Systems Engineering Cases and Instructions

Rune Hylsberg Jacobsen and Stefan Hallerstede
Aarhus University Department of Engineering

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1.1	2011-03-01	Added Appendix	Rune Jacobsen
1.2	2012-01-18	Additional exercise integrated. Modification of exercises to align better with learning objectives. New chapter division. SEcase process description elaborated. Typographical corrections	Rune Jacobsen
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2.4	2021-02-01	Set up the case work for 8 groups, improved presentation	Stefan Hallerstede

Contents

Chapter 1

Introduction

This document has been prepared to as part of the Systems Engineering course at Aarhus University Department of Engineering (ENG). The course is based on current methods, best practices and standards in systems engineering as defined by the The International Council on Systems Engineering (INCOSE) organisation [6].

Learning objectives

Upon the completion of the course the students should be able to:

- Explain the overall concepts that make up system engineering.
- Explain and analyse the systems engineering process and the significance and relationship among its phases.
- Perform important techniques of system requirements analysis, rigorous modelling, evaluation of solution alternatives, and system design iteration including their subsequent validation and verification
- Explain and discuss the roles of the customer, acquirers and suppliers.
- Analyse and discuss stakeholders' needs and requirements and how they find their way into the end product
- Sketch and discuss plans for the development of systems.
- Implement and explain principles and techniques of engineering management.
- Explain and present proposed system engineering processes and solutions in a clear and concise way.

Chapter 2

Case work

2.1 Way of working with the case

The case work descriptions included in this chapter are based on realistic challenges from two companies. They represent past projects and business evaluations.

The case descriptions are presented in the format of a Statement of Work (SoW). The SoW explains its purpose, the scope of the work, location of work, period of performance, delivery schedule, applicable standards, acceptance criteria and any special requirements and the type of contract/payment schedule.[1]

The way of working with the cases is perhaps best described as a *role play* game. Put yourself in the position of a systems engineer working in the company described in the case. Image that this company has an ongoing discussion with a customer on an engineering contract. Identify and carry out the relevant systems engineering work processes in order to pursue the challenge of the company. Deliver the requested information (system documentation) in the cases. Work in accordance with the mantra: Rather complete a work process than to work out all the details in limited parts of a process.

2.1.1 The SE-case process

For large, complex systems the work with the systems engineering process can run for several months and even years. For the purpose of training the practice of systems engineering we will tailor a systems engineering process scope and duration to be suitable for the course. The tailored *SE-case* process, described below, is a tailored process based on the systems engineering framework from [6]. The abbreviations have the following meaning:

- SRR: System Requirement Review
- PDR: Preliminary Design Review
- CDR: Critical Design Review
- TRR: Test Readiness Review
- CPR: Customer Presentation

[1] Note, that SoWs may purposely be incomplete and ambiguous.

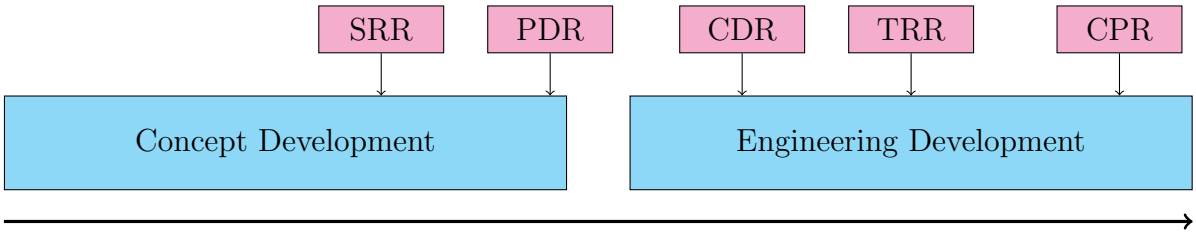

Figure 2.1: SE-case process

The process is the same for a subsystem. By the end of the course a plan is ready that covers all main system engineering phases. This plan is the basis for the tendering for the contract.

Roughly, the following phases of a systems engineering project are planned:

(1) *Concept and project definition phase.* Prepare the System requirements based on the input from a stakeholder requirement definition phase. Requirements must be verifiable.
Typical document outputs from this phase are the Concept documents, System Requirement Specification, initial Requirement Traceability Matrix, project steering documents including a project plan.

(2) *System design phase.* The overall design of the system is decided. Subsystems are identified. Major interfaces between subsystems are defined. System verification and qualification of the project are planned. Processes for production are selected. Possible new subcontractors are approved and negations of contracts are started. Requirements and changes to requirements are properly handled.
Typical document outputs from this phase are preliminary and detailed design documentation, system test specification etc.

