first step in creating a culture conducive to asset management is for the top management team to produce a clear vision of what they are trying to achieve and why they believe their approach to achieve this will be successful. Obviously, this should support the asset management objectives and strategy (SAMP) and be aligned to the wider aims of the organisation. It should also take into account the constraints under which the organisation operates. Organisational structure can have a major influence on the culture of the organisation and vice versa. Culture is less tangible than structure and more complex as there are many more variables at play. Creating an appropriate culture is an essential step in achieving the level of integration between functions that good asset management requires.

There are a number of leading practice principles to apply when deciding on the appropriate organisation structure and culture for asset management activities. These include:

- being clear about the purpose of the organisation;
- ensuring visible support and engagement from top management;
- being consistent across the whole organisation;
- ensuring everyone understands the need for collaboration and teamwork, the boundaries of their responsibility and authority within the chain of command, and how, and under what circumstances, issues are escalated;
- ensuring everyone accepts their responsibilities and authority;
- ensuring everyone is clear about the organisation's channels of communication and how information gets passed from the top to the bottom, sideways and back up again;
- ensuring communications are received as intended;
- ensuring that actions are effectively assigned, carried out and reviewed; and
- ensuring everyone knows where, when and how decisions are made and who makes them.

Sustaining cultural change requires consistent behaviours, especially from management (at all levels from the top management to line managers and supervisors), continuous communication and reinforcement.

6.5.5 Competence Management

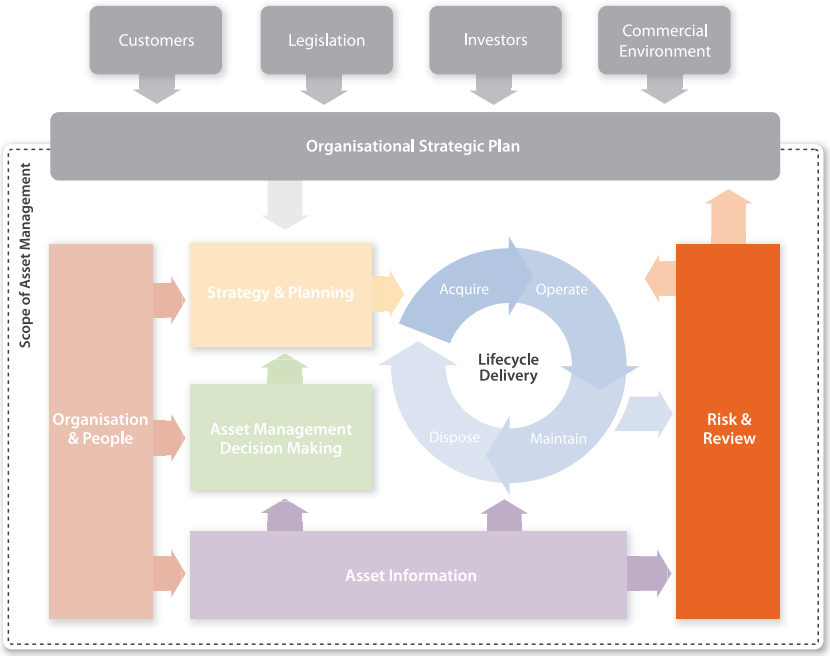
One of the most widely used definitions of competence is the ability to perform activities to the expected standard. Competence does not guarantee good performance but it does enable it. Competence tends to deteriorate if not practised, and even highly competent people can struggle to perform well in a dysfunctional team or organisation. Some activities occur infrequently which makes it difficult to maintain the competence of those who perform them. These factors make the management of competence an important topic.

A fundamental task for all organisations is to ensure sufficient numbers of suitably competent people are available to undertake the activities their success depends on. Development of a resourcing strategy enables management to understand the implications of the asset management objectives and strategy (SAMP) on the competence requirements of the workforce. Being clear about competence requirements at all levels and ensuring these are used to select, develop and review people and define roles and responsibilities and the relationships between them supports the structure and culture of the organisation.

A structured approach to competence management need not be bureaucratic or expensive. It is generally agreed that organisations need to adopt a structured approach to managing competence and behaviour that covers both the development of individual competence and the development of organisational competence.

The IAM Competences Framework is increasingly used by organisations to define their specific competence requirements and build competence management systems around them. The Competences Framework is free to download at *www.theIAM.org/CF*

6.6 Group 6 - Risk & Review



Group 6 - Risk & Review

31. Risk Assessment & Management
32. Contingency Planning & Resilience Analysis
33. Sustainable Development
34. Management of Change
35. Asset Performance & Health Monitoring
36. Asset Management System Monitoring
37. Management Review, Audit & Assurance
38. Asset Costing & Valuation
39. Stakeholder Engagement

6.6.1 Risk Assessment and Management

Risk is defined in ISO 55001 and ISO 31000:2009 as the *'effect of uncertainty on objectives'*. An 'effect' is a deviation from the expected. ISO 31000 also establishes several risk management principles. In particular the ideas that risk management creates and protects value; is part of decision making and an integral part of all organisational processes. Risk management deals with uncertainty in a systematic, structured and timely manner using the best available information to reach the best possible decisions. Risk management comprises a coordinated set of activities and methods used to monitor and control the many unplanned events that can affect an organisation's ability to achieve its objectives. It includes the identification, assessment, prioritisation and treatment of risks to reduce, monitor, and control the probability and/or consequences of unwanted events or to maximise the realisation of opportunities.

An organisation's approach to risk management will be determined by its risk appetite and tolerance, where:

- Risk appetite is the amount and type of risk that an organisation is willing to pursue or retain; and
- Risk tolerance is the readiness of an organisation or stakeholder to bear the risk, after risk treatment, in order to achieve its objectives.

These will vary depending on an organisation's sector, culture and objectives.

Risk assessment and management interacts with all other asset management subjects and comprises the following management activities:

- Generation of risk management policies;
- Development of risk management processes and risk mitigation strategies;
- Execution of risk management processes; and
- Alignment of strategic, tactical and operational risks and risk registers.

