
FRAMEWORKS FOR SELECTED SYSTEM ENGINEERING REPORTS

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1. INTRODUCTION

1.1 PURPOSE OF THIS BOOK

Businesses and projects rely on well-structured reports to ensure accurate communication about goals and objectives, requirements, designs, measuring and recording progress, etc. There is some truth in the saying that engineers don't make products, but that they make reports describing the products to be made by other members of the technical team. Unfortunately, many engineering and management reports are, for a variety of reasons, not conveying its message as clear as it should. In order to alleviate this problem - particularly for engineers and managers in the early stages of their careers – this book contains suggested **frameworks** for a selection of commonly used system engineering reports. (Two other books by the same authors contain frameworks for *project management reports* and *business management reports*.)

This book is intended as a **reference guide**, from which ideas can be sourced about the typical structure and contents of commonly used system engineering reports. The book does not provide blueprints for all reports that a system engineer might ever have to write, but it provides **guidelines** which should be **tailored** and **adapted** by common sense and experience, in order to suit specific circumstances.

The philosophy underlying this book is: **contents follow structure** - i.e. first carefully think about, and decide upon a report's structure, and then systematically fill in the contents. It is often when bits and pieces of contents are randomly gathered and combined, that irrelevant ideas are included in a report. Many report writers are reluctant to discard good-looking and nice-sounding ideas, once it had been gathered with great effort. However, when a report structure is defined first, the gathering of information becomes focused, and unnecessary material is either not collected at all, or it can be filtered out systematically.

It is not suggested here that once a report structure had been chosen, that this structure may then never be changed. However, by having a baseline structure, systematic and rational changes - instead of haphazard ones - can be made to the structure, in order to ensure an effective report. Very few people would first build a house and draw up the plans afterwards, but this mistake is far too often made when engineering and management reports are prepared.

1.2 SCOPE OF THIS BOOK

This book is about **frameworks** for system engineering reports typically compiled in engineering businesses. It is neither intended as a handbook on report writing (refer to NAGLE 1996 for this), nor as a detailed textbook on system engineering. However, a few thoughts on the major generic

elements of reports and on report quality assurance are provided in this chapter; while the main concepts of system engineering are addressed in Chapter 2.

Fifteen types of system engineering reports are addressed in subsequent chapters of this book. Each of these reports is briefly discussed in terms of its typical purpose and scope, followed by a suggested framework for the report.

1.3 GENERIC ELEMENTS OF A REPORT

This section provides an overview of the typical major elements of engineering and management reports. It is again emphasised that the layout and contents of each of these elements must be tailored to suit specific requirements.

1.3.1 TITLE PAGE

The title page of a report should typically show the report's title, the authors' names, the issue date, name of the organisation issuing the report, report reference number, revision status (edition number), and a list of people to whom the report is distributed.

1.3.2 EXECUTIVE SUMMARY / ABSTRACT

Providing a concise summary of engineering and management reports tells readers what the report is all about and enables them to ascertain whether the report contains relevant information for them, or maybe rather for someone else in their team. The summary should provide an overview of the whole report, and should not merely be a copy of the introduction or the final conclusions. It is normally included just before or just after the table of contents, but it might also be a section in the introductory chapter. After reading the executive summary / abstract, there should be no doubt in the reader's mind about:

- the reasons why the report was compiled;
- the issues addressed in the report; and
- the main conclusions and/or recommendations made in the report.

1.3.3 TABLE OF CONTENTS

Besides a normal table of contents, a list of appendices, a list of tables, and a list of figures and/or photographs, plus the relevant page numbers, can also be included in order to:

- provide the reader with an overview of what information is provided in the report by means of appendices, tables, figures, and photographs; and
- to make it easier for the reader to locate these when referred to in the text.