(3) *Development phase.* Subsystems and units are designed and documented. Prototypes of the critical sub-systems are produced in order to verify the principles, functionality and performance. Implementation and verification of subsystems in accordance with requirements. Individual subsystems are integrated successively into a complete system. Compliance to all the requirements of the System Requirement Specification is verified.
Typical document outputs from this phase are design documentation and test reports.

(4) *Production phase.* Production (or manufacturing) is the use of machines, tools and labor to produce the systems and the services supporting the system. The main tasks in the phase is production planning and the first unit serial production. This phase typically involves low rate initial production (LRIP).

(5) *Production and deployment phase.* In this phase systems are installed at the customer premises and training of personnel is undertaken. A change from LRIP to mass production takes place.

(6) *Operational support phase.* In this phase the organisation is supporting the systems in use at customer premises.

2.1.2 Case organisation

The case work is carried out in small systems engineering and integration teams (SEITs). Each team has around 9 team members and acts as a prime contractor for a case. The SEITs receives a statement of work and has a fixed deadline for the delivery of an offer/product for the system-of-interest. Secondly, each SEIT is requested to use a subcontractor for parts of the system. In the case exercise this is simulated by letting another team become the subcontractor to a prime contractor.

Figure 2.2 illustrates this setup with six interacting SEITs and two cases: Case I and Case II. From the figure the following can be concluded:

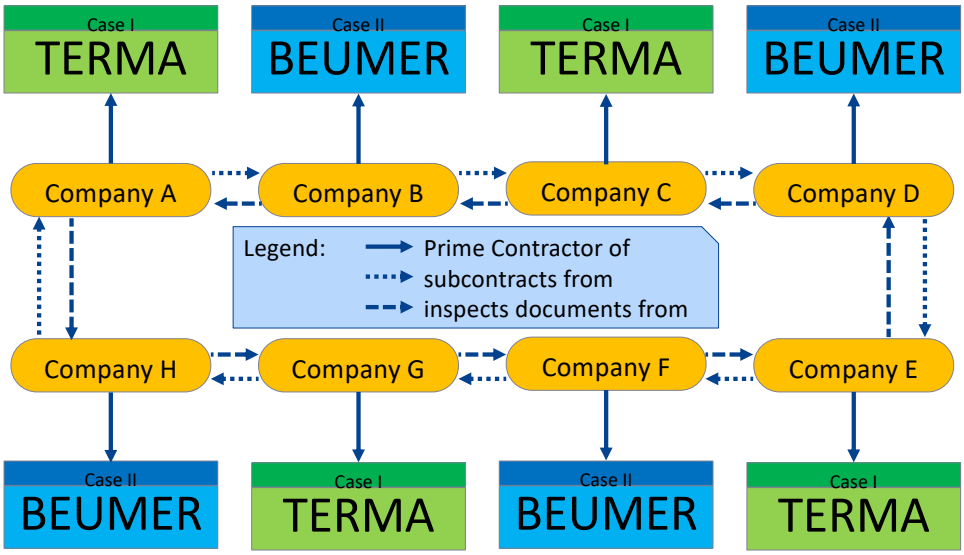

Figure 2.2: Context flow diagram for the case work. The typical input for describing the case is a Statement of Work (SoW) and/or use case requirements (U.C. Req.). The term "use case requirement" is used for the output of a use case-based requirement analysis process.

- Company A is *prime contractor* of customer TERMA (Case I) and *subcontractor* of Company B.
- Company B is *prime contractor* of customer BEUMER (Case II) and *subcontractor* of Company C.
- Company C is *prime contractor* of customer TERMA (Case I) and *subcontractor* of Company D.
- Company D is *prime contractor* of customer BEUMER (Case II) and *subcontractor* of Company E.
- Company E is *prime contractor* of customer TERMA (Case I) and *subcontractor* of Company F.
- Company F is *prime contractor* of customer BEUMER (Case II) and *subcontractor* of Company G.
- Company G is *prime contractor* of customer BEUMER (Case II) and *subcontractor* of Company H.
- Company H is *prime contractor* of customer BEUMER (Case II) and *subcontractor* of Company A.

And concerning the inspection:

- Company A is *inspector* for Company H.
- Company B is *inspector* for Company A.
- Company C is *inspector* for Company B.
- Company D is *inspector* for Company C.
- Company E is *inspector* for Company D.
- Company F is *inspector* for Company E.
- Company G is *inspector* for Company F.
- Company H is *inspector* for Company G.