A risk management policy sets out an organisation's approach to risk management and is integral to its internal control and governance arrangements. Risk management requires:

- Procedures to manage risk processes;
- Strong linkages to the planning and budgeting cycles in order to align objectives, agree action plans, and allocate resources to deliver the actions;
- A robust reporting and performance management process to ensure regular monitoring of the risk management activities;

- A risk assessment / measurement framework to provide consistent scoring and ranking with guidance on scalability and appropriate control measures. This framework would be approved by top management and guides the identification, assessment, and monitoring of risks at a level appropriate to their significance;
- Risk Registers - the simplest and most common way to share risk information - are maintained at an appropriate frequency with emerging risks added as they are identified. They include actions and indicators to drive and monitor progress; and
- An audit programme. Usually, an internal audit function is responsible for the periodic review of management controls including risk management. The audit plan should be guided by the risks in the risk register and include the process of risk management as well as the outputs.

Organisations generally have an established corporate risk matrix to identify risk levels – high, medium, low or some refinement of this. These are a function of the probability of an event occurring and its consequence. Consequences are identified as financial, health & safety, environmental, reputational or a combination of these. In practice an event will seldom have a single consequence, nor will a consequence have a single potential cause, so it is important that consequence levels are aligned across the different impacts to enable comparison and prioritisation of risks. For example the consequence associated with a safety risk that is classified as minor, should be equivalent to the consequence of an environmental or financial risk that is also classified as minor.

The term 'criticality' is used as a measure of the importance of an asset to the delivery of an organisation's objectives, with the level of criticality being proportional to the degree the business objectives rely on the correct operation of the asset. Understanding the criticality of assets is important to enable the ranking of risks and prioritising actions. All endeavour carries risk. Having identified and assessed the risks, the responses available to handle these, are often grouped into the so-called '4Ts':

- Tolerate a risk and its likely impact;
- Transfer a risk to another party. The consequence of some risks can be transferred on to a second or third party by mutual agreement eg a contractor or insurance;
- Treat a risk by reducing the likely impact and/or exposure; and
- Terminate the activity that generates the risk.

Risk treatment has the widest range of interventions. Risk treatment is the process of developing, selecting, and implementing measures to modify a risk for the reduction of negative impacts, or to maximise opportunities on the upside of a risk. As with any decision, treatment options should be evaluated by considering both the cost of implementing the control and the benefit(s) achieved from the risk reduction. An organisation's decision to treat, or not to treat, a risk will be determined by its risk appetite, risk tolerance and its available financial and other resources (see 6.2.4 Resourcing Strategy and 6.3.8 Resource Management)

Managing risk within tolerable levels is a key consideration in asset management decision-making. An organisation's risk management approach influences its asset management strategies and objectives, capital investment decisions and the choice of regimes for the operation and maintenance of its assets. Effective risk management is an essential part of the successful delivery of all life cycle activities.

ISO 31000 and ISO 31010:2009[19] provide further guidance on good practice approaches to risk assessment and management.

6.6.2 Contingency Planning & Resilience Analysis

This subject covers the processes and systems put in place by an organisation to ensure that it is either able to maintain the services delivered by its assets despite serious events, incidents or disasters, or is able to recover these services within an acceptable period. Responding to failures and incidents is addressed within Fault & Incident Response (see 6.3.10).

19. ISO/IEC 31010:2009, Risk management – Risk assessment techniques

Resilience is the ability of a system or organisation to withstand and recover from adversity. The resilience of assets and asset systems is initially established during asset creation, through the use of systems engineering (see 6.3.3) and reliability engineering (see 6.3.6). However, the environment within which an organisation and its assets operate may well change over time, so in order to maintain acceptable levels of resilience, it is essential that a full awareness of the critical points of an organisation and its assets is captured. An understanding of the minimum requirements, to ensure the organisation or asset can operate, is developed and an assessment of all potential threats is completed. These threats may include natural occurrences (such as flooding, storms or extreme temperatures) and accidental or deliberate events.

Once this understanding is achieved and a detailed risk assessment is completed, contingency planning can be introduced to deal with a majority of the threats faced. Adopting a consistent methodology can ensure that all threats and vulnerabilities are captured, and effectively risk assessed, that responses, other mitigations and contingency plans are developed, tested and exercised and a review process introduced. This approach to business continuity management typically contains the following steps:

- Complete a threat and vulnerability study (sometimes referred to as a business impact analysis), by considering the criticality of assets against all potential threats faced. This is linked to the relevant risk assessment and management processes to identify the key areas of vulnerability that need to be addressed.
- Determine and select strategies to protect, resume and recover the activities delivered by the assets.
- Develop and implement the response, introducing identified mitigations where required including detailed contingency plans.
- Regularly test / exercise, maintain and review the mitigations and plans to ensure that the responses remain fit for purpose and feed outcomes into the continual review process.

More information can be found in ISO 22301:2012, *'Societal security – Business continuity management systems - Requirements'*.

6.6.3 Sustainable Development

The most widely used definition of sustainable development is from the World Commission on Environment and Development, (in 1987): "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

Asset management has an important and enduring role to play in sustainable development including:

- The effective management of the assets in a nation's infrastructure and manufacturing base, which can be key enablers for economic well-being and many societal structures;
- The potential impact on the environment of assets and asset management activities; and
- The approach to whole life evaluation of risks, costs and performance of assets.

Sustainable development incorporates the environmental, social and economic aspects of activities (sometimes referred to as the triple bottom line approach) in decision-making processes. As the implications of incorporating sustainable development within an organisation's activities can be wide-ranging, top management should determine the overall approach. A sustainable development review supports the development of a long-term, holistic approach for an organisation's asset management and is a key input to the subjects in Strategy & Planning (see 6.1) and Asset Management Decision-Making (see 6.2).

An organisation's physical assets determine much of its economic, social and environmental impact. An organisation's Corporate Social Responsibility report can therefore often be a reflection on its asset management.

Further information can be found in the guidance document BS 8900-1:2013, *'Managing sustainable development of organizations. Guide.'*

6.6.4 Management of Change

There can be a wide range of permanent and temporary changes that an organisation needs to consider in relation to asset management, for example the need to comply with new legislation or regulations, the introduction of new technologies or processes, the loss of experienced staff and their knowledge of ageing assets. The organisation needs

to consider how these changes could impact on organisational objectives or tolerance to risk. While some changes are predictable, others are not. An appropriate approach to the management of change will reflect this.

The activities in Risk Assessment & Management (see 6.6) should identify and prioritise risks associated with change, and determine actions to mitigate their potential impacts. It is important to consider how changes may affect the criticality of an asset or asset system, as a previously unimportant asset could become critical to business operations.