2. SYSTEM ENGINEERING

2.1 THE SYSTEM ENGINEERING PROCESS

System engineering is an extensive and complex process, best applied to large development projects such as those undertaken in the military-, space- and aviation industries. The *system engineering process* can be defined as the application of scientific and engineering efforts to:

- Transform a user requirement into a system specification - which defines system performance parameters and the preferred system components and system configuration.
- Co-ordinate the acquisition of the defined system components, and their integration into a system which satisfies the user requirement.

System engineering is a multi-faceted, iterative process of problem definition, analysis, design, construction, test and evaluation, commissioning, operational support, and finally phase-out and disposal. It requires attention to a wide variety of aspects such as interfacing, reliability, availability, maintainability, safety, survivability, producibility, ergonomics, etc. To co-ordinate the system engineering process, a *System Engineer* - supported by a team of technical specialists - is required. The system engineering process can only be executed sensibly if it is done systematically according to a well defined *System Engineering Management Plan (SEMP)*. Execution of the plan normally takes place in phases, and will result in various other system engineering reports – all aimed at producing a solution to satisfy the user requirement, within the constraints of cost, schedule, and achievable technical performance.

The aim of this chapter is not to treat system engineering in detail, but merely to set the scene for defining frameworks for some of the main reports resulting from the system engineering process. More information about system engineering can be found in sources such as ASLAKSEN & BELCHER 1992, BLANCHARD & FABRYCKY 1990, BOARDMAN 1990, KASSER 1995, KAYTON 1997, RHOADS 1983, and VERMA & FABRYCKY 1997.

2.2 SYSTEM LIFE CYCLE

The development and utilisation of any complex engineering system typically take place in four main life cycle phases, as shown in Table 2-1 and Table 2-2. Names of reports for which frameworks are provided in subsequent chapters are printed in ***bold italics*** in Table 2-2. Overlaps between the life cycle phases, and iteration, are often essential. After each major system engineering phase, all reports compiled up to that stage should be thoroughly reviewed and updated where necessary.

4. SYSTEM ENGINEERING MANAGEMENT PLAN

4.1 PURPOSE AND SCOPE OF A SYSTEM ENGINEERING MANAGEMENT PLAN

A System Engineering Management Plan (SEMP) defines all the engineering tasks identified during project planning, and it should convey information about the system engineer's intended role in the system acquisition process as defined in Table 2-2. The SEMP is a system-level report, from which all role players can see what the overall technical *game plan* is, and which processes and reports are required in order to meet the user requirements.

A high-level SEMP is compiled by the system engineer for the whole project, and then more detailed plans can be compiled by sub-system engineers. (This depends on the project size and its management structure.) Because it is impossible to plan a major project in detail for many years ahead, it is more sensible to compile the detailed plans phase-by-phase (refer to Table 2-2); and to review the system level SEMP before each new phase is entered. As for any other plan, a SEMP should address at least the following four basic elements:

- a definition of the tasks to be executed;
- a definition of resources required to execute the defined tasks;
- a schedule of activities; and
- an allocation of responsibilities.

4.2 FRAMEWORK FOR A SYSTEM ENGINEERING MANAGEMENT PLAN

Exhibit 2 contains an example of a framework for a System Engineering Management Plan. This framework is closely related to that of a project plan, as presented in the authors' book on frameworks for project management reports. (Also refer to MIL-STD-499.)

Exhibit 2: Framework for a System Engineering Management Plan

1. INTRODUCTION
Describe the purpose and the scope of the document; and pay special attention to a clear description of the goals pursued with the plan, and the boundaries within which the plan will be executed. It is important to make it very clear for which phase of system acquisition (refer to Tables 2-1 and 2-2) the System Engineering Management Plan is compiled; and also at which level of the system hierarchy (refer to Tables 2-3 and 2-4) it is done.
2. SYSTEM DESCRIPTION
Describe the system for which the SEMP is compiled by means of a product breakdown structure, system block-and functional diagrams, and a description of system functions.

