Software Requirements Specification for ProgName: subtitle describing software

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Contents

Revision History

Date	Version	Notes
Date 1	1.0	Notes
Date 2	1.1	Notes

1 Reference Material

This section records information for easy reference.

1.1 Table of Units

Throughout this document SI (Système International d'Unités) is employed as the unit system. In addition to the basic units, several derived units are used as described below. For each unit, the symbol is given followed by a description of the unit and the SI name.

symbol	unit	SI
m	length	metre
kg	mass	kilogram
s	time	second
°C	temperature	centigrade
J	energy	Joule
W	power	Watt ($\mathrm{W} = \mathrm{J\,s^{-1}}$)

[Only include the units that your SRS actually uses. —TPLT]

[Derived units, like newtons, pascal, etc, should show their derivation (the units they are derived from) if their constituent units are in the table of units (that is, if the units they are derived from are used in the document). For instance, the derivation of pascals as $\mathrm{Pa} = \mathrm{N\,m^{-2}}$ is shown if newtons and m are both in the table. The derivations of newtons would not be shown if kg and s are not both in the table. —TPLT]

[The symbol for units named after people use capital letters, but the name of the unit itself uses lower case. For instance, pascals use the symbol Pa, watts use the symbol W, teslas use the symbol T, newtons use the symbol N, etc. The one exception to this is degree Celsius. Details on writing metric units can be found on the NIST web-page. —TPLT]

1.2 Table of Symbols

The table that follows summarizes the symbols used in this document along with their units. The choice of symbols was made to be consistent with the heat transfer literature and with existing documentation for solar water heating systems. The symbols are listed in alphabetical order.

symbol	unit	description
A_C	$\mathrm{m^2}$	coil surface area
A_{in}	$\mathrm{m^2}$	surface area over which heat is transferred in

[Use your problems actual symbols. The si package is a good idea to use for units.

—TPLT]

1.3 Abbreviations and Acronyms

symbol	description
A	Assumption
DD	Data Definition
GD	General Definition
GS	Goal Statement
IM	Instance Model
LC	Likely Change
PS	Physical System Description
R	Requirement
SRS	Software Requirements Specification
ProgName	[put an expanded version of your program name here (as appropriate) —TPLT]
T	Theoretical Model

[Add any other abbreviations or acronyms that you add —TPLT]

[This SRS template is based on Smith and Lai (2005); Smith et al. (2007). It will get you started. You should not modify the section headings, without first discussing the change with the course instructor. Modification means you are not following the template, which loses some of the advantage of a template, especially standardization. Although the bits shown below do not include type information, you may need to add this information for your problem. If you are unsure, please can ask the instructor. —TPLT]

[Feel free to change the appearance of the report by modifying the LaTeX commands. —TPLT]

[This template document assumes that a single program is being documented. If you are documenting a family of models, you should start with a commonality analysis. A separate template is provided for this. For program families you should look at Smith (2006); Smith et al. (2017). —TPLT]

[The SRS is not generally written, or read, sequentially. The SRS is a reference document. It is generally read in an ad hoc order, as the need arises. For writing an SRS, and for reading one for the first time, the suggested order of sections is:

- Goal Statement
- Instance Models
- Requirements
- Introduction
- Specific System Description

—TPLT]

[Guiding principles for the SRS document:

- Do not repeat the same information at the same abstraction level. If information is repeated, the repetition should be at a different abstraction level. For instance, there will be overlap between the scope section and the assumptions, but the scope section will not go into as much detail as the assumptions section.