Any change associated with assets or asset management activities will almost certainly involve or affect people working in, or for, the organisation. The likelihood of achieving successful implementation of change can be strongly affected by how the change is documented and communicated to those involved in the change, or affected by it. The approach to managing change should be in proportion to the significance of the change and its potential impacts, for example a major change may require its own specific change management plan.

As a result of incidents with significant safety and/or environmental impacts, the management of change has become a strong focus in a number of industry sectors. For example, the Center for Chemical Process Safety (CCPS) - an arm of the American Institute of Chemical Engineers (AIChE) – has produced *'Guidelines for the Management of Change for Process Safety'*.

6.6.5 Asset Performance & Health Monitoring

Effective monitoring of asset performance and health is essential for good asset management. A robust measurement framework includes measures and indicators that relate to the performance and health of assets and asset systems. The term 'asset health' is used in relation to measures that monitor the current (or predicted) condition or capability of an asset to perform its desired function, by considering potential modes of failure.

It is important that measures, and associated targets, align to the organisation's asset management objectives and strategy (SAMP) and provide feedback on, and understanding of, the assets. This feedback is a key input to asset management decision-making processes.

The asset management strategy (SAMP) defines the desired current functional performance, level of service and condition of assets. Clear criteria are required to understand when there is a deviation from the level of performance required for an asset, so that the need for appropriate remedial action can be evaluated. It is common for asset systems to have specific performance criteria. In order to understand and manage their performance, and support strategic and tactical decisions, it is usually necessary to monitor performance of the component assets as well as the overall asset system.

To manage the current and future performance of assets a range of performance measures can be required, including lagging (or outcome) measures to monitor the past performance (eg for incidents,

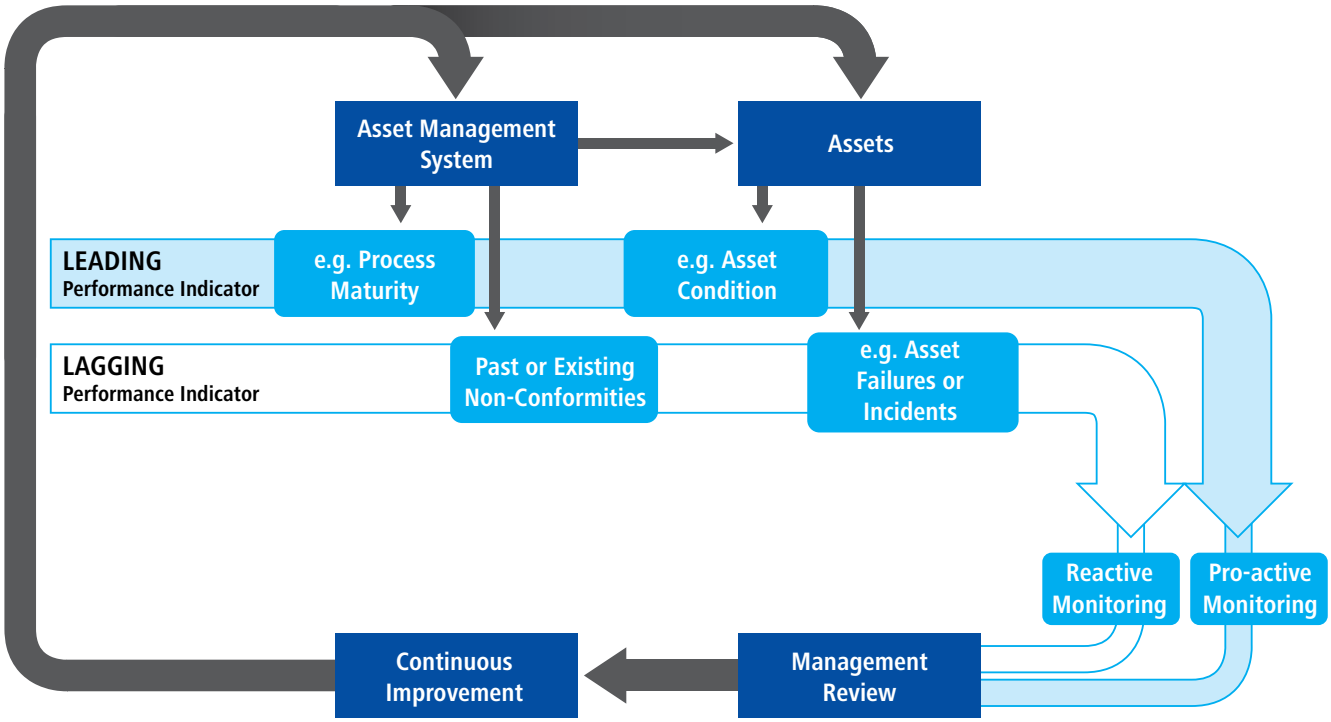


Figure 14: Performance measurement for assets and the Asset Management System

failures and defects) and leading (process) measures to predict future performance in order to avoid incidents and failures. Condition monitoring is a form of proactive, predictive monitoring for physical assets. This can range in sophistication from periodic visual inspection to 'on-line' continuous monitoring. It is important to review the cost effectiveness of monitoring. In a production facility, it is also essential that monitoring programmes involve both operations and maintenance personnel, as many failure modes can be detected by operators.

Monitoring can generate large quantities of data, which will impact on an organisation's information systems. This is considered in Asset Information (see 6.4).

Figure 14 illustrates the principles of these different types of measures or indicators, and how they also contribute to continual improvement. The diagram applies to the monitoring of both assets and the elements of the asset management system (AMS), which is addressed in the next section.

6.6.6 Asset Management System Monitoring

As well as monitoring the performance of its assets, an organisation should monitor the performance of the AMS that supports them. The overall purpose of this monitoring is to enable the organisation to evaluate the extent to which it is delivering its asset management objectives and the effectiveness of the management system.

As for Asset Performance & Health Monitoring (see Figure 14) financial and non-financial performance measures are required at various levels of granularity to give insight on the current and potential future performance of the AMS. The measures, and their analysis and evaluation should be designed to identify whether the policies and processes of its AMS are being followed, and whether the outcomes of the processes are in line with the expected outcomes. At the highest level, summary information is presented to top management, with increasing levels of detail provided through the organisation appropriate to the decisions and issues that are being managed. Good practice requires clear accountabilities for both the reporting of measures and acting on them.

