

# National Manual of Assets and Facilities Management

## Volume 5, Chapter 20

### System Knowledge Requirements Procedure



Document No. EOM-ZO0-PR-000092 Rev 001



## System Knowledge Requirements Procedure

### Document Submittal History:

| Revision: | Date:      | Reason For Issue |
|-----------|------------|------------------|
| 000       | 28/03/2020 | For Use          |
| 001       | 18/08/2021 | For Use          |



## System Knowledge Requirements Procedure

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## 1.0 PURPOSE

This document outlines the standards by which System Requirements (SR) shall be developed and where applicable, including recognized international best practices.

The aim of this document is to encourage Entities to follow guidelines and best practices, in relation to System Requirements. This document shall also support the Entities, towards defining and developing methods and procedures within KSA, to achieve high-performance Assets and Facilities Management, business excellence, and a competitive advantage that meets with the Entity's goals.

## 2.0 SCOPE

This document has been developed specifically for A&FM, which describes the fundamental aspects of SR. Although references made to commonly used SR best practices, each Entity shall establish its own individual requirements of engineering models according to its predefined mission, vision, and strategic plans, where applicable.

This document is not designed to fully explain or develop any specific SR models or components, for any Entity in particular, rather its purpose is to demonstrate key aspects of how to use engineering methods and techniques, and apply best practices and standards, during SR development. Furthermore, this procedure has been developed to guide Entities through SR engineering concepts, process, methods, and tools' processes, in order to apply these within A&FM activities, and achieve intended business goals. Entities should fulfil the Expro standards and guidelines during their SR development process.

### 2.1 System Requirement Concept

The concept of System Requirements associated with A&FM activities, considers the required detail and delivery methods and techniques, for the effective delivery of complex and technical systems. These may have a direct or indirect bearing upon the environment of an Entity in terms of cost effectiveness, maintenance and asset longevity.

SR ensures design specifications are aligned with the customer's needs, through validation and verification processes at every stage of product or project delivery, through constant stakeholder engagement and involvement. SR details the configuration that a system shall have in order for it to function effectively, and efficiently. If the system fails to meet the specified requirements, the output may be of a substandard quality, or provide inferior performance, which may then require further resources or funding to be applied.

The main objective of SR, is to convert the stakeholder view of anticipated services, into a technical consideration of the required outcome that meets the requirements and objectives, such as performance, reliability and availability.

### 2.2 Advantages of Adopting SR with A&FM

SR is fundamental to delivering complex projects or systems, in order to ensure users and customer requirements are met. It outlines the concepts for customer expectations from project initiation (or identified need), to completion. It also tracks requirements at key points, to ensure that customer's expectations are fulfilled. When SR techniques and methods are fully embedded in a project or product, advantages and benefits will be accomplished. These may include, but are not limited to:

- Reduced waste
- Completing on-schedule
- Assisting with all-configured systems
- Asset maintainability
- Reduction in maintenance costs
- Asset longevity



### 3.0 DEFINITIONS

| Term     | Definition                                                                                                                                                                                              |
|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Entity   | An Entity includes a Government Ministry, Enterprise Project Management Office (EPMO), Engineering Management Company, or any other agency, authorized by the Government Ministry to work on its behalf |
| Expro    | National Project, Management Organization                                                                                                                                                               |
|          | of Facility and assets. The Entity may be required to enter into single, or multiple agreements with second parties to perform works or services                                                        |
| Acronyms |                                                                                                                                                                                                         |
| A&FM     | Assets and Facilities Management                                                                                                                                                                        |
| BIFM     | British Institute of Facilities Management                                                                                                                                                              |
| EPMO     | Enterprise Project Management Office                                                                                                                                                                    |
| HSE      | Health, Safety and Environmental                                                                                                                                                                        |
| KSA      | Kingdom of Saudi Arabia                                                                                                                                                                                 |
| NCLOM    | National Committee for Legislation and Standardization of Operation and Maintenance                                                                                                                     |
| NMA & FM | National Manual of Assets and Facilities Management                                                                                                                                                     |
|          | Operations and Maintenance                                                                                                                                                                              |
| PM       | Project Manager                                                                                                                                                                                         |
| RAMS     | Risk Assessment and Method Statement                                                                                                                                                                    |
| SYE      | System Engineering                                                                                                                                                                                      |
| SR       | System Requirement                                                                                                                                                                                      |