—TPLT]

[The template description comments should be disabled before submitting this document for grading. —TPLT]

[You can borrow any wording from the text given in the template. It is part of the template, and not considered an instance of academic integrity. Of course, you need to cite the source of the template. —TPLT]

2 Introduction

[The introduction section is written to introduce the problem. It starts general and focuses on the problem domain. The general advice is to start with a paragraph or two that describes the problem, followed by a "roadmap" paragraph. A roadmap orients the reader by telling them what sub-sections to expect in the Introduction section. —TPLT]

2.1 Purpose of Document

[This section summarizes the purpose of the SRS document. It does not focus on the problem itself. The problem is described in the "Problem Description" section (Section 4.1). The purpose is for the document in the context of the project itself, not in the context of the CAS 741 course. Although the "purpose" of the document is to get a grade in 741, you should not mention this. Instead, "fake it" as if this is a real project. The purpose section will be similar between projects. The purpose of the document is the purpose of the SRS, including communication, planning for the design stage, etc. —TPLT]

2.2 Scope of Requirements

[Modelling the real world requires simplification. The full complexity of the actual physics, chemistry, biology is too much for existing models, and for existing computational solution techniques. Rather than say what is in the scope, it is usually easier to say what is not. You can think of it as the scope is initially everything, and then it is constrained to create the actual scope. For instance, the problem can be restricted to 2 dimensions, or it can ignore the effect of temperature (or pressure) on the material properties, etc. —TPLT]

[The scope section is related to the assumptions section (Section 4.2.1). However, the scope and the assumptions are not at the same level of abstraction. The scope is at a high level. The focus is on the "big picture" assumptions. The assumptions section lists, and describes, all of the assumptions. —TPLT]

2.3 Characteristics of Intended Reader

[This section summarizes the skills and knowledge of the readers of the SRS. It does NOT have the same purpose as the "User Characteristics" section (Section 3.2). The intended readers are the people that will read, review and maintain the SRS. They are the people that will conceivably design the software that is intended to meet the requirements. The user, on the other hand, is the person that uses the software that is built. They may never read this SRS document. Of course, the same person could be a "user" and an "intended reader." —TPLT]

[The intended reader characteristics should be written as unambiguously and as specifically as possible. Rather than say, the user should have an understanding of physics, say what kind of physics and at what level. For instance, is high school physics adequate, or should the reader have had a graduate course on advanced quantum mechanics? —TPLT]

2.4 Organization of Document

[This section provides a roadmap of the SRS document. It will help the reader orient themselves. It will provide direction that will help them select which sections they want to read, and in what order. This section will be similar between project. —TPLT]

3 General System Description

This section provides general information about the system. It identifies the interfaces between the system and its environment, describes the user characteristics and lists the system constraints. [This text can likely be borrowed verbatim. —TPLT]

3.1 System Context

[Your system context will include a figure that shows the abstract view of the software. Often in a scientific context, the program can be viewed abstractly following the design pattern of Inputs → Calculations → Outputs. The system context will therefore often follow this pattern. The user provides inputs, the system does the calculations, and then provides the outputs to the user. The figure should not show all of the inputs, just an abstract view of the main categories of inputs (like material properties, geometry, etc.). Likewise, the outputs should be presented from an abstract point of view. In some cases the diagram will show other external entities, besides the user. For instance, when the software product is a library, the user will be another software program, not an actual end user. —TPLT]

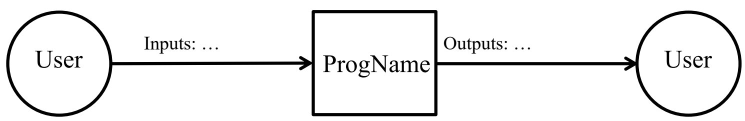


Figure 1: System Context

[For each of the entities in the system context diagram its responsibilities should be listed. Whenever possible the system should check for data quality, but for some cases the user will need to assume that responsibility. —TPLT]

- User Responsibilities:
  -
- ProgName Responsibilities:
  - Detect data type mismatch, such as a string of characters instead of a floating point number
  -

3.2 User Characteristics

[This section summarizes the knowledge/skills expected of the user. Measuring usability, which is often a required non-function requirement, requires knowledge of a typical user. As mentioned above, the user is a different role from the "intended reader," as given in Section 2.3. As in Section 2.3, the user characteristics should be specific an unambiguous. For instance, "The end user of ProgName should have an understanding of undergraduate Level 1 Calculus and Physics." —TPLT]

3.3 System Constraints

[You may not have any system constraints —TPLT]

4 Specific System Description

This section first presents the problem description, which gives a high-level view of the problem to be solved. This is followed by the solution characteristics specification, which presents the assumptions, theories, definitions and finally the instance models. [Add any project specific details that are relevant for the section overview. —TPLT]

4.1 Problem Description

ProgName is [what problem does your program solve? —TPLT]

4.1.1 Terminology and Definitions

This subsection provides a list of terms that are used in the subsequent sections and their meaning, with the purpose of reducing ambiguity and making it easier to correctly understand the requirements:

-

4.1.2 Physical System Description

The physical system of ProgName, as shown in Figure ?, includes the following elements:

PS1:

PS2: ...