20. 'The Three Lines of Defense in Effective Risk Management and Control', Institute of Internal Auditors Position Paper, January 2013. https://na.theiia.org/training/templates/Pages/The-Three-Lines-of-Defense-in-Effective-Risk-Management-and-Control.aspx

Outcomes from the AMS monitoring identify changes in the organisation's risk profile or issues with its ability to achieve its objectives feed into to management review.

6.6.7 Management Review, Audit & Assurance

Many organisations have adopted an assurance model known as the 'Three Lines of Defence'[20]. In this model:

- the first line of defence is operational management, which is responsible for maintaining effective internal controls and executing risk and control processes on a day-to-day basis.
- the second line of defence comprises various risk management and compliance functions to help build and/or monitor the first line of defence controls, for example functions that monitor compliance with applicable laws and regulations. These are management functions that have a degree of independence from the first line of defence, and ensure that it is properly designed and operating as intended.
- the third line of defence is Internal Audit. This is independent of line management, to provide assurance on the effectiveness of governance, risk management and internal controls to the governing body and senior management. This covers all parts of the organisation and their activities, and includes the manner in which the first and second lines of defence achieve risk management and control objectives. It will include activities relevant to the organisation's asset management capability. An Internal Audit function would normally report into an independent audit committee.

In addition to this independent Internal Audit function, audit activities are also usually undertaken within the different parts of an organisation, as an activity within the 'second line of defence'. Organisations would typically have Health & Safety, Environmental, Quality and technical auditors who evaluate the level of compliance with technical standards, legislation and regulatory requirements. These audits would cover work done by the organisation's own staff and outsourced to suppliers.

Further information on good audit practice can be found in ISO 19011:2001 'Guidelines for auditing management systems'.

Determining whether an organisation's management system processes are in place and effective also utilises the activities with the subjects for Asset Performance & Health Monitoring (see 6.6.5), Asset Management System Monitoring (see 6.6.6), and Fault & Incident Investigation (see 6.3.10).

Management Review is a periodic review by an organisation's top management to ensure its AMS continues to be suitable, adequate and effective. It would consider a number of inputs, including:

- internal and external changes which impact on the organisation's asset management activities;
- asset and asset management performance; and
- changes in the profiles of asset management related risks and opportunities.

The review can result in changes or improvements being made to the AMS. The visibility of top management undertaking the review is a key part of demonstrating their commitment to asset management and its continual improvement.

6.6.8 Asset Costing & Valuation

This is concerned with how an organisation manages the financial information relating to its assets and asset management activities. This includes ensuring the quality and timeliness of financial information is appropriate for the financial reporting framework of the organisation.

Each organisation is typically governed by a set of accounting codes and practices according to the jurisdiction in which they operate. Like many standards, accounting codes are harmonising across countries and irrespective of the codes applied, there are common elements from an asset management perspective outlined as follows:

- Asset valuations - the method of valuation used by the organisation, its appropriateness and the accuracy with which the valuations have been developed including schedules & rates. It also includes the methods used to update this information and the alignment of asset valuations with the financial balance sheet of the organisation;
- Depreciation - the method used to establish the residual or effective lives of the individual assets and if necessary their components and the accuracy of the depreciation calculations;

- Operational costs - the method used by the organisation to assess the cost of operations of individual facilities and assets and the breakdown of these operational costs in terms of labour, energy, chemicals and plant & equipment;
- Maintenance costs - the method used by the organisation to assess maintenance costs (planned, predictive and unplanned) including the breakdown of these costs into labour, materials, plant and equipment;
- Renewal costs - the method used by the organisation to assess renewal costs in terms of the unit costs of individual renewal activities including the breakdown of these costs into labour, materials, plant and equipment;
- Renewal liabilities - the processes used to identify future capital expenditure renewal liabilities, including any backlog in maintenance; and
- Social, environmental, safety and reputational costs – the method used by the organisation to quantify social, environmental, safety and reputational costs in monetary terms.

Organisations that are demonstrating good practice in asset costing & valuation would typically be able to demonstrate the ability to:

- recognise and adopt appropriate valuation practices that may be driven by local regulatory or legislative regimes;
- value assets at all levels of the hierarchical asset register structure & update this valuation cost effectively in both value, unit rates and effective residual lives;
- understand the operational costs of individual assets and/facilities in terms of the above break up, together with special costs for smaller plant or equipment that may consume high power costs;
- identify the maintenance and renewal costs from the asset management information system or elsewhere for all levels of the hierarchy down to the chosen item;
- identify the organisation's future renewal programme, and the associated residual business risk exposure/s; and
- include social, environmental, safety and reputational costs and risks in asset management decision-making.

In addition to the information laid down in local Generally Accepted Accounting Principles (GAAP) and the International Financial Reporting Standards (IFRS), relevant information regarding the financial, technical and operational information relating to asset management activities should be made available to the relevant stakeholders. This is particularly important in the case of asset-intensive companies, where assets constitute a substantial portion of the total balance sheet value and annual expenditure. The comprehensibility, relevance, reliability and comparability of the financial statements will be improved by adding information on financial, technical and operational aspects of physical assets in the Annual Report. Organisations will need to consider whether the transparency requirements of ISO 55001 can be combined with the transparency requirements from other sources such as the applicable financial reporting framework (e.g. local GAAP, IFRS, US GAAP), legal and regulatory requirements, international applicable frameworks on internal control, risk management and/or corporate governance requirements.

6.6.9 Stakeholder Engagement

Understanding the requirements and expectations of stakeholders who can have an impact on an organisation's asset management activities is a critically important activity. Stakeholder engagement includes the activities of identifying, communicating and interacting with stakeholders. For some organisations this is becoming an increasingly formalised area of business, for example in some parts of the utilities sector where Regulators are setting expectations for consultation with stakeholder groups.

Organisations typically engage with their stakeholders to:

- establish which aspects of their activities matter most to them;
- understand their risk appetite; and
- understand their willingness to pay for products and services.

This is an important input to the strategic planning processes and developing the asset management strategy (SAMP) and asset management objectives. It can help the organisation to improve decision-making and accountability, and can be used to articulate different scenarios within an organisation's

asset management plan(s) to understand and reflect stakeholder priorities and select those scenarios that most closely meet their aspirations.