Milestone review	Mandatory deliverables	Optional deliverables
SRR (customer)	ConOps, SEMP, Time Plan, System Requirement Specification, RVTM	Verification matrix, List of system objects, Request for Proposal
PDR (customer)	Preliminary Design Description, Preliminary Interface Control Document, RVTM	
CDR (customer)	Detailed Design Description, Interface Control Document, Preliminary Verification Plan, RVTM	Parts List (internal), Updated SEMP
TRR (customer)	System Test Description (including verification plan, procedure and verification matrix), RVTM	
CPR (customer)	Customer presentation of project, product & offer, Document Baseline	Project Flyer

Table 2.1: Milestone reviews and deliverables in case-SE process.

Process schedule

The intention is that the case work process runs over a period of 9 weeks within a semester at the Department of Engineering. See the lecture plan for the dates of the deliverables and review meetings.

Milestone reviews and deliverables

The milestone reviews (MSRs) and the required deliverables that are relevant for the case work are given in Table 2.1. Some of the review meetings are held internally (marked "(internal)", if any) and do not require participation of the customer. The SRR, PDR, CDR, TRR, CPR review involve the customer. Reviews will be conducted in accordance with the practices outlined in Appendix N of the NASA Systems Engineering Handbook [7]. The three type roles will be assigned to SEIT members. For the case review the following roles shall be assigned to individuals:

- Author(s)
- Moderator
- Inspectors

The roles and responsibilities are described in [7]. The customer will assume the role of an inspector.

Note, that document templates for (some of) the deliverables can be found in Chapter 3. You may choose to apply these templates for the case work and adapt them to the needs of your case project.

Minutes of Meetings

At the specified deadlines on Blackboard all *minutes of meetings* produced since the last deadline must be delivered. This includes minutes from prime contractor meetings, sub-contractor meetings and review meetings. Action points listed in minutes must be followed up in subsequent minutes.

Minutes of meetings typically contain the following information:

- Date, time, purpose of meeting ("title")
- List of invited attendees split into present/not present
- Agenda of meeting (including previous action points status)
- What has been discussed
- What has been agreed
- Action points with deadlines

Inspection Guidelines

The documents must comply with the following quality requirements that are ensured in the review process.

A) General Quality Requirements

- All requested documents are present.
- All documents have a unique ID.
- All documents have a review version.
- All documents have a revision history.
- All documents have a cover page identifying the company and the case.
- All documents have page numbers of the shape "x/y" where "x" is the current page and "y" the total number of pages.

B) Document Specific Requirements

SRR:

- All requirements are categorised.
- Needs are stated and explained.
- All requirements are traceable. (Each requirement is a clear, identifiable statement).
- All requirements are verifiable.

PDR:

- The functionality of the systems is clearly described the preliminary design.
- The requirements are traced to design components.
- All components are clearly mapped to engineering capabilities of the company.
- Each component has one engineering discipline associated with it.
- All requirements are accounted for in the design.

CDR:

- Each component has one engineering discipline associated with it.
- The interfaces between the components are described.
- Each component is traceable to a requirement.
- All requirements are accounted for in the design.

TRR:

- Each requirement is associated with at least one test.
- The resources and facilities required for each test are stated.
- A success criterion is given for each test.

Responsibilities of the SEIT

The following responsibilities apply for the prime contractor' s MSR with the customer:

§1 All documents for the MSR shall be delivered to the customer no less that 48 hours in advance.

§2 Delivery information: Reports must be delivered to Blackboard and the reviewing company. (In case of technical problems with the delivery contact Hao Feng "haof@ece.au.dk". The email must include the name of the company name in the subject field and the course code: **SYSENG1**.)

§3 All documents must be in portable document format (PDF) format and written in English. (Non-compliant documents are rejected. Note, that the 48-hour rule must be obeyed under any circumstances.)

§4 All documents must be revision controlled and a project-unique document identification must be clearly visible on the first page.

§5 The MSR shall be conducted at a time agreed with the customer. It is the prime contractor's responsibility that the MSR time is not conflicting with other meetings. (The customer must be contacted by way of e-mail.)

The following responsibilities apply for the subcontractor's MSR with the prime-contractor:

§6 The requirements for the documentation are the same as for the prime-contractor's MSR with the customer.

§7 The prime-contractor's point of contact is Blackboard.

§8 Minutes of meeting (MoM) from the MSR shall be produced and sent to the customer by the prime contractor no less that 48 hours after the MSR meeting

§9 Minutes of meeting shall be in PDF format containing a maximum of 1000 words.