[A figure here may make sense for most SRS documents —TPLT]

4.1.3 Goal Statements

Given the [inputs —TPLT], the goal statements are:

GS1: [One sentence description of the goal. There may be more than one. Each Goal should have a meaningful label. —TPLT]

4.2 Solution Characteristics Specification

The instance models that govern ProgName are presented in Subsection 4.2.5. The information to understand the meaning of the instance models and their derivation is also presented, so that the instance models can be verified.

4.2.1 Assumptions

This section simplifies the original problem and helps in developing the theoretical model by filling in the missing information for the physical system. The numbers given in the square brackets refer to the theoretical model [T], general definition [GD], data definition [DD], instance model [IM], or likely change [LC], in which the respective assumption is used.

A1: [Short description of each assumption. Each assumption should have a meaningful label. Use cross-references to identify the appropriate traceability to T, GD, DD etc., using commands like dref, ddref etc. —TPLT]

4.2.2 Theoretical Models

This section focuses on the general equations and laws that ProgName is based on. [Modify the examples below for your problem, and add additional models as appropriate. —TPLT]

Number	T1
Label	**Conservation of thermal energy**
Equation	$-\nabla \cdot \mathbf{q} + g = \rho C \frac{\partial T}{\partial t}$
Description	The above equation gives the conservation of energy for transient heat transfer in a material of specific heat capacity C ($\mathrm{J\,kg^{-1}\,{}^{\circ}C^{-1}}$) and density ρ ($\mathrm{kg\,m^{-3}}$), where $\mathbf{q}$ is the thermal flux vector ($\mathrm{W\,m^{-2}}$), g is the volumetric heat generation ($\mathrm{W\,m^{-3}}$), T is the temperature (°C), t is time (s), and ∇ is the gradient operator. For this equation to apply, other forms of energy, such as mechanical energy, are assumed to be negligible in the system (A**??**). In general, the material properties (ρ and C) depend on temperature.
Source	http://www.efunda.com/formulae/heat_transfer/conduction/overview_cond.cfm
Ref. By	GD**??**

4.2.3 General Definitions

This section collects the laws and equations that will be used in deriving the data definitions, which in turn are used to build the instance models. [Some projects may not have any content for this section, but the section heading should be kept. —TPLT] [Modify the examples below for your problem, and add additional definitions as appropriate. —TPLT]

Number	GD1
Label	**Newton's law of cooling**
SI Units	$\mathrm{W\,m^{-2}}$
Equation	$q(t) = h\Delta T(t)$
Description	Newton's law of cooling describes convective cooling from a surface. The law is stated as: the rate of heat loss from a body is proportional to the difference in temperatures between the body and its surroundings. $q(t)$ is the thermal flux ($\mathrm{W\,m^{-2}}$). h is the heat transfer coefficient, assumed independent of T (A**??**) ($\mathrm{W\,m^{-2}\,°C^{-1}}$). $\Delta T(t) = T(t) - T_{\text{env}}(t)$ is the time-dependent thermal gradient between the environment and the object (°C).
Source	Citation here
Ref. By	DD1, DD**??**

Detailed derivation of simplified rate of change of temperature

[This may be necessary when the necessary information does not fit in the description field. —TPLT]

4.2.4 Data Definitions

This section collects and defines all the data needed to build the instance models. The dimension of each quantity is also given. [Modify the examples below for your problem, and add additional definitions as appropriate. —TPLT]