Stakeholders with an interest in an organisation's physical assets and asset management activities will typically include:

- customers, both strategic and non-strategic;
- top management;
- governments;
- local community and neighbours;
- owners;
- regulators;
- employees;
- labour organisations; and
- vendors / suppliers of equipment and materials.

Each stakeholder can have an impact on how an organisation performs. Influencing stakeholders can lead to positive outcomes; aligning goals, influencing legislation and regulation, shortening supply chains or improving products. Stakeholders themselves can also have adverse impacts on the organisation in many ways, including: introducing defective equipment (supply chain); withholding a license to operate or imposing improvement actions (regulators); affecting operations through industrial action (labour organisations); reducing the operating budget (finance providers); and reducing the demand for the product (customers).

The relationships with each external stakeholder reflect their interactions with the organisation. These interactions are measurable and can be used to monitor performance. The quality of these stakeholder relations determines how these stakeholders interact with an organisation and how well they support the asset management strategy (SAMP) and objectives. Effective external stakeholder engagement supports an organisation's ability to manage assets effectively, efficiently, and reliably. It may also be necessary to understand and manage conflicting expectations and requirements between groups of stakeholders.

By definition, many of these stakeholders are outside the direct control of an organisation. However, stakeholder engagement is influenced by what an organisation does internally to align the outcomes of these interactions with the organisation's strategic objectives. Organisations can change business processes, introduce and enforce policies and procedures, develop incentives to drive employee behaviour to align with a vision of how that organisation wants external stakeholders to perceive it. Measuring the delivery of this vision provides visibility and a drive to do business differently redefining how the organisation relates to its external stakeholders.

7 IAM Resources

The IAM has produced, and continues to develop, resources to support both individuals and organisations in their asset management journeys. Some of the main items are:

The Big Picture

This is a highly visual tool designed to start conversations about asset management within an organisation, and with customers, suppliers and wider stakeholders. It comprises a set of materials, including a short video that explains the structure and key points of Asset Management. The intention is not to provide a model or template for how to do asset management, but to capture what it feels like, depicting the cultural as well as the technical barriers. A number of Big Picture images illustrate this version of the Anatomy.
https://theiam.org/knowledge/Big-Picture

Subject Specific Guidance documents (SSGs)

These documents are designed to expand and enrich the content of the 39 Asset Management Landscape subjects summarised in this Anatomy document. The SSGs identify what should be considered when creating, maintaining and improving an asset management system in relation to that subject. Where appropriate SSGs also provide case study examples. *www.theIAM.org/SSG*

IAM Competences Framework

Asset management spans a wide range of disciplines. The precise mix of competences that people and organisations need depends on their objectives, the context and circumstances they are operating in. The Competences Framework: supports organisations with planning and developing the asset management capability they need to meet current and future needs; helps individuals plan their training and professional development and creates a firm base for designing training. *www.theIAM.org/CF*

SAM+ tool

The Self Assessment Methodology 'Plus' has been designed to help organisations assess their capabilities against the requirements of PAS 55 or ISO 55001 or the 39 Subjects. *www.theIAM.org/SAM*

Asset Management Maturity Scale and Guidance

This introduces the subject of asset management maturity and how it can be defined, scaled and recognised. It contains a generic maturity scale, ranging from 'Innocence' to 'Excellence', with the attributes and symptoms that could be expected for each of the 39 Subjects. *www.theIAM.org/Maturity*

IAM Handbook

Guidance for organisations starting their journey, on where to start, what to avoid and step-by-step 'how to' guides (in draft). This will support organisations that may not be ready for, or even interested in, external certification and/or compliance with ISO 55001.

8 References and Further Reading

Standards and Publicly Available Specifications

- **BS 8900-1:2013**, Managing sustainable development of organizations. Guide.
- **BS 8900-2:2013**, Managing sustainable development of organizations. Framework for assessment against BS 8900-1. Specification
- **BSI PAS 55:2008**, Asset Management - Part 1: Specification for the optimized management of physical assets
- **BSI PAS 1192-2:2013**, Specification for information management for the capital/delivery phase of construction projects using building information modelling
- **BSI PAS 1192-3:2014**, Specification for information management for the operational phase of assets using building information modelling
- **BSI PAS 1192-5:2015**, Specification for security-minded building information modelling, digital built environments and smart asset management
- **EIA-649-A 2004**, National Consensus Standard for Configuration Management
- **ISO 9000:2008**, Quality management systems – Fundamentals and vocabulary
- **ISO 9001:2008**, Quality management systems – Requirements
- **ISO 9004:2009**, Managing for the sustained success of an organization - A quality management approach
- **ISO 10007:2003**, Quality Management Systems – Configuration Management
- **ISO 14001:2004**, Environmental management systems – Requirements with guidance for use
- **ISO/IEC 15288:2015**, Systems and software engineering – System life cycle processes
- **ISO 17021:2011** Conformity assessment – Requirements for bodies providing audit and certification of management systems
- **ISO 17021-5** Conformity assessment – Requirements for bodies providing audit and certification of management systems – Part 5: Competence requirements for auditing and certification of asset management systems
- **ISO 19011:2011**, Guidelines for auditing management systems
- **ISO 21500:201**2, Guidance on project management
- **ISO 22301:2012**, Societal security - Business continuity management systems –Requirements
- **ISO 31000:2009**, Risk management – Principles and guidelines
- **ISO 31010:2009**, Risk management – Risk assessment techniques
- **ISO 37500:2014**, Guidance on outsourcing
- **ISO 55000:2014**, Asset management - Overview, principles and terminology
- **ISO 55001:2014**, Asset management - Management systems – Requirements
- **ISO 55002:2014**, Asset management - Management systems – Guidelines for the application of ISO 55001
- **ISO Guide 73:2009**, Risk management – Vocabulary

Global Forum

- **'The Asset Management Landscape'**, Second Edition, Global Forum On Maintenance & Asset Management. ISBN 978-0-9871799-2-0, Published March 2014.
  http://www.gfmam.org/files/ISBN978_0_9871799_2_0_GFMAMLandscape_SecondEdition_English.pdf
- **'GFMAM Competency Specification for an ISO 55001 Asset Management System Auditor/Assessor'**, First Edition, Version 2, ISBN 978-0-9871799-5-1
  http://www.gfmam.org/files/
  ISBN978_0_9871799_5_1_GFMAM_ISO55001_Auditor_Assessor_Specification_Edition_1_v2_English.pdf