**Table 1: Definitions**

### 4.0 REFERENCES

National Manual of Assets and Facilities Management Documents

- ENT-ZAO-SD-000001 – Asset Management System Standard Requirements
- ENT-ZAO-SD-000002 – Assets Register Standard Requirements
- ENT-ZCO-SD-000001 – Condition Assessment Standard Requirements
- EOM-ZO0-PR-000097– Configuration Management Program Procedure
- EOM-ZO0-PR-000090 – System Engineering Program description
- EOM-ZO0-PR-000091 – System Assessment and Monitoring
- EOM-ZO0-PR-000096 – System Engineer Qualification Process

### 5.0 RESPONSIBILITIES

| Role                       | Description                                                                                                                                                       |
|----------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Maintenance Representative | The individual who ensures that asset condition and performance, is optimized                                                                                     |
| Operations Representative  | The individual who ensures that the asset is operable to the required levels                                                                                      |
| Sponsor                    | The individual who has an ownership of projects, on behalf of the client organization, or the Entity                                                              |
| Project Manager (PM)       | The individual who has an overall responsibility for the successful initiation, planning, design, execution, monitoring, controlling, and closure of a project    |
| Engineering Manager        | The individual who ensures that the overall quality and fitness for purpose of engineering solutions, within a project portfolio or program of work, are achieved |
| Design Engineer            | The individual who may be involved in various engineering disciplines to design the system or product, to meet set requirements                                   |



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|                       |                                                                                                                                                                                                                                    |
|-----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Project Engineer      | The individual who must co-ordinate the engineering activities within the project's team, with the primary objective of delivering safe, compliant, efficient, economic, and assured engineering solutions, and in a timely manner |
| Discipline Engineer   | The individual who provides specialist technical knowledge and delivery support to the business, in specific asset areas                                                                                                           |
| Subject Matter Expert | The individual responsible for ensuring that the overall contents are adequately and accurately covered                                                                                                                            |
| Other Stakeholders    | The individual to ensure that stakeholders' requirements can be satisfied                                                                                                                                                          |

**Table 2: Responsibilities**

## 6.0 PROCESS

### 6.1 Introduction to System Requirements

SR are the arrangements that a system must have, in order for either a system, product, or application, to run effectively and efficiently.

It is especially important to establish and understand what a system is. A system can be described as a combination of interacting elements, organized to achieve one or more purposes. The elements could be hardware, software, data, processes, procedures, facilities and/or materials. In practice, these are considered as products, services, or assets.

The outcome of not meeting these requirements could result in poor-performance issues. If systems are not configured as designed, or if the outcome is not clearly stated at the design stage, this may significantly impact the operations and end-users, in terms of reliability, availability, maintainability, performance and safety.

An organization that fails to develop and implement adequate, effective and efficient SR strategies, processes and procedures, is unlikely to demonstrate a strong operational commitment to the customers they serve. It is important to develop and implement system engineering at every stage of a product or project, from its original concept, design, initiation and implementation through to its successful handover.

The ultimate goal of SR is to meet with the business needs, and end-user requirements. The business, or user's requirements, is a high-level, critical activity that is identified by the Entity. This shall be performed in an effective manner, to meet the strategic objectives and goals. The emphasis is on the requirement, rather than on the methodology of how it is to be achieved. It is therefore recommended that a formal system involving stakeholders at key stages is employed, with clear milestone and project outcomes that may be tracked and reported. This helps to identify any obstacles to final progress, whilst allowing sufficient time to act and resolve problems, before they arise and impact the outcome.