Number	DD1
Label	**Heat flux out of coil**
Symbol	q_C
SI Units	$\mathrm{W\,m^{-2}}$
Equation	$q_C(t) = h_C(T_C - T_W(t))$, over area A_C
Description	T_C is the temperature of the coil (°C). T_W is the temperature of the water (°C). The heat flux out of the coil, q_C ($\mathrm{W\,m^{-2}}$), is found by assuming that Newton's Law of Cooling applies (A**??**). This law (GD1) is used on the surface of the coil, which has area A_C ($\mathrm{m^2}$) and heat transfer coefficient h_C ($\mathrm{W\,m^{-2}\,°C^{-1}}$). This equation assumes that the temperature of the coil is constant over time (A**??**) and that it does not vary along the length of the coil (A**??**).
Sources	Citation here
Ref. By	IM1

4.2.5 Instance Models

This section transforms the problem defined in Section 4.1 into one which is expressed in mathematical terms. It uses concrete symbols defined in Section 4.2.4 to replace the abstract symbols in the models identified in Sections 4.2.2 and 4.2.3.

The goals [reference your goals —TPLT] are solved by [reference your instance models —TPLT]. [other details, with cross-references where appropriate. —TPLT] [Modify the examples below for your problem, and add additional models as appropriate. —TPLT]

Number	IM1
Label	**Energy balance on water to find T_W**
Input	m_W, C_W, h_C, A_C, h_P, A_P, t_{final}, T_C, T_{init}, $T_P(t)$ from IM**??** The input is constrained so that $T_{\text{init}} \leq T_C$ (A**??**)
Output	$T_W(t)$, $0 \leq t \leq t_{\text{final}}$, such that $\frac{dT_W}{dt} = \frac{1}{\tau_W}[(T_C - T_W(t)) + \eta(T_P(t) - T_W(t))]$, $T_W(0) = T_P(0) = T_{\text{init}}$ (A**??**) and $T_P(t)$ from IM**??**
Description	T_W is the water temperature (°C). T_P is the PCM temperature (°C). T_C is the coil temperature (°C). $\tau_W = \frac{m_W C_W}{h_C A_C}$ is a constant (s). $\eta = \frac{h_P A_P}{h_C A_C}$ is a constant (dimensionless). The above equation applies as long as the water is in liquid form, $0 < T_W < 100^o$C, where 0^oC and 100^oC are the melting and boiling points of water, respectively (A**??**, A**??**).
Sources	Citation here
Ref. By	IM**??**

Derivation of ...

[May be necessary to include this subsection in some cases. —TPLT]

4.2.6 Data Constraints

Table 1 shows the data constraints on the input output variables. The column for physical constraints gives the physical limitations on the range of values that can be taken by the variable. The column for software constraints restricts the range of inputs to reasonable values. The constraints are conservative, to give the user of the model the flexibility to experiment with unusual situations. The column of typical values is intended to provide a feel for a common scenario. The uncertainty column provides an estimate of the confidence with which the physical quantities can be measured. This information would be part of the input if one were performing an uncertainty quantification exercise.

The specification parameters in Table 1 are listed in Table 2.

(*) [you might need to add some notes or clarifications —TPLT]

Table 1: Input Variables

Var	Physical Constraints	Software Constraints	Typical Value	Uncertainty
L	$L > 0$	$L_{\text{min}} \leq L \leq L_{\text{max}}$	1.5 m	10%

Table 2: Specification Parameter Values

Var	Value
L_{min}	0.1 m

4.2.7 Properties of a Correct Solution

A correct solution must exhibit [fill in the details —TPLT]. [These properties are in addition to the stated requirements. There is no need to repeat the requirements here. These additional properties may not exist for every problem. Examples include conservation laws (like conservation of energy or mass) and known constraints on outputs (which are usually summarized in tabular form. A sample table is shown in Table 3 —TPLT]

Table 3: Output Variables

Var	Physical Constraints
T_W	$T_{\text{init}} \leq T_W \leq T_C$ (by A??)

5 Requirements

This section provides the functional requirements, the business tasks that the software is expected to complete, and the nonfunctional requirements, the qualities that the software is expected to exhibit.