Other publications

- **Asset Management Body of Knowledge (AMBoK)**, Asset Management Council (Australia)
  http://www.amcouncil.com.au/knowledge/publications/ambok-publications.html
  - Publication 000: Framework for Asset Management, Second Edition
  - Publication 001: Companion Guide to ISO 55001
- **Asset Management Decision-Making: The SALVO Process**, by John Woodhouse (Editor), ISBN: 0956393470
- **Asset Management: Whole-life Management of Physical Assets**, by Chris Lloyd, ISBN: 9780727736536
- **Association for project management, Body of Knowledge**, 6th Edition. ISBN: 978-1-903494-40-0
  https://www.apm.org.uk/BOK6
- **Guidelines for the Management of Change for Process Safety**, CCPS (Center for Chemical Process Safety) ISBN: 978-0-470-04309-7
- **International Case Studies in Asset Management**, by Chris Lloyd, ISBN: 0000727757393
- **International Infrastructure Management Manual**, 5th Edition 2015, produced by New Zealand Asset Management Support (NAMS) and the Institute of Public Works Engineering Australia (IPWEA)
  http://www.nams.org.nz/pages/6/manuals---guidelines.htm
  http://www.ipwea.org/publications/bookshop/ipweabookshop/iimm
- **'Living Asset Management'**, by J.R. Lafraia, John Hardwick, Madeleine Berenyi, Deryk Anderson, 2013. ISBN: 9781922107251
- **Strategic Asset Management: The Quest for Utility Excellence**, by Clive Deadman, ISBN: 9781848763661
- **The New Asset Management Handbook**, Reliability Web, Ft Myers, 2014, ISBN 978-1-939740-51-9
- **'Understanding Michael Porter: The Essential Guide to Competition and Strategy'**, Joan Magretta, ISBN: 9781422160596
- **'The Three Lines of Defense in Effective Risk Management and Control'**, The Institute of Internal Auditors Position Paper, January 2013.
  https://na.theiia.org/training/templates/Pages/The-Three-Lines-of-Defense-in-Effective-Risk-Management-and-Control.aspx

9 Glossary

This Glossary does not include all terms used within the Anatomy. Some terms are explained in the body of the text.

ISO 55000 contains definitions for some terms relating to asset management. A number of these are included in this Glossary, as the definitions and their associated notes aid understanding (where more clarification is provided than within the Anatomy).

Where text within a definition is in bold, this identifies that the term is defined elsewhere in the Glossary.

asset	Item, thing or entity that has potential or actual value to an **organization**. Notes: *(1) Value can be tangible or intangible, financial or non-financial, and includes consideration of **risks** and liabilities. It can be positive or negative at different stages of the **asset life**.* *(2) Physical assets usually refer to equipment, inventory and properties owned by the organization. Physical assets are the opposite of intangible assets, which are non-physical assets such as leases, brands, digital assets, use rights, licences, intellectual property rights, reputation or agreements.* *(3) A grouping of assets referred to as an **asset system** could also be considered as an asset.*	ISO 55000:2014 (3.2.1)
asset life	period from **asset** creation to asset end-of-life	ISO 55000:2014 (3.2.2)
asset management	Coordinated activity of an **organization** to realize value from **assets**. Notes: *1. Realization of value will normally involve a balancing of costs, **risks**, opportunities and **performance** benefits.* *2. Activity can also refer to the application of the elements of the **asset management system**.* *3. The term "activity" has a broad meaning and can include, for example, the approach, the planning, the plans and their implementation.*	ISO 55000:2014 (3.3.1)
asset management plan	Documented information that specifies the activities, resources and timescales required for an individual asset, or a grouping of assets, to achieve the **organization's** asset management **objectives**. Notes: *(1) The grouping of assets may be by **asset type**, asset class, **asset system** or **asset portfolio**.* *(2) An asset management plan is derived from the **strategic asset management plan**.* *(3) An asset management plan may be contained in, or may be a subsidiary plan of, the **strategic asset management plan.***	ISO 55000:2014 (3.3.3)
asset management system	**Management system** for **asset management** whose function is to establish the **asset management policy** and asset management **objectives.** *Note: The asset management system is a subset of asset management.*	ISO 55000:2014 (3.4.3)

asset management strategy (also refer to definition for the SAMP)	long-term optimized approach to management of the assets, derived from, and consistent with, the organizational strategic plan and the asset management policy Notes: (1) The asset management strategy converts the objectives of the organizational strategic plan and the asset management policy into a high-level, long-term action plan for the assets and/or asset system(s), the asset portfolios and/or the asset management system. (2) The high-level, long-term action plans for the assets and the asset management objectives are normally the outputs of the asset management strategy. These elements together form the basis for developing more specific and detailed asset management plan(s).	PAS 55-1:2008 (3.9)
asset portfolio	**Assets** that are within the scope of the **asset management system.** Notes: (1) A portfolio is typically established and assigned for managerial control purposes. Portfolios for physical hardware might be defined by category (e.g. plant, equipment, tools, land). Software portfolios might be defined by software publisher, or by platform (e.g. PC, server, mainframe). (2) An asset management system can encompass multiple asset portfolios. Where multiple asset portfolios and asset management systems are employed, **asset management** activities should be coordinated between the portfolios and systems.	ISO 55000:2014 (3.2.5)
asset system	Set of **assets** that interact or are interrelated.	ISO 55000:2014 (3.2.6)
asset type	grouping of **assets** having common characteristics that distinguish those assets as a group or class *EXAMPLE Physical assets, information assets, intangible assets, **critical assets**, enabling assets, linear assets, information and communications technology (ICT) assets, infrastructure assets, moveable assets.*	ISO 55000:2014 (3.2.7)
capability	<asset management> measure of capacity and the ability of an entity (system, person or **organization**) to achieve its **objectives** *Note:* ***Asset management** capabilities include processes, resources, **competences** and technologies to enable the effective and efficient development and delivery of **asset management plans** and **asset life** activities, and their continual improvement.*	ISO 55000:2014 (3.1.2)
competence	ability to apply knowledge and skills to achieve intended results	ISO 55000:2014 (3.1.3)
critical asset	**asset** having potential to significantly impact on the achievement of the **organization**'s **objectives** *Notes:* *(1) Assets can be safety-critical, environment-critical or performance-critical and can relate to legal, regulatory or statutory requirements.* *(2) Critical assets can refer to those assets necessary to provide services to critical customers.* *(3) **Asset systems** can be distinguished as being critical in a similar manner to individual assets.*	ISO 55000:2014 (3.2.8)
effectiveness	extent to which planned activities are realized and planned results achieved	ISO 55000:2014 (3.1.7)
FMEA	Failure Mode and Effects Analysis – A step-by-step approach for identifying potential failures of an asset, or process, and analysing the consequences of the failures.	ISO 55000:2014 (3.2.6)