ATTENTION!

Only a limited amount of documents need to be exchanged with the subcontractor:

- a request for proposal (RFP),
- a requirements document and a preliminary design.

AND ALSO

It is expected that the customer is contacted at least twice per week per prime contractor.

Chapter 3

Document templates

This section includes document templates relevant for the case work. The list of templates are:

- Concept of Operations (CONOPS)
- System requirement specification (SRS)
- Requirement traceability matrix (RTM)
- Detailed design document (DDD)
- Interface Control Document (ICD)
- System Test Description (STD)
- Request for Proposal (RFP)

3.1 Concept of operation

The Concept of Operations (CONOPS) documents the ways of working with need analysis in the project.

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1. Introduction

1.1 **Purpose**

1.2 **Output**

1.3 **Executive summary**

1.4 **Revision summary**

2. Capability Need

2.1 **Business Need(s)**

2.2 **Business Need Capability Gap**

2.3 **Current situation**

3. Operations and Support Description

3.1 **Missions (Primary/Secondary)**

3.2 **Users and Other Stakeholders**

3.3 **Policies, Assumptions and Constraints** — Policy, Assumption, Constraint

3.4 **Operation Description** — Operating Concept (OpCon), Employment Modes, Scheduling and Operations Planning, Operating Environment, Geographic Area(s), Environmental Conditions, Interoperability with Other Elements,

3.5 **Product Support Description**

3.6 **Potential Impacts**

3.7 **Scenarios** — Support Name, Functional Capabilities Needed

4. Functional Capabilities

4.1 **Operations**

4.2 **Support**

5. CONOPS Development Team

List the office codes and names of personnel who made meaningful contributions to the document. This provides the reader with points of contact to follow-up when questions arise.

A. Additional Information

Attach any additional information that supplements this plan.

A.1 **Analysis reports**

4.2 **Glossary and Terms**

4.3 **Acronyms and Abbreviations**

4.4 **References**

3.2 System requirement specification (SRS)

The purpose of the SRS is to document the functional as well as the non-functional requirements derived from the Requirement Analysis phase. The SRS clearly identifies the requirements and contains detail information about it. This template is adapted from [4].

---

1. Scope

1.1 **Identification**. This section includes a full identification of the system-of-interest to which this document applies.

1.2 **System overview**. A brief statement of the purpose of the system of interest.

1.3 **Document overview**. Summarise the purpose and the content of the document. Security and privacy considerations associated with the use of this document might be added.

2. Referenced documents

Provide a list of the document references in this specification. The documents shall be uniquely identifiable.

3. Requirements

The section on system requirement can be organised into a number of subsections. Both functional and non-functional requirements shall be included. Each requirement shall be assigned a project-unique identifier to support testing and traceability.

3.1 **Required states and modes**. If the system is required to operate in multiple states or modes, these states and modes shall be defined.

3.2 **System capability requirements**. This paragraph specifies requirements on the behaviour of the system and shall include applicable relevant parameters. It shall be divided further into subparagraphs depending on the system capability in question.

3.3 **System external interface requirements**. This paragraphs shall be divided into subparagraphs to specify the requirements, if any, for the system's external interfaces. Interfaces shall be assigned a project-unique identifier. One or more interface diagrams shall be provided.

3.4 **System internal interface requirements**. This paragraph shall be divided into subparagraphs to specify the requirements, if any, for the system's internal interfaces. It shall state if there are internal interfaces left to the design or to system requirement specifications for components. Furthermore, the description in item 3.3 also applies to internal interfaces.

3.5 **System internal data requirements**. Requirements on data internal to the system such as databases, data files etc. shall be stated. If there are internal interfaces left to the design or to system requirement specifications for components these shall be identified.

3.6 **Adaptation requirements**. Requirements on installation-dependent data and operational parameters that the system requires.

3.7 **Safety requirements**. System requirements concerning minimising unintended hazards to personnel, property and the physical environment.

3.8 **Security and privacy requirements**. This paragraph shall specify the system requirements, if any, concerned with the maintaining security and privacy.

3.9 **System environment requirements**. This paragraph shall specify the system requirements, if any, regarding the environment in which the system must operate.

3.10 **Computer resource requirements**. This paragraph specifies resource utilisation requirements. It can be further divided into hardware, software, communications etc.

3.11 **System quality factors**. This paragraph specifies quantitative requirements concerning system functionality, reliability, maintainability, availability, flexibility, portability (software), reusability, testability, usability an other attributes.