### 6.2 Requirements Specification

The requirements specification is demonstrated as the need or condition that has to be satisfied on behalf of users or customers, in this case, the Entity. It identifies a system, product or process' characteristics, which must be clear, consistent, authentic, and verifiable. The SR shall be fit for purpose for the intended system or system component, to satisfy the needs, standards and/or specifications. Often changes or modifications will need to be applied as the project develops, such as from items that were not evident at the start. A formal process needs to be adopted so that any change of specification is agreed to before implementation, to avoid delays, additional maintenance, and/or costs that were not planned.

The SR must follow a formal process in order to stipulate the requirements in an official document. The Entity or user's requirements shall be clear, in terms of what is required by the Entity, who may lack the technical background/knowledge to decide. Where this may not be available, third party consultation may be necessary.

The credentials and formal instruction of the third party should follow the guidelines within the National Manual of Assets and Facilities Management Volume 9.



### 6.2.1 Types of System Requirements

Requirements generally falls into two classifications:

- Functional
- Non-Functional

#### 6.2.1.1 Functional Requirements

Functional requirements identify and describe what the system should provide and/or how it should function, often in relation to other associated systems.

Functional requirements also detail the system's expectations against the original design and verify whether it meets with these requirements. It also confirms that the outcome meets with the performance, resilience, and reliability standards that are necessary to demonstrate a successful outcome. Functional Requirements will take the Entity's/user's requirements to further develop more detailed levels of requirements for the project and allow for a testing and handover matrix to be developed.

The question must be, "Is the system doing what the Entity (initiator), or customer, expected of it?"

To clarify, "can the user/customer carry out the specific task(s) which they expect from the system?"

If the answer is "No", this would suggest that the process has failed, and needs to be reviewed and actioned.

Early engagement from the project team with the sponsor/customer is vital in ensuring that their needs are clearly understood, defined, and agreed upon by the relevant stakeholders.

Typical Functional Requirements may include:

- Business System Processes
- Administrative Requirements
- Authority and Security Levels
- Interfaces with Other Systems
- Additional Maintenance Requirements
- Structural or System Changes that may require Approvals
- Reporting Requirements
- Data Analysis
- Statutory Requirements

#### 6.2.1.2 Non-Functional Requirements

These describe how the system works system attributes, such as security, reliability, maintainability, scalability, and usability. They can also be constraints or restrictions to the design of the system (in which case, they may be referred to as 'design constraints').

Non-functional classification is primarily concerned with system or overall asset functionality, its characteristics, limits, and response under varying loads. It is vital that the expected requirements are clearly understood and defined by the project teams, sponsors and end-users, at the earliest stage(s).

Early and continual engagement with stakeholders is necessary, in order to ensure that all are engaged, and have provided input to the requirements. This engagement is key to achieving an effective delivery of the project, without numerous change requests. At each phase of the project, there should be a process in place to validate the requirements, before the project can proceed to subsequent phases. A gate-keeper shall be appointed at every stage, to validate that the system requirements have been met, and if so, the project can continue. As previously stated, milestones should be set so that the 'gates' can be confirmed with key stakeholder approvals, to ensure that the requirements are met at every stage/point.

Typical examples in addition to the above are, but not limited, to:

- Scalability
- Serviceability



- Manageability
- Capacity
- Data Integrity
- Usability

### 6.3 Requirements Development, and Management

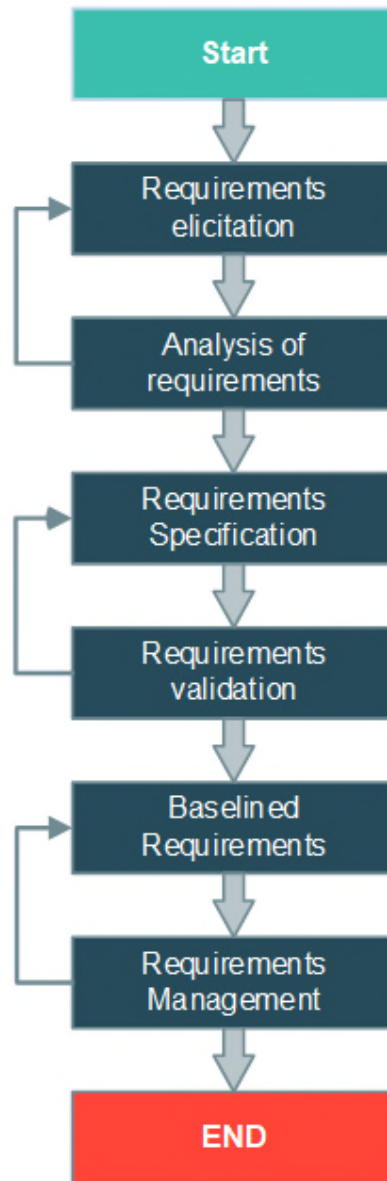
Requirements Development should be initiated from requirements elicitation. This is the data-collection process and techniques that are used to gather relevant information. It is a process of gaining an understanding of customer and end-user requirements, both technical and non-technical, which are subsequently analyzed by stakeholders and technical teams. After the data is analyzed, the requirement specification is developed and validated, at each stage of the life cycle.

Requirements Management refers to establishing and maintaining an agreement with the user or customer, on the requirements of the project or the product. This agreement covers both the technical and non-technical requirements, and forms the basis for estimating, planning, performing, and tracking the projects activities, throughout the project or product lifecycle. This is where the Entity's expectations and specifications of a system are managed (by a sponsor or representative), through regular meetings, presentations, or other means, with all relevant stakeholders present and involved at each stage/gate of the project life cycle.

Figure 1 shows the process for Requirements Development, and Requirements Management. The Requirements Management process may decide to alter the current baseline for various reasons, which may be a change in requirements by the customer, or a negotiated change by all parties. In all stages, a change management policy and approvals policy, should be provided, and agreed upon by all stakeholders. Key personnel should be identified, and where necessary, alternative, qualified, personnel should be nominated as substitutes.



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**Figure 1: Requirements Development and Requirements Management Process**

The System Requirements are expected to deliver the following:

- Establish and maintain an agreement with customers and users, through the life of the project
- Confirm the baseline requirements
- Maintain the requirements, consistent with plans and products
- Negotiate new commitments based on impact of approved changes
- Manage complex projects effectively

The requirements shall be monitored and controlled during each phases of the project life cycle, by developing and implementing conditions and processes, which will be strictly adhered to, by all concerned.

For the Entity to achieve or maximize value from Requirements Management, the correct level of a management structure should be in place, with clear accountabilities, responsibilities, and the right competency levels. Typical roles should include, but not be limited to:

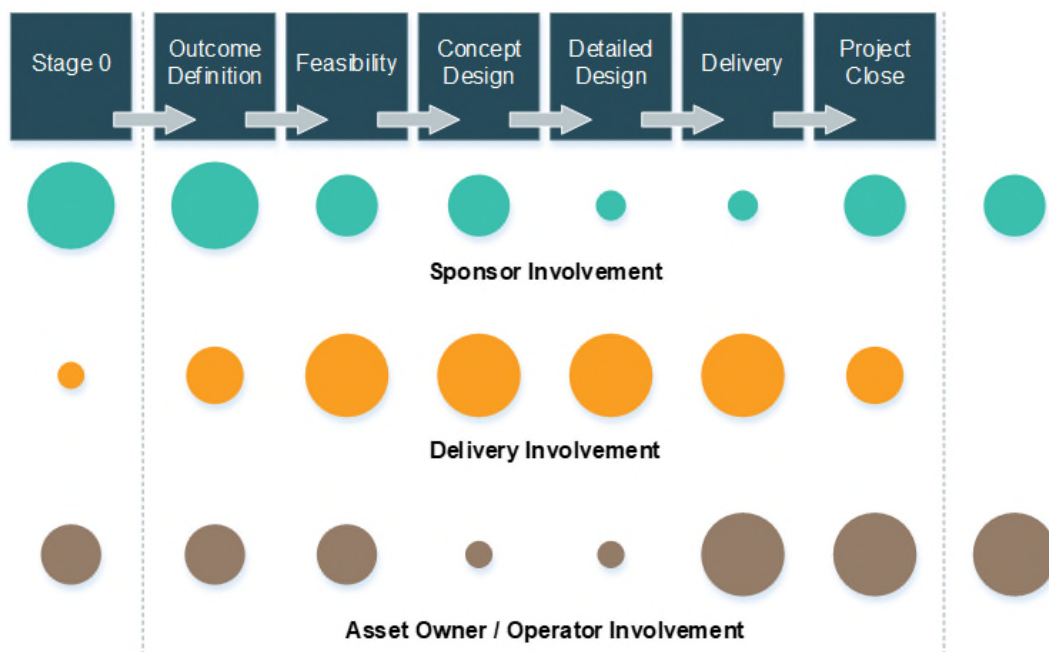


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- PM (Project Manager)
- Sponsor
- Design Engineer
- Project Administrator
- Customer / User
- Contractor

These are the core roles, common to all projects and product delivery. The key roles are the Sponsor, Design Engineer, and Project/Program Manager, along with an Asset Owner or Operator. Additionally, amongst the key subject matter experts contributing to the project delivery, there will be a requirement for procurement/commercial leads, and Health, Safety & Environmental (HSE) leads. However, these roles will be dependent upon the complexity of the project, and the level of interaction required between internal and external stakeholders.

### 6.4 Project Phases and Stakeholder Involvement



**Figure 2: Project Life Cycle and Stakeholder Levels of Involvement**

Figure 2 above, demonstrates that at the outset, the sponsors' level of engagement and involvement is at its highest, and reduces gradually until the product approaches final close-out, when the sponsor's involvement peaks again. At the outcome definition phase, the sponsor establishes the Entity's objectives and benefits. It is vital that the sponsor is clear about the requirements to achieve project expectations.

Delivery involvement is very high, from feasibility right through to delivery a very concentrated effort with Project Managers, Design Team and Project Engineers all ensuring that feasibility is transformed into detailed design and the actual, expected product. Time must be factored in to allow sufficient engagement by those identified, so that subsequent change-control is minimized. These personnel are best placed to highlight any possible delays or impact to later stages, based upon their experience, system knowledge and future programme, to which all stakeholders may not have visibility. Additionally the impact with their current roles should be considered to allow for 'management time' associated with the additional project

Many projects can be demonstrated as failing, due to the lack of input at the design and planning stage, which subsequently results in project overruns and additional costs. Previous experience, and lessons learned records, can help to avoid this.



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| No. | Stages             | Definition                                                                                                                                                                                          |
|-----|--------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1   | Outcome Definition | Establishes the business outcome, and the benefits that the project must deliver                                                                                                                    |
| 2   | Feasibility        | Determines whether the outcomes and benefits are achievable – the options for their delivery and the options that will deliver them for the best value                                              |
| 3   | Concept Design     | Defines the design principles, and freezes the scope of the project                                                                                                                                 |
| 4   | Detailed Design    | Produces a detailed design that delivers the required outcomes, and is used as the basis of a contract for delivery of the physical outputs                                                         |
| 5   | Delivery           | Builds the physical outputs of the project, confirms acceptance by end users and hands the outputs over into operational/business use and maintenance, including necessary supporting documentation |
| 6   | Project Close      | Ensures that the project is closed in a controlled manner                                                                                                                                           |

**Table 3: Definitions of Project Life Cycle Stages**

### 6.5 The V Process Technique

In each project, product or system delivery, a verification and validation process must take place progressively, throughout the project or system life cycle. The engineering approach is based on the V model, illustrated below in Figure 3. The validation and verification process is critical in the delivery of a system, by ensuring that the expected system specifications and requirements are on track to meet customer/user requirements, until delivery and into service.

The validation and verification activities should be undertaken either by competent in-house facility staff engaged upon the project / requirement, or by an external, approved supplier. This may be an external commissioning company/specialist, or through engagement with an Independent Certification and Verification Engineer (ICVE). All these activities must follow the structure of engineering design assurance, compliance, and approvals, which should be set out by the Entity.