GAAP	Generally Accepted Accounting Principles. A set of rules, conventions, standards, and procedures for reporting financial information, as established by the US Financial Accounting Standards Board (FASB).	
IFRS	International Financial Reporting Standards. Guidelines and rules set by the International Accounting Standards Board (IASB) that companies and organizations can follow when compiling financial statements. The creation of international standards allows investors, organizations and governments to compare the IFRS-supported financial statements. All listed EU companies have been required to use IFRS since 2005.	http://www.ifrs.org
incident	unplanned event or occurrence resulting in damage or other loss	ISO 55000:2014 (3.1.8)
level of service	parameters, or combination of parameters, which reflect social, political, environmental and economic outcomes that the **organization** delivers *Note:* *The parameters can include safety, customer satisfaction, quality, quantity, capacity, reliability, responsiveness, environmental acceptability, cost and availability.*	ISO 55000:2014 (3.3.6)
management system	set of interrelated or interacting elements of an **organization** to establish **policies** and **objectives** and processes to achieve those objectives *Notes:* *(1) A management system can address a single discipline or several disciplines.* *(2) The system elements include the organization's structure, roles and responsibilities, planning, operation, etc.* *(3)The scope of a management system may include the whole of the organization, specific and identified functions of the organization, specific and identified sections of the organization, or one or more functions across a group of organizations.*	ISO 55000:2014 (3.4.2)
monitoring	determining the status of a system, a process or an activity Notes: *(1) To determine the status, there may be a need to check, supervise or critically observe.* *(2) For the purposes of asset management, monitoring may also refer to determining the status of an asset. This is typically referred to as "condition monitoring" or "performance monitoring".*	ISO 55000:2014 (3.1.9)
objective	Result to be achieved. *Notes:* *(1) An objective can be strategic, tactical or operational.* *(2) Objectives can relate to different disciplines (such as financial, health and safety, and environmental goals) and can apply at different levels (such as strategic, organization-wide, project, product and process).* *(3) An objective can be expressed in other ways, eg as an intended outcome, a purpose, an operational criterion, an asset management objective or by the use of other words with similar meaning (e.g. aim, goal, or target).* *(4) In the context of **asset management systems**, asset management objectives are set by the **organization**, consistent with the **organizational objectives** and asset management **policy**, to achieve specific measurable results.*	ISO 55000:2014 (3.1.12)

optimize	Achieve by a quantitative or qualitative method, as appropriate, the best value compromise between conflicting factors such as performance, costs and retained risk within any non-negotiable constraints.	PAS 55-1:2008 (3.23)
organizational (strategic) plan	documented information that specifies the programmes to achieve the organizational objectives *Notes:* *(1) ISO 55000 uses the term **organizational plan*** *(2) PAS 55 uses the term organizational strategic plan (OSP).* *(3) The terms mean the same. This term OSP is used in places in the Anatomy and other documentation produced by the IAM.*	ISO 55000:2014 (3.1.15)
organizational objective	overarching **objective** that sets the context and direction for an **organization's** activities *Note:* *Organizational objectives are established through the strategic level planning activities of the organization.*	ISO 55000:2014 (3.1.14)
outsource	make an arrangement where an external **organization** performs part of an organization's function or process *Note:* *An external organization is outside the scope of the **management system**, although the outsourced function or process is within the scope if its activities influence the effectiveness of the **asset management system**.*	ISO 55000:2014 (3.1.16)
performance	measureable result *Notes:* *(1) Performance can relate either to quantitative or qualitative findings.* *(2) Performance can relate to the management of activities, processes, products (including services), systems or **organizations**.* *(3) For the purposes of **asset management**, performance can relate to **assets** in their ability to fulfil requirements or **objectives**.*	ISO 55000:2014 (3.1.17)
policy	intentions and direction of an **organization** as formally expressed by its top management	ISO 55000:2014 (3.1.18)
process safety	Process Safety is a blend of engineering and management skills focused on preventing catastrophic accidents, particularly explosions, fires, and toxic releases, associated with the use of chemicals and petroleum products.	Centre for Chemical Process Safety (American Institute of Chemical Engineers)
project	*There are 2 commonly used definitions for a project:* Unique process consisting of a set of co-ordinated and controlled activities with start and finish dates, undertaken to achieve an objective conforming to specific requirements, including constraints of time, cost and resources.	ISO 10006:2003 (3.5)
	A temporary endeavour undertaken to create a unique product or service.	Project Management Institute (PM Body of Knowledge, Section 1.2)
Property, Plant and Equipment	According to International Accounting Standard 16 (IAS16), "Property, Plant and Equipment" comprise tangible assets held by an entity for use in the production or supply of goods or services, for rental to others, of for administrative purposes that are expected to be used for more than one period. Depending on the applicable financial reporting framework, another definition of "Property, Plant and Equipment" might be appropriate.	International Accounting Standard 16 (IAS16)