3.12 **Design and construction constraints**. This paragraph specifies the requirements, if any, that constrain the design and construction of the system.

3.13 **Personnel-related requirements**. This paragraphs specifies the requirements, if any, included to accommodate the number, skill levels, duty cycles, training needs, or other information about the personnel who will use or support the system.

3.14 **Training-related requirements**. System requirements pertaining to training.

3.15 **Logistics-related requirements**. This paragraphs specifies the requirements, if any, concerned with logistics considerations.

3.16 **Packaging requirements**. This paragraphs specifies the requirements, if any, for packaging, labelling and handling the systems and its components for delivery.

3.17 **Other requirements**. Examples include requirements for system documentation not covered in other contractural documents.

4. Quality provisions

A set of qualification methods shall be defined for each requirement. These are the methods to ensure that the requirements have been met. Qualification methods may include but are not limited to: a) demonstration, b) test, c) analysis, d) inspection, or other special methods.

5. Requirements traceability

Based on the information in the section is shall be possible to trace system requirements to user needs. An RTM may be included (see Figure 3.1). If this is a subsystem-level specification this paragraph shall contain the traceability from each subsystem requirement to the system requirement that it addresses (backwards) as well as from each system requirement that has been allocated to the subsystem. All system requirements allocated to the subsystem shall be accounted for.

6. Other

General information that aids in understanding this document e.g,. background information, glossary etc. may be included here.

Project name:			Business Area:					
Project manager:			Business Analysts lead:					
QA lead:			Target implementation date:					

Req. id.	Category or functional activity	Requirement description	Use case reference	Design document reference	Code or module reference	Test case reference	User acceptance validation	Comments

Table 3.1: Requirement traceability matrix template

3.3 Detailed design document (DDD)

The DDD documents how the system or subsystem will be structured to satisfy the system requirements. It is the primary reference for subsequent implementation and it must contain all the information needed by developers to construct the system. The DDD is based on a preliminary design in which the overall system architecture and data architecture are defined; but it is more detailed. This template is adapted from [3].

---

1. Scope

1.1 **Identification**. This section includes a full identification of the system-of-interest to which this document applies.

1.2 **System overview**. A brief statement of the purpose of the system of interest.

1.3 **Document overview**. Summarise the purpose and the content of the document. Security and privacy considerations associated with the use of this document might be added.

2. Referenced documents

Provide a list of the document references in this specification. The documents shall be uniquely identifiable.

3. System-wide design decisions

This section shall be divided into paragraphs as needed to present decisions about the system's behavioural design and other decisions affecting the selection and design of system components. This includes also design decisions that are explicit in the requirements or that are deferred to the design of the system components. Examples of system-wide design decisions are the following:

a) Design decisions regarding inputs the system will accept and outputs it will produce.

b) Design decisions on system behaviour in response to each input or condition, including actions the system will perform, response times and other performance characteristics.

c) Design decisions on how system databases/data files will appear to the user.

d) Selected approach to meet safety, security, and privacy requirements.

e) Design and construction choices for hardware or hardware-software systems, such as physical size, color, shape, weight, materials, and markings.

f) Other system-wide design decisions made in response to requirements, such as selected approach to providing required flexibility, availability, and maintainability.

4. System architectural design

This section shall be divided into multiple paragraphs to describe the system architectural design. If part or all of the design depends upon system states or modes, this dependency shall be indicated.

4.1 **System components**. Identify the components of the system (configuration items and manual operations). Each component shall be assigned a project-unique identifier. Show the static relationship(s) of the components. State the purpose of each component and identify the system requirements and system-wide design decisions allocated to it. Identify each component's development status/type, if known. Provide characteristics for resources identified for use in the system such as e.g., processors, memory, input/output devices, and communications/network equipment for computer systems.

4.2 **Concept of execution**. This paragraph shall describe the concept of execution among the system components. It shall include diagrams and descriptions showing the dynamic relationship of the components, that is, how they will interact during system operation.

4.3 **Interface design**. This paragraph shall be divided into subparagraphs to describe the interface characteristics of the system components. It shall include both internal and external interfaces. If part or all of this information is contained in Interface Control Descriptions (ICDs) or elsewhere, these sources may be referenced.