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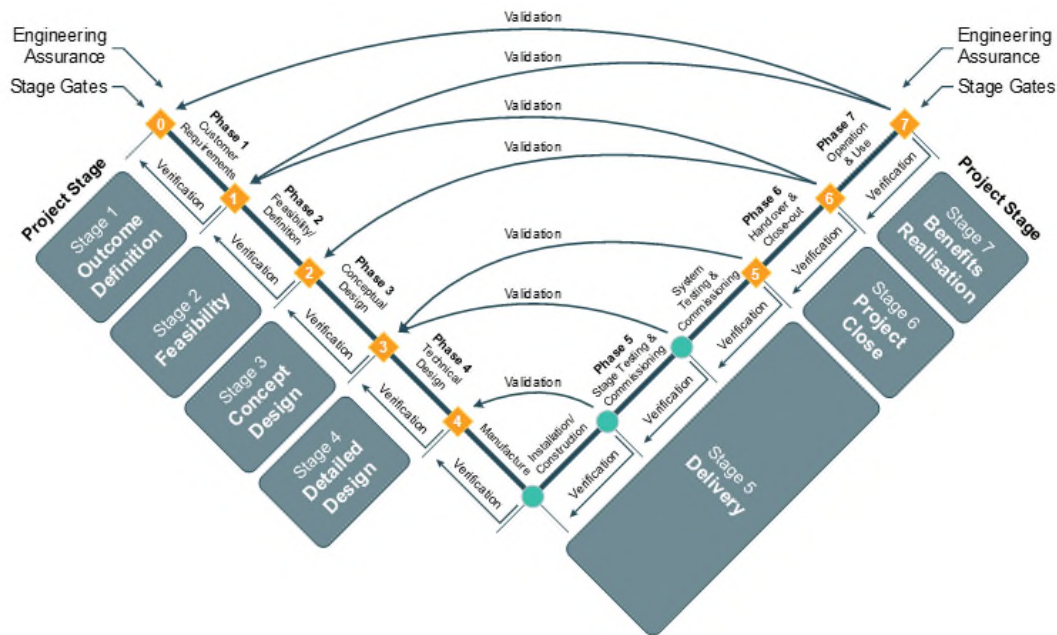


Figure 3: The V Model Process

### 6.5.1 Validation & Verification

At the start, and until the end of each project or product delivery, a validation process shall be carried out to validate that the Entity's/user's requirements and specifications, have been fully met. This process of confirmation through the provision of objective evidence, ensures that the requirements for a specific application have been fulfilled.

The validation process is a set of activities which aims to ensure and gain confidence that a system is able to accomplish its planned use, goals and objectives, in the intended environment. Validation requirements asks: "Are the requirements the right ones, (and how do we know)?", in order to provide confirmation that 'the project teams are building the right thing'.

Below are some key examples of the objectives of the validation process, though not limited to:

- Punch or Snag List Items have been resolved
- Business Requirements
- User Requirements have been met
- System Requirements have been met and demonstrated, through all Modes of Operation
- Design Requirements have been achieved (including all CR's)
- Documentation Handover ( Manuals, BOQ, Asset List and AS BUILT Drawings)

The verification process is confirmed through the provision of objective evidence, that the specified requirements have been fulfilled. It is a set of activities that compares a system or system elements, against its fulfilled characteristics. Verification of requirements asks "Has the project captured the requirements correctly?" and "What has been measured, in order to provide confirmation?"

As mentioned, verification happens at each stage of the project. Activities considered for verification are as follows, but not limited to.

- Verify that the Technical Elements of the Project Requirements support the delivery of the outputs, or outcomes defined in the business case
- System Migration with new and old products
- Acceptance Criteria have been met



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- Verify that the system, as constructed, works together as a system
- Configuration Management Verification
- Safety Verification
- Verify Concept Design that delivers the Project Requirements
- Approval of New Products

The above activities, verification, and validation, can be undertaken either by the Entity, or by an external supplier. All these activities shall follow the structure of engineering design assurance, compliance, and approvals.

