The Institute of Asset Management

Strategy and Planning

Asset Management Decision-Making

Life Cycle Delivery

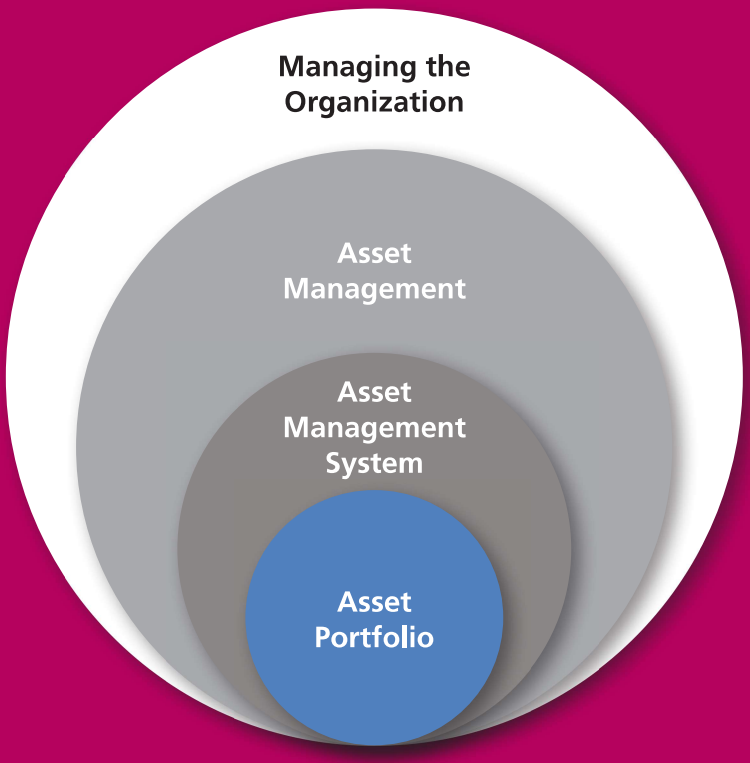
Systems Engineering

Asset Information

Organization & People

Risk & Review

Version 1 January 2024



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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 organizations 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.

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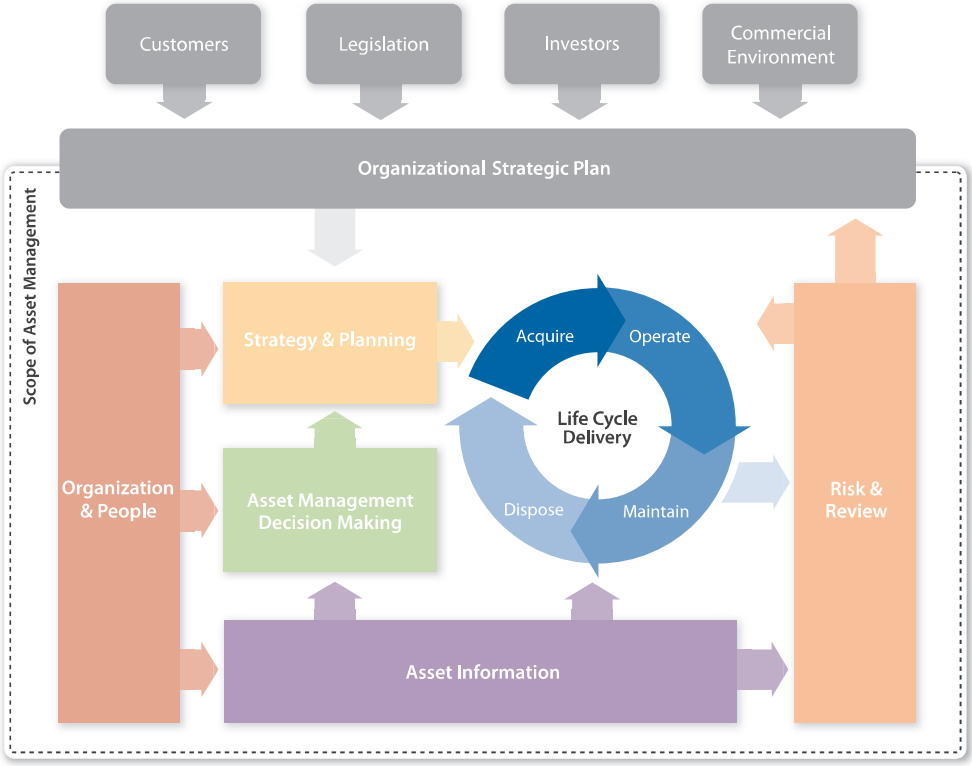
Authoring:

- Tim Ingram (SSG Lead) – Atkins
- Mike Brownsword – Realistic EA
- JD Solomon – JD Solomon Inc.
- Mike Niblett – Zupbadura
- Rob Gabrielczyk – Aeon Engineering
- Dan Wilson – Electricity North West
- Adam Wood – Teledyne e2v
- David McNaught – Frazer-Nash Consultancy
- Gareth Willoughby – Atkins
- Robert English – MMI Thornton Tomasetti

Reviewing:

- Grame Hind – AMCL
- Ben Mogridge – Ministry of Defence
- Steve Little – TetraTech

The Scope of Asset Management



Group 1

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

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7. Operations & Maintenance Decision-Making
8. Life Cycle Value Realization
9. Resourcing Strategy
10. Shutdowns & Outage Strategy

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2.1 Purpose of the SSGs

This Subject Specific Guidance (SSG) is part of a suite of documents designed to expand and enrich the description of the Asset Management discipline as summarized in the IAM's document 'Asset Management – an Anatomy' (referred to throughout this document as 'The Anatomy'). This document provides guidance for good Asset Management. Specific SSG documents aim to explain the 39 subject areas identified in "The Anatomy".

In 2014 the International Standards Organization published the BSI ISO55000 series Asset Management, that sets out the requirements for the auditing of effective Asset Management. ISO55001 describes how competence in Asset Management can be assessed, however it does not offer advice on how it should be done. The standard should therefore be read as a means of assessing how close to effective Asset Management an organization is. The standard is not prescriptive. It is intended to help organizations by providing a consolidated view of good practice, drawn from experienced practitioners across many sectors and many counties that organizations can assess themselves against.

The SSGs are intended to develop the next level of detail for each subject in the Anatomy and may include details such as: -

- Roles and responsibilities of people
- Process flow
- Information management
- Current challenges and how to avoid them
- Examples of good industry practice
- Success factors and how to achieve them
- Suitable benchmarks

The SSGs include simple as well as complex solutions, together with real-life examples from different industries to support the explanatory text because it is understood that industries and organizations differ in scale, sophistication and ability and desire to accept enabling new technologies. In addition, these industries are at different stages of Asset Management; some may be relatively mature while others are at the beginning of the journey and accordingly, there is flexibility for each organization to adopt their own 'fit for purpose' alternative practical approaches and solutions that are economic, viable, understandable, and usable. The underlying requirement for continual improvement should drive progress and the desire to create value through defined improvements.

2.2 The SSGs in Context

The SSGs are a core element within the IAM Body of Knowledge, and they have been peer reviewed and assessed by the IAM Expert Panel. They align fully with the IAM's values and beliefs that relate to both the development of excellence in the Asset Management discipline, and provision of support to those who seek to achieve that level of excellence.

2.3 Assessing Asset Management Capability

Maturity models exist for many different functions and disciplines and they provide an approach for organizations to identify gaps in performance versus best practices, and benchmarks in a structured way to define priorities for improvement that will deliver value, assess capabilities and create a roadmap for improving them. A maturity model is a set of characteristics, attributes, indicators, or patterns that represent progression and achievement in a particular domain or discipline. The artifacts that make up the model are typically agreed upon by the domain or discipline and are validated through application and iterative recalibration.

A maturity model allows an organization or industry to have its practices, processes, and methods evaluated against a clear set of artifacts that establish a benchmark. These artifacts typically represent best practice and may incorporate standards or other codes of practice that are important in a particular domain or discipline. While this SSG is not a maturity model it does borrow some of these concepts and presents a set of tools and techniques to be considered.

The IAM has produced an ISO55000 Self-Assessment Methodology (SAM+) which contains a series of

questions to explore the maturity of an organization's Asset Management capability across all the elements of ISO55001:2014, and enables organizations to undertake a self-assessment and 'gap analyses' of their current Asset Management practices, and it is available as a download for members of the IAM.

2.4 SSGs and the Issue of Complexity Versus Maturity

It is important to understand and contrast the terms complexity and maturity and how they impact an organization looking to improve its Asset Management capability, specifically within the area covered by this SSG. When reading the SSG, the reader should have a view of the complexity and maturity of the organization, the business context and interpret the guidance that is offered in that context.

- The complexity of the business will drive the complexity of the solution required.
- The maturity of the organization will determine its ability to recognize and implement an appropriate solution and an understanding of best practices, and recognize vendors in the marketplace that can help accelerate improvements.