4.3.1 Interface identification and diagrams. Project-unique identifier shall be assigned to each interface.

4.3.x (Project-unique identifier of interface). This paragraph shall briefly identify the interfacing entities, and shall describe the interface characteristics of one or both of the interfacing entities. The description shall include the following, as applicable:

1. Type of interface (such as real-time data transfer, storage-and-retrieval of data, etc.) to be implemented.
2. Characteristics of data elements that the interfacing entity(ies) will provide.
3. Characteristics of data element assemblies (records, messages, files, arrays, displays, reports, etc.) that the interfacing entity(ies) will provide, store, send, access, receive, etc.
4. Characteristics of communication methods that the interfacing entity(ies) will use for the interface.

5. Characteristics of protocols the interfacing entity(ies) will use for the interface.
6. Other characteristics, such as physical compatibility of the interfacing entity(ies) e.g., dimensions, tolerances, loads, voltages, plug compatibility, etc.

...

5. Requirements traceability

The traceability from each system component to the system requirements allocated and the traceability from each system requirement to the system components to which it is allocated is described here. An RTM may be included (see Figure 3.1).

6. Other

This section shall contain any general information that aids in understanding this document e.g., background information, glossary, rationale.

3.4 Interface control document (ICD)

The ICD describes the interface characteristics of one or more systems, subsystems, configuration items, manual operations, or other system components. An ICD may describe any number of interfaces and can be used to supplement the Detailed Design Description (DDD). This template is adapted from [1].

---

1. Scope

1.1 **Identification**. This section includes a full identification of the system-of-interest to which this document applies.

1.2 **System overview**. A brief statement of the purpose of the system of interest.

1.3 **Document overview**. Summarise the purpose and the content of the document. Security and privacy considerations associated with the use of this document might be added.

2. Referenced documents

Provide a list of the document references in this specification. The documents shall be uniquely identifiable.

3. Interface design

This section shall be divided into paragraphs to describe the interface characteristics of one or more systems, subsystems, configuration items, manual operations, or other system components.

3.1 **Interface identification and diagrams**. For each interface this paragraph shall state the project-unique identifier assigned to the interface and shall identify the interfacing entities (systems, configuration items, users, etc.) by name, number, version, and documentation references, as applicable.

The identification shall state which entities have fixed interface characteristics and which interfaces are being developed or modified. One or more interface diagrams shall be provided, as appropriate, to depict the interfaces.

3.x **(Project-unique identifier of interface)**. This paragraph shall briefly identify the interfacing entities, and shall be divided into subparagraphs as needed to describe the interface characteristics of one or both of the interfacing entities.

The design description shall include the following, as applicable,

1. Type of interface (such as real-time data transfer, storage-and-retrieval of data, etc.) to be implemented.
2. Characteristics of individual data elements that the interfacing entity(ies) will provide, store, send, access, receive, etc.
3. Characteristics of data element assemblies (records, messages, files, arrays, displays, reports, etc.) that the interfacing entity(ies) will provide, store, send, access, receive, etc.
4. Characteristics of communication methods that the interfacing entity(ies) will use for the interface.
5. Characteristics of protocols the interfacing entity(ies) will use for the interface.
6. Other characteristics, such as physical compatibility of the interfacing entity(ies) (dimensions, tolerances, loads, voltages, plug compatibility, etc.)

...

4. Requirements traceability

The traceability from each system component to the system requirements allocated and the traceability from each system requirement to the system components to which it is allocated is described here. An RTM may be included (see Figure 3.1).

5. Other

This section shall contain any general information that aids in understanding this document e.g., background information, glossary, rationale.

3.5 System test description (STD)

The STD describes the test preparations, test cases and test procedures to be used to perform qualification testing of the system or subsystem. The STD enables the acquirer to assess the adequacy of the qualification testing performed. This template is adapted from [2].

---

1. Scope

1.1 **Identification**. This section includes a full identification of the system-of-interest to which this document applies.

1.2 **System overview**. A brief statement of the purpose of the system of interest.

1.3 **Document overview**. Summarise the purpose and the content of the document. Security and privacy considerations associated with the use of this document might be added.

2. Referenced documents

Provide a list of the document references in this specification.

3. Test preparations

3.x (Project-unique identifier of a test). This section identifies a test and provides a brief description of the test. The section shall include description for the hardware and software preparations needed as well as other preparations needed to carry out the test. Diagrams and step-by-step instructions shall be provided as applicable.

...

4. Test descriptions

This section shall identify and describe the test cases. The test cases are mapped to requirements and preconditions must be established prior to performing the test. The following considerations shall be discussed:

1. Hardware and software configuration.
2. Control parameters or initial data to be set/reset prior to the start of the test.
3. Preset system conditions or states of relevant subsystems necessary to run the test case.