5.1 Functional Requirements

R1: [Requirements for the inputs that are supplied by the user. This information has to be explicit. —TPLT]

R2: [It isn't always required, but often echoing the inputs as part of the output is a good idea. —TPLT]

R3: [Calculation related requirements. —TPLT]

R4: [Verification related requirements. —TPLT]

R5: [Output related requirements. —TPLT]

6 Likely Changes

LC1: [Give the likely changes, with a reference to the related assumption (aref), as appropriate. —TPLT]

7 Unlikely Changes

LC2: [Give the likely changes, with a reference to the related assumption (aref), as appropriate. —TPLT]

8 Traceability Matrices and Graphs

The purpose of the traceability matrices is to provide easy references on what has to be additionally modified if a certain component is changed. Every time a component is changed, the items in the column of that component that are marked with an "X" may have to be modified as well. Table 4 shows the dependencies of theoretical models, general definitions, data definitions, and instance models with each other. Table 5 shows the dependencies of instance models, requirements, and data constraints on each other. Table 6 shows the dependencies of theoretical models, general definitions, data definitions, instance models, and likely changes on the assumptions.

[You will have to modify these tables for your problem. —TPLT]

The purpose of the traceability graphs is also to provide easy references on what has to be additionally modified if a certain component is changed. The arrows in the graphs represent dependencies. The component at the tail of an arrow is depended on by the component at the head of that arrow. Therefore, if a component is changed, the components that it points to should also be changed. Figure **??** shows the dependencies of theoretical models, general definitions, data definitions, instance models, likely changes, and assumptions on each other. Figure **??** shows the dependencies of instance models, requirements, and data constraints on each other.

9 Values of Auxiliary Constants

[Show the values of the symbolic parameters introduced in the report. —TPLT]

[The definition of the requirements will likely call for SYMBOLIC_CONSTANTS. Their values are defined in this section for easy maintenance. —TPLT]

	T1	T??	T??	GD1	GD??	DD1	DD??	DD??	DD??	IM1	IM??	IM??	IM??
T1													
T??			X										
T??													
GD1													
GD??	X												
DD1				X									
DD??				X									
DD??													
DD??								X					
IM1					X	X	X				X		
IM??					X		X		X	X			X
IM??		X											
IM??		X	X				X	X	X		X		

Table 4: Traceability Matrix Showing the Connections Between Items of Different Sections

	IM1	IM??	IM??	IM??	4.2.6	R??	R??
IM1		X				X	X
IM??	X			X		X	X
IM??						X	X
IM??		X				X	X
R??							
R??						X	
R??					X		
R2	X	X				X	X
R??	X						
R??		X					
R??			X				
R??				X			
R4			X	X			
R??		X					
R??		X					

Table 5: Traceability Matrix Showing the Connections Between Requirements and Instance Models

	A??	A??	A??	A??	A??	A??	A??	A??	A??	A??	A??	A??	A??	A??	A??	A??	A??	A??	A??
T1	X																		
T??																			
T??																			
GD1		X																	
GD??			X	X	X	X													
DD1							X	X	X										
DD??			X	X						X									
DD??																			
DD??																			
IM1											X	X		X	X	X			X
IM??												X	X			X	X	X	
IM??														X					X
IM??													X					X	
LC??				X															
LC??								X											
LC??									X										
LC??											X								
LC??												X							
LC??															X				

Table 6: Traceability Matrix Showing the Connections Between Assumptions and Other Items

References

W. Spencer Smith. Systematic development of requirements documentation for general purpose scientific computing software. In *Proceedings of the 14th IEEE International Requirements Engineering Conference, RE 2006*, pages 209–218, Minneapolis / St. Paul, Minnesota, 2006. URL http://www.ifi.unizh.ch/req/events/RE06/.

W. Spencer Smith and Lei Lai. A new requirements template for scientific computing. In J. Ralyté, P. Ȧgerfalk, and N. Kraiem, editors, *Proceedings of the First International Workshop on Situational Requirements Engineering Processes – Methods, Techniques and Tools to Support Situation-Specific Requirements Engineering Processes, SREP'05*, pages 107–121, Paris, France, 2005. In conjunction with 13th IEEE International Requirements Engineering Conference.