A very mature organization may choose a simple solution where a less mature organization may incorrectly perceive that a complex solution will solve all its problems. In truth, there is no universal best practice in Asset Management – only good practice that is appropriate for the operating context of any organization. What is good practice for one organization may not be good practice for another.

For example, an organization that is managing a small scope of maintenance or capital work may choose to manage work through an Excel-based tool or similar, whereas an organization with a large content of planned work and high level of resources may choose to leverage more complex planning and scheduling tools or technology to track resources. A significant influence will also be the business context, i.e., an organization where the daily costs of outages are significant will be more focused on schedule adherence than the cost of resources to deliver.

2.5 Further Reading

The Anatomy provides a starting point for development and understanding of Asset Management capability and the SSGs follow on to support that further. However, the opportunity doesn't end there; the IAM provides a range of expert and general opinion and knowledge which is easily accessed by members through the IAM website.

In addition to this, the authors of this SSG identify the following references that can provide useful insight and help you on the journey of understanding Systems Engineering:

- ISO/IEC/IEEE 15288:2015, Systems and software engineering - System life cycle processes;
- Systems engineering body of knowledge - The principles of Systems Engineering are underpinned by systems engineering standards and knowledge through ISO15288 and the Systems Engineering Body of Knowledge (https://www.sebokwiki.org/wiki/Guide_to_the_Systems_Engineering_Body_of_Knowledge_(SEBoK));
- INCOSE Systems Engineering Handbook;
- INCOSE UK Don't Panic! Series:
  - The Absolute Beginner's Guide to Managing Interfaces;
  - The Absolute Beginner's Guide to Architecture Framework;
  - The Absolute Beginner's Guide to Architecture and Architecting.
- INCOSE Z-guides (http://www.incoseonline.org.uk/Program_Files/Publications/zGuides.aspx):
  - Z1: What is Systems Engineering? (Issue 3.0);
  - Z2: Enabling Systems Engineering (Issue 2.0);
  - Z3: How Systems Engineering Can Save your Business Money (Issue 4.0);
  - Z4: SSM - Soft Systems Methodology (Issue 2.0);
  - Z5: Lean Systems Engineering (Issue 1.0);
  - Z6: Systems Engineering Competency Framework ;
  - Z7: What is Systems Thinking?;
  - Z8: System Architecture;
  - Z9: What is Model Based Systems Engineering;
  - Z11: Project Management and Systems Engineering (Issue 1.1);

  - Z12: Human Factors for System Engineers;
  - Z13: Systems Engineering and Project Management - Top Ten Tips;
  - Z14: An introduction to systems approaches for SMEs (Issue 1).
- EN50126 [5], Within its title as per IAM Anatomy, RAMS has been defined as 'The specification and demonstration of reliability, availability, maintainability and safety (RAMS), basic requirements and generic process';
- ISO55000 Series, specifically ISO55002:2018; Asset management - Management systems - Guidelines for the application of ISO55001;
- ISO 31000:2018, Risk management – Guidelines;
- S3000L: International procedure specification for Logistic Support Analysis (LSA);
- BS EN 60300-1:2014 Dependability management. Guidance for management and application;
- BS EN 50126-1:2017 Railway Applications. The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS). Generic RAMS Process.

3 Scope of this SSG

3.1 Intended Use and Audience

ISO5500x[1] is the formal specification and standard for the implementation of an Asset Management System, setting out the minimal requirements an organization would need to meet to gain accreditation to that specification or standard. For any organization or individual wanting to master the discipline, knowledge of ISO5500x is not the whole picture. As well as the standard and management system aspects, they need to understand the full breadth and depth of the component parts that make up the landscape of asset management and this is supported through the SSGs.

Standards could therefore be regarded as 'what' is required for an Asset Management System. This SSG, as one of many being developed by the IAM, supports the 'how' to deliver the component parts and in its development has tried to cover the range of industry sectors currently associated with the IAM and recognize that differences in levels of maturity and operating contexts exist within those sectors and the organizations within them. To provide additional context, this SSG includes case study examples from different sectors to demonstrate the key points of guidance. However, any document generic enough to be applied to multiple industry sectors must be at a relatively high level of detail.

The Asset Management Anatomy (see Figure 1 below) has been built around 6 Subject Groups and 39 subjects and now provides a stable platform on which the IAM can develop SSGs. These six subject groups and 39 subjects are also aligned with The Asset Management Landscape[2] (published by The Global Forum on Maintenance and Asset Management) to facilitate the exchange and alignment of maintenance and Asset Management knowledge and practices.