3. SYSTEM ENGINEERING MANAGEMENT

This chapter of the System Engineering Management Plan is used to provide a task breakdown and task description for the system engineering process. For each system acquisition phase, four main categories of system engineering activities are typically addressed:

- System Design;
- Integration / Implementation;
- Test and Evaluation; and
- Technical Risk Reduction.

The level of detail to which each of these categories is addressed, strongly depends on the life-cycle phase for which it is considered; and also on the level in the system hierarchy for which the SEMP is compiled. During the concept exploration phase, the main emphasis will be on system design for functionality, while not too much emphasis will be placed on risk reduction. This situation will reverse in the industrialisation phase.

Each of the above four categories can further be divided into a number of tasks (as shown in sections 3.1 through 3.4 of this Exhibit), and then discussed in terms of:

- Inputs - describing all inputs required in order to execute each task.
- Activities - describing all activities required for execution of each task.
- Outputs - describing the expected outputs of each task.

3.1 SYSTEM DESIGN

System design is the process whereby new or additional data is generated and added to the system data pack. It involves a top-down allocation of system functions to subsequent lower levels in the system hierarchy, and then a bottom-up design of components and their interfaces in order to meet the specified functional and other requirements. The data pack from each acquisition phase is used as the baseline from which to start the next phase - with the data pack from the industrialisation phase eventually being used as the production baseline. The tasks typically addressed by the system engineer (and by sub-system engineers down to the lowest level of the system hierarchy), as part of system design, are:

- System analysis (interpretation and translation of user requirements to functional requirements, grouping of functional requirements, and identification and evaluation of potential functional configurations).
- System synthesis (definition of functional units and appropriate effectiveness measures - i.e. parameters, values and tolerances).
- System specification (translation of functional requirements to requirements for roll-down to individual technical teams who will perform detail design).

It is important to note that it is not only the *system* and its lower level items that are designed as part of the system engineering process, but also aspects such as test equipment, the logistic support system, quality assurance, etc.

11. RESEARCH THESIS

11.1 PURPOSE AND SCOPE OF A RESEARCH THESIS

One of the definitions in the Oxford dictionary, for a thesis is: "a lengthy written essay submitted by a candidate for a university degree". Many engineers working on complex system developments undertake part-time university research in order to help with their system design. Therefore this chapter addresses a framework for a research thesis in engineering. Although different universities and different thesis supervisors have different ideas as to what the contents of a thesis should be, generically a thesis is a description of research methodologies and research results contributing to the universal pool of knowledge. Like any other report, a thesis should have a properly developed, logical story line. (The term *dissertation* is sometimes used as a synonym for *thesis*. Although *dissertation* is often reserved for a doctoral thesis, there is no general agreement on this matter.)

11.2 FRAMEWORK FOR A RESEARCH THESIS

Exhibit 12 contains an example of a framework for a research thesis. The structure of a thesis depends very much on the subject matter and on the individual researcher's approach. The framework provided is for research where an engineering problem is identified, where one or more potential solutions are proposed and investigated experimentally, and where conclusions are drawn. This process is typically used for engineering research which involves extensive experimental work. For research fields involving less experimental work, the framework requires tailoring.

Exhibit 12: Framework for a Research Thesis

1. INTRODUCTION
<i>1.1 PROBLEM STATEMENT</i>
Define the research problem addressed by the thesis - i.e. clearly state the "question" for which an "answer" was searched. (It is senseless trying to find an answer if the question is not known.) Following from the problem statement, one or more hypotheses can be formulated, whereby a certain solution to the problem is postulated. The research is then aimed at proving the hypotheses either true or false.
<i>1.2 MOTIVATION, GOALS AND OBJECTIVES</i>
Briefly describe why the research was undertaken and what the goals and objectives were. (Although the latter two terms are sometimes interchanged, "goals" can be defined as broad targets, while "objectives" can be defined as specific destinations.)
<i>1.3 BOUNDARIES OF THE RESEARCH</i>
Clearly state what issues were addressed by the research; and also which important related issues were not addressed. (A short motivation as to why some issues were considered, and others not, can also be given.)