4. Initial conditions to be used in making timing measurements.

5. Conditioning of the simulated environment.

6. Other special conditions peculiar to the test case.

Test input and expected output shall be specified as well as the criteria for evaluating the results. The section also define the test procedure for the test cases. Any assumptions made and constraints or limitations imposed in the description of the test case, due to system or test conditions, shall be mentioned.

5. Requirements traceability

Traceability from any test case to the system requirement (or any other relevant requirement) is addressed here. An RTM may be included (see Figure 3.1).

6. Other

General information that aids in understanding this document e.g., background information, glossary etc. can be included here.

3.6 Request for proposal

While the RFP may differ depending on the context and the engineering domain the template below constitute a common set of sections found in most RFPs. Before sending the RFP, consider the need for all bidders to sign a non-disclosure agreement to keep the entire RFP process confidential.

---

1. Statement of purpose

Describe the general scope, nature, specifications, and purpose of goods, products, and services to be acquired in a manner that will enable providers to early decide to submit either an offer or a no-proposal letter.

2. Background information

Present a brief overview of your organisation and its operations. Use statistics, customer demographics and psychographics. State strengths and weaknesses of your company. Do not forget to include comprehensive information on the people who will handle future correspondence.

3. RFP process and scope of work

Describe the steps potential bidders must follow to complete the RFP process. Specify the different project phases broken down into tasks, detailing their objectives, timeline, and provisions in competitive procurement. Share the schedule for the various events that will ultimately lead to the selection of a supplier. Enumerate future tasks, obligations, and responsibilities for the soliciting organisation, the contractor, and subcontractors, if any, in regards to the performance of the contract.

4. Outcome and performance standards

Specify the expected outcome, minimal performance standards expected from the contractor, and methods for monitoring performance and process for implementing corrective actions.

5. Evaluation criteria and award process

Outline the general procedures, criteria, and priorities used to evaluate and rank proposals, and to make the final selection decision. The evaluation criteria can be elaborated here based on the parameters that you have decided such as price, duration, quality, flexibility, reliability, innovation etc.

6. Deliverables and proposal response format

Provide a list of all products, reports, and plans that will be delivered to your organisation and propose a delivery schedule. To facilitate the analysis of responses to the RFP, you can ask vendors to prepare the proposals in a specific format which can be outlined in this section.

7. Payments, incentives, and penalties

Specify the preferred procurement or compensation model. List all the terms of payment for adequate performance. Highlight the basis for incentives for superior performance and penalties for inadequate performance or lack of compliance.

8. Contractual terms and conditions

Specify length, start-date and end-date of the contract, as well as specific clauses for governing law, performance and default, termination and renewal, protest procedures, cost for proposal preparation, confidentiality, intellectual property, subcontracting, advertising of the contract award, compliance with laws and regulations, insurance, and indemnity.

9. Requirements for proposal preparation

A consistent structure in terms of content, information, and documents types simplifies things for the people evaluating the proposals. Describe the requirements in simple language avoiding jargons.

10. Process Schedule

Clearly and concisely present the timeline for the steps leading to the final decision, such as the dates and deadlines for submitting the letter of intent, sending questions and extension requests, attending the pre-proposal conference, withdrawing and submitting the proposal, filing a protest, etc.

12. Contacts

Include a complete list of people to contact for information on the RFP, or with any other questions. Incorporate their name, title, responsibilities, and the various ways of contacting them into this list.

3.7 Trade study report

The trade study report documents the analysis and conclusion of a trade study. This template is adapted from [6].

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1. Scope

2. Trade study team members

Names and specialties of the contributors to the trade study.

3. Referenced documents

Provide a list of the document references in this specification. The documents shall be uniquely identifiable.

4. Functional and performance and design requirements

A.

B.

C.

5. Design approaches

Describes the design approaches considered and their significant characteristics.

Alternative 1

Alternative 2

Alternative 3

...

6. Comparison matrix

Feature or design requirement	Alternative 1	Alternative 2	Alternative 3
Requirement 1			
Requirement 1			
Requirement 1			
...			

7. Design approach recommended

A.

B.

C.

3.8 Systems engineering plan

The Systems engineering plan (SEMP) documents the ways of working with systems engineering in the project. This template is adapted from [5].

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1. Scope

2. Referenced documents

3. Systems engineering process

3.1 **Systems engineering planning** — decision database (deliverables), process inputs, technical objectives, work breakdown structure, training, standards and procedures, resource allocation, constraints, work authorisation, verification planning.