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Figure 1: Requirements for Good Asset Management Practices

1. The term ISO5500x is used generically in this document to refer to the family of standards comprised on ISO55000, 55001, and 55002 unless specific reference is made to a section within one of those standards
2. Second Edition, March 2014

This SSG specifically pertains to Systems Engineering, which can be used to complement and provide significant benefits to each of the other Asset Management Subject Groups. It will become part of a full series of SSGs covering all 39 Subjects and a smaller series of Sector Specific Guidelines (where these are desired by a particular sector). These are not designed as textbooks or course material but as reference documents for professionals working in or requiring guidance in this field. We would expect everybody involved in Asset Management to have a working knowledge of the 39 Subjects, but the degree to which they might need deep, or specialist knowledge will depend on the job or task they perform.

Systems Engineering has a broad scope, with multiple interpretations across multiple sectors. The SSG has been authored assuming that the reader will look for better ways to manage the requirements associated with new, conceptual or existing assets. The group developing this SSG considers life cycle as a central component of this document, for this reason, this SSG focuses on all phases of the asset life cycle.

An organization will always spend more time and money if they don't have the right assets in the first place. Thus, the initial stages in the life cycle are important, especially the definition of the requirements the chosen asset must satisfy to select the right solution. As can be seen in the IAM's Anatomy (Figure 1 above) the life cycle delivery subject group can be broken down into several individual subject areas, Systems Engineering is a discipline which can be applied to all stages in an asset's life cycle as displayed below.

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.

In applying this SSG, the reader is requested to have an open mind on the applications of Systems Engineering techniques and tool sets and how they can be used to help create and manage assets better, ensuring improved performance, reliability, and maintainability. Many of these tool sets are applicable throughout the entire life cycle, whereas others may be more suitable for specific situations. For example, it is best practice to capture and categorize smart requirements at the start of a project, however when they are used to formulate a requirements management plan, they must be reviewed and evaluated throughout the asset's life.

3.2 Aligning this Document

This SSG will illustrate how Systems Engineering complements the rest of the Asset Management life cycle and the six fundamental subject groups. All organizations have assets, which based on ISO55000 can be defined as:

> *An asset is an item, thing or entity that has potential or actual value to an organization. The value will vary between different organizations and their stakeholders, and can be tangible or intangible, financial or non-financial.*

Systems Engineering can be used to provide auditable line-of-sight from the corporate and organizational goals to the Asset Management decisions. It can also be used to structure and frame the requirements of the tangible and non-tangible assets to foster innovation, and effective delivery without over commitment.

In the context of Asset Management, Systems Engineering includes topics such as Requirements Management and Reliability Availability Maintainability Safety (RAMS). Figure 1 identifies the interactions between the subject groups discussed within this SSG (highlighted in sections 5-10) and other topic areas and how this SSG relates. The summary conclusions of these are provided in Section 12 of this document.

3.3 Navigating and Using this Document

This SSG has been developed to align to the Asset Management Subject Groups as described within the Anatomy. The following diagram summarizes the structure and context.

Figure 2: SSG structure

4 What does 'Systems Engineering' mean?

4.1 Definition of Systems Engineering

Systems Engineering considers the need for delivering the right solution, at the right time. The following definition for Systems Engineering was extracted from the INCOSE Z1 guide [12]:

"Systems Engineering is a transdisciplinary and integrative approach to enable the successful realization, use, and retirement of engineered systems, using systems principles and concepts, and scientific, technological, and management methods.

We use the terms "engineering" and "engineered" in their widest sense: "the action of working artfully to bring something about". "Engineered systems" may be composed of any or all of people, products, services, information, processes, and natural elements."

Reference: https://www.incose.org/systems-engineering

Systems Engineering can be applied to any systems/assets and is typically applied during the acquisition phase, but is equally applicable in operational and decommissioning life cycle phases. Systems in question can range from individual components within a machine, to a complete facility or even an organization. This breadth is increased within the definition of Systems Engineering within the Asset Management community as it includes topics such as Requirements Management, alongside Reliability, Availability, Maintainability and Safety (RAMS) which are generally managed through different disciplines and techniques. However, they complement each other implicitly as they provide overarching assurance and governance that a solution is (or is going to) meet the end user's needs throughout its life, delivering Operational Performance, Availability and Safe operations.

This SSG will articulate how specific tools and techniques can support an Asset Management System. For example, requirements management principles can be used to support the development of corporate objectives and how they are linked to strategy and planning. This SSG will address some of the more complex issues of interaction across an organization, but also the simpler topics of

terminology and definition of "systems", which can be lost in translation and lead to misunderstanding and failure to deliver.