### 6.6 Design Compliance Requirements

Before a system or a product is built, it must be designed to be compliant with set requirements, established by the Entity, or required legislation in KSA. From an A&FM perspective, the system or subsystems shall go through a design-compliance process to ensure that it is fit for purpose, maintainable, and delivered into service for operational use.

The typical sequence of design compliance, requiring formal approval, is illustrated in Figure 4, below.

The sequence of these products and their approval may need to be varied, to accommodate staged design and construction. The Entity shall ensure that a robust process is in place to guarantee that each product or a system's requirements and design, are completely fulfilled. The Entity shall ensure that competent persons and suppliers are able to demonstrate that they have compliant systems and processes in place, during the procurement phase.

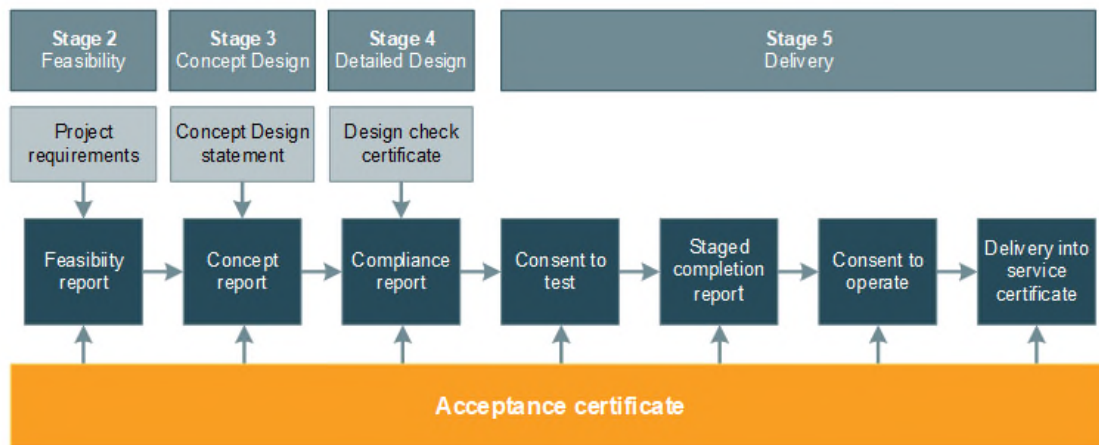


Figure 4: Typical Design Compliance Requirements



### 6.7 Configuration Management

Configuration Management plays a key role in system engineering and requirements. Where systems contain many inter-reliant subsystems to function to a required level, Configuration Management processes should be embedded in the entire requirements process, in order to ensure that all systems are fully, and effectively configured to meet expectations.

Refer to National Manual of Assets and Facilities Management Document No. EOM-ZO0-PR-000097 for further information on Configuration Management.

### 6.8 Governance

Systems or products that are to be delivered in a complex environment can be very difficult to manage, due to high levels of uncertainty, which may result in high costs, and poor system specifications and design, which may then lead to late delivery.

SR is the appropriate model for a complex project environment it transforms the governance from “more project-based” to “system-based”. This increases the chances of universal success by using methodologies, techniques, and tools from concept to delivery, that are not used in project-based governance. With traditional project-based governance, complex projects cannot be fully specified at inception, and require continuous learning during the life cycles. This is not the case with system-based governance, which intends to get it right from the start.

The entity shall ensure that robust, systems governance is in place for every complex project. The Entity's sponsor should ideally chair the governance board, and ensure challenges and input from Board Members, as well as seek decision by consensus.

Below are some reasons for ensuring that robust governance is applied:

- Good governance requires checks and balances
- Accountable roles need a voice in governance
- Decision-making through Boards ensures better informed decisions
- Decision-making through Boards fosters collective ownership of decisions

A Governance Board shall make the decisions about the project or product that impact the following:

- Forecasted spend or income
- Reportable delivery milestones
- Benefits identified in the business case
- Scope and requirements
- Stakeholder relationship and perceptions
- Risks to delivery

The entity shall set up a steering group with agreed terms of reference, and appropriate levels of authority to effectively manage the above activities.