3.2 **Requirements analysis** — reliability and availability; maintainability, supportability, and integrated logistics support (ILS); survivability; electromagnetic compatibility; human engineering and human systems integration; safety, health hazards, and environmental impact; system security; producibility; test and evaluation; testability and integrated diagnostics; computer resources;M transportability; infrastructure support; other engineering specialties.

3.3 **Functional analysis** — Scope, approach, method, procedures tools (system-level functional block diagram).

3.4 **Synthesis** — approach, methods to transform the functional architecture into a physical architecture, to define alternative system concepts, to define physical interfaces, and to select preferred product and process solutions.

3.5 **System analysis and control** — trade studies, system/cost effectiveness analysis, risk management, configuration management, interface management, data management, system engineering master schedule (SEMS), technical performance measurement (TPM), technical reviews (design reviews), supplier control, requirements traceability.

4. Risk Management

Process, prioritised main risks in the different phases of the project, avoidance, mitigation, removal, issue handling.

5. Transitioning critical technologies

Activities, risks, criteria for selecting technologies and for transitioning these technologies.

6. Integration of the system engineering effort

Team organisation, technology verification, process proofing, manufacturing of engineering test articles, development test and evaluation, implementation of software designs for system end items, sustaining engineering and problem solution support, other systems engineering implementation tasks.

7. Additional system engineering activities

Long-lead items, engineering tools, design to cost/cost as an independent variable, value engineering, system integration plan, compatibility with supporting activities, other plans and controls.

8. Systems engineering schedule

Systems engineering master schedule (SEMS), systems engineering detailed schedule (SEDS).

9. Systems engineering process metrics

Cost and schedule performance measurement, other process control technique (control charts).

10. Systems engineering process metrics

Cost and schedule performance measurement, other process control technique (control charts).

11. Other

General information that aids in understanding this document e.g., background information, glossary etc. can be included here.

Bibliography

[1] Interface Design Description (IDD), DI-IPSC-81436, 1994.

[2] Software Test Description (STD), DI-IPSC-81439, 1994.

[3] System/Subsystem Design Description (SSDD), DI-IPSC-81432, 1994.

[4] System/Subsystem Specification (SSS), DI-IPSC-81431, 1994.

[5] Benjamin S. Blanchard and Wolter J. Fabrycky. *Systems Engineering and Analysis*. Persons Education, Inc., 5th ed. edition, 2011.

[6] INCOSE. *INCOSE Systems Engineering Handbook v. 3.2*. INCOSE, 2010.

[7] NASA. Appendix N: Guidance on Technical Peer Reviews/Inspections, NASA Systems Engineering Handbook, 1995.

Appendix A

Glossary

This glossary lists the specific terms and abbreviation used in the exercises and in the case work.

Bill of material	A bill of materials (sometimes bill of material or BOM) is a list of the raw materials, sub-assemblies, intermediate assemblies, sub-components, components, parts and the quantities of each needed to manufacture an end product.
C2	Command and Control
CDR	Critical Design Review
CMMI	Capacity Maturity Model Integration
COP	Common Operations Picture
COTS	Commercially available Off-The-Shelf (COTS) is a term defining a non-developmental item (NDI) of supply that is both commercial and sold in substantial quantities in the commercial marketplace, so it can be procured and utilised under a supplier contract.
EW	Electronic Warfare
FAI	First Article Inspection is one of the primary methods for the inspection and testing of vendor components. The testing of a pre-production sample is considered essential in the process of approving an order or contract. The FAI should determine if the product meets acceptance requirements and quality control requirements.
GFE	Government Furnished Equipment
ICT	Information Communication Technology
INCOSE	The International Council on Systems Engineering
LRIP	Low rate initial production (LRIP) is a term commonly used in military weapon projects/programs to designate the phase of initial, small-quantity production of a systems.
LRU	Line Replaceable Unit
MIP	Multi-lateral Interoperability Programme
MSR	Milestone Review
MWS	Missile Warning System
PDR	Preliminary Design Review
PUID	The Project uniques identifier (PUID) is a tag to uniquely identify a delivery item of a project such as e.g., a document.
QA	Quality Assurance
QR	Qualification Review
RFP	Request for Proposal

SAT	Site Acceptance Test
SEIT	Systems Engineering and Integration Team
SOW	A statement of work (SOW) is a formal document that captures and defines the work activities, deliverables and timeline a vendor will execute against in performance of specified work for a client.
SRR	System Requirement Review
TRR	Test Readiness Review
U.C. Req.	Use Case Requirement