4.2 Benefits Of Systems Engineering

Due to the broad nature of how Systems Engineering can be deployed and how it can add value, this SSG has been structured to walk through the subject groups of Asset Management and explain how Systems Engineering Principles could add value. Table 1 highlights how elements of Systems Engineering can complement and support Asset Management practices.

Table 1: How Systems Engineering can support Asset Management objectives

The benefits of Asset Management can include, but are not limited to the following:	How Systems Engineering can complement Asset Management Objectives
a) improved financial performance: improving the return on investments and reducing costs can be achieved while preserving asset value and without sacrificing the short or long-term realization of organizational objectives;	A clear line of sight, clear definition of need, not nice-to-haves, or a leap straight to solutions
b) informed asset investment decisions: enabling the organization to improve its decision making and effectively balance costs, risks, opportunities and performance;	Frame the requirements to remove nice-to-haves and structure the requirements in such a way to foster a platform for cost-effective innovative solutions
c) managed risk: reducing financial losses, improving health and safety, good will and reputation, minimizing environmental and social impact, can result in reduced liabilities such as insurance premiums, fines and penalties;	Clear identification of risk within the related requirements, framing of requirements as above
d) improved services and outputs: assuring the performance of assets can lead to improved services or products that consistently meet or exceed the expectations of customers and stakeholders;	Clear linkage from stakeholders' needs to organizational objectives and facility function Supports initiatives such as product line engineering
e) demonstrated social responsibility: improving the organization's ability to, for example, reduce emissions, conserve resources and adapt to climate change, enables it to demonstrate socially responsible and ethical business practices and stewardship;	A fundamental element of Systems Engineering is enabling the identification and consideration of ALL relevant stakeholders' requirements in the widest sense. This includes society and the environment, where applicable, as these are all part of the system. Effective identification of needs can also provide a platform for innovation that can develop opportunities that can satisfy the needs in a potentially unconventional manner.
f) demonstrated compliance: transparently conforming with legal, statutory and regulatory requirements, as well as adhering to Asset Management standards, policies and processes, can enable demonstration of compliance;	Tool and techniques that provide clear line of sight that can be robustly audited, as well as interrogated by all staff.

Table 1: How Systems Engineering can support Asset Management objectives contd.

The benefits of Asset Management can include, but are not limited to the following:	How Systems Engineering can complement Asset Management Objectives
g) enhanced reputation through improved customer satisfaction, stakeholder awareness and confidence;	Increased assurance in program delivery and line of sight back to organizational need. Provides clarity over "Are we building / maintaining the right system?" vs. "Are we building / maintaining the system right?"
h) improved organizational sustainability: effectively managing short and long-term effects, expenditures and performance can improve the sustainability of operations and the organization;	Indirectly, this will be delivered through improved program delivery
i) improved efficiency and effectiveness: reviewing and improving processes, procedures and asset performance can improve efficiency and effectiveness, and the achievement of organizational objectives.	Optimized operational performance is delivered through clear process delivery and line of sight to organizational needs.

4.3 SSG Approach to Systems Engineering

As mentioned in the previous section, Systems Engineering tool sets can be useful for identifying and formulating solutions that benefit the entire system throughout its life cycle. Depending on the properties of a system, including its size, application, and its status (conceptual/in-service/decommissioned), the approaches will vary. This SSG will cover various options or types of implementation through the key principles of Systems Engineering for the benefit of an organization and its assets. The following three themes (or concepts) highlight different complementary approaches to utilize Systems Engineering tool sets to benefit Asset Management practices:

- **Theme A – Systems Thinking** - applies the principles of requirements, systems architecture and contextual thinking, often at a whole program or business level, to assure that the problem to be solved is clearly understood and can be communicated to relevant stakeholders. Often delivered through facilitation, this level of thinking brings consistency and re-use to programs, businesses, and, in some cases, whole industries, and fosters a platform for innovation by focusing on a need rather than a solution.
- **Theme B – Requirements Management** - focuses on the integration of systems to enable holistic design and delivery. Key areas within this are system requirements definition, interface management, change control as well as a range of analysis applied to the system design including human factors, safety, Reliability, Availability, Maintainability, performance.
- **Theme C – System Assurance** - provides the confidence that a whole system has been developed and delivered following the agreed processes against the requirements and that the information associated with the development and delivery is in place. This enables the ongoing support of the asset through its life cycle.

For the purpose of this document, these three themes have been described against the subject groups described in the Anatomy and shown in the IAM Asset Management Conceptual Model (Figure 3).

Note: The themes described have been created to be meaningful to the Asset Management community to provide an introduction to Systems Engineering and encourage further research rather than provide a comprehensive analysis.