risk	Effect of uncertainty on **objectives**. *Notes:* *(1) An effect is a deviation from the expected – positive and/or negative.* *(2) Objectives can relate to different disciplines (such as financial, health and safety, and environmental goals) and can apply at different levels (such as strategic, organization-wide, project, product and process).* *(3) Risk is often characterized by reference to potential "events" (as defined in ISO Guide 73:2009, 3.5.1.3) and "consequences" (as defined in ISO Guide 73:2009, 3.6.1.3), or a combination of these.* *(4) Risk is often expressed in terms of a combination of the consequences of an event (including changes in circumstances) and the associated "likelihood" (ISO Guide 73:2009, 3.6.1.1) of occurrence.* *(5) Uncertainty is the state, even partial, of deficiency of information related to, understanding or knowledge of, an event, its consequence, or likelihood.*	ISO Guide 73:2009 (1.1)
stakeholder	person or organization that can affect, be affected by, or perceive themselves to be affected by a decision or activity *Note:* *A "stakeholder" can also be referred to as an "interested party".*	ISO 55000:2014 (3.1.22)
strategic asset management plan (SAMP) (also refer to definition for asset management strategy)	documented information that specifies how **organizational objectives** are to be converted into **asset management objectives**, the approach for developing **asset management plans**, and the role of the **asset management system** in supporting achievement of the asset management objectives Notes: (1) A strategic asset management plan is derived from the ***organizational (strategic) plan***. (2) A strategic asset management plan may be contained in, or may be a subsidiary plan of, the organizational plan.	ISO 55000:2014 (3.3.2)
Sustainable	Achieving or retaining an optimum compromise between performance, costs and risks over the Life Cycle, whilst avoiding adverse long-term impacts to the organization from short-term decisions.	PAS 55-1:2008 (3.32)
value chain	*"a set of activities that an organization carries out to create value for its customers"*	Porter, Michael E., *"Competitive Advantage: Creating and Sustaining Superior Performance"*. 1985

10 Appendix A

How the 39 Subjects map to the clauses of ISO 55001:2014

Subject Group	Subject Title	Ref	ISO 55001:2014	
Strategy & Planning	Asset Management Policy	1	4 Context of the Organisation	4.1 Understanding the organization and its context
Strategy & Planning	Asset Management Strategy & Objectives	2		4.2 Understanding the needs and expectations of stakeholders
Strategy & Planning	Demand Analysis	3		4.3 Determining the scope of the asset management system
Strategy & Planning	Strategic Planning	4		4.4 Asset management system
Strategy & Planning	Asset Management Planning	5	5 Leadership	5.1 Leadership and commitment
Asset Management Decision Making	Capital Investment Decision-Making	6		5.2 Policy
Asset Management Decision Making	Operations & Maintenance Decision-Making	7		5.3 Organizational roles, responsibilities and authorities
Asset Management Decision Making	Lifecycle Value Realisation	8	6 Planning	6.1 Actions to address risks and opportunities for the AM system
Asset Management Decision Making	Resourcing Strategy	9		6.2.1 Asset management objectives
Asset Management Decision Making	Shutdowns & Outage Strategy	10		6.2.2 Planning to achieve asset management objectives
Lifecycle Delivery	Technical Standards & Legislation	11	7 Support	7.1 Resources
Lifecycle Delivery	Asset Creation & Acquisition	12		7.2 Competence
Lifecycle Delivery	Systems Engineering	13		7.3 Awareness
Lifecycle Delivery	Configuration Management	14		7.4 Communication
Lifecycle Delivery	Maintenance Delivery	15		7.5 Information requirements
Lifecycle Delivery	Reliability Engineering	16		7.6 Documented information
Lifecycle Delivery	Asset Operations	17	8 Operation	8.1 Operational planning and control
Lifecycle Delivery	Resource Management	18		8.2 Management of change
Lifecycle Delivery	Shutdown & Outage Management	19		8.3 Outsourcing
Lifecycle Delivery	Fault & Incident Response	20	9 Performance Evaluation	9.1 Monitoring, measurement, analysis and evaluation
Lifecycle Delivery	Asset Decommissioning and Disposal	21		9.2 Internal audit
Asset Information	Asset Information Strategy	22		9.3 Management review
Asset Information	Asset Information Standards	23	10 Improvement	10.1 Nonconformity and corrective action
Asset Information	Asset Information Systems	24		10.2 Preventive action
Asset Information	Data & Information Management	25		10.3 Continual Improvement
Organisation & People	Procurement & Supply Chain Management	26		
Organisation & People	Asset Management Leadership	27		
Organisation & People	Organisational Structure	28		
Organisation & People	Organisational Culture	29		
Organisation & People	Competence Management	30		
Risk & Review	Risk Assessment and Management	31		
Risk & Review	Contingency Planning & Resilience Analysis	32		
Risk & Review	Sustainable Development	33		
Risk & Review	Management of Change	34		
Risk & Review	Asset Performance & Health Monitoring	35		
Risk & Review	Asset Management System Monitoring	36		
Risk & Review	Management Review, Audit & Assurance	37		
Risk & Review	Asset Costing & Valuation	38		
Risk & Review	Stakeholder Engagement	39		

The Institute of Asset Management

The IAM is both a Professional Association and a Learned Society: we are dedicated to extending and developing the discipline and knowledge base as well as encouraging, enabling and recognising personal knowledge, capability and high standards of practice.

The Vision of the Institute is: **"To be recognised as the leading, international, professional body for asset management".**

The following key priorities are defined as 'enduring' and they are will not be varied except during formal strategic reviews, whereas the Objectives, Goals, Budget and Work Plans for each year are developed annually:

1) Collect / Collate / Disseminate existing knowledge and good practice
2) Generate and extend knowledge and good practices
3) Influence public policy and stakeholder expectations
4) Promote capability and excellence in asset owning organisations or their suppliers and structured schemes for recognising these achievements
5) Promote knowledge and competence of individuals and structured schemes for recognising these achievements
6) Deliver Member publications, engagement and networking opportunities and other valuable Member Services
7) Raise profile and respect for IAM and the profession
8) Collaborate with and support other bodies having similar objectives
9) Develop and maintain an appropriate and sustainable organisation

In pursuing these aims we will be led by our key behaviours: include and collaborate, seek convergence of the discipline, celebrate good practice wherever it is found, inspire the adoption of asset management. *www.theIAM.org/Strategy*

One of the IAM's key activities is to promote engagement and interaction of its members so that they learn from events, publications, training and discussion as well as formal professional development. Members can direct their own learning as suits their needs and to that end, the IAM is creating appropriate resources to support them.

Contributors

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- Aled Williams, AW Asset Management Ltd
- Tom Smith, University of Wisconsin-Madison
- Donald Miller, Scottish Power
- Mike Dixon, Mike Dixon Ltd
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- Peter Jay, The Woodhouse Partnership Ltd
- Trevor Taylor, Arup
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