W. Spencer Smith, Lei Lai, and Ridha Khedri. Requirements analysis for engineering computation: A systematic approach for improving software reliability. *Reliable Computing, Special Issue on Reliable Engineering Computation*, 13(1):83–107, February 2007.

W. Spencer Smith, John McCutchan, and Jacques Carette. Commonality analysis for a family of material models. Technical Report CAS-17-01-SS, McMaster University, Department of Computing and Software, 2017.

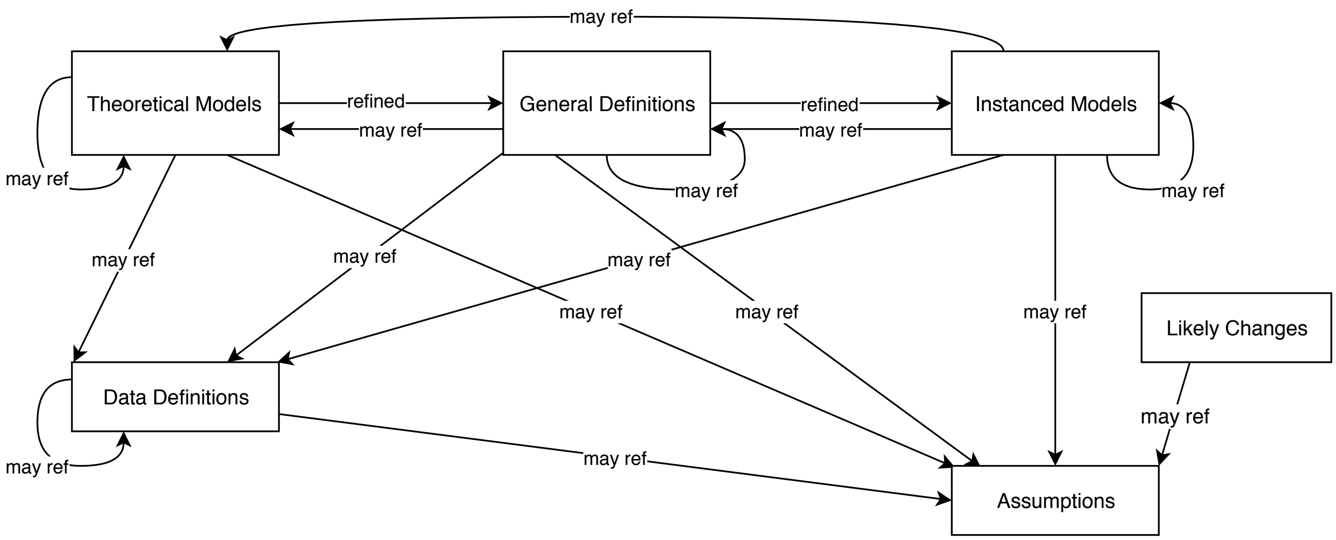
[The following is not part of the template, just some things to consider when filing in the template. —TPLT]
[Grammar, flow and LaTeXadvice:

- For Mac users `*.DS_Store` should be in `.gitignore`
- LaTeX and formatting rules
  - Variables are italic, everything else not, includes subscripts (link to document)
    - Conventions
    - Watch out for implied multiplication
  - Use BibTeX
  - Use cross-referencing
- Grammar and writing rules
  - Acronyms expanded on first usage (not just in table of acronyms)
  - "In order to" should be "to"

—TPLT]
[Advice on using the template:

- Difference between physical and software constraints
- Properties of a correct solution means *additional* properties, not a restating of the requirements (may be "not applicable" for your problem). If you have a table of output constraints, then these are properties of a correct solution.
- Assumptions have to be invoked somewhere
- "Referenced by" implies that there is an explicit reference
- Think of traceability matrix, list of assumption invokations and list of reference by fields as automatically generatable
- If you say the format of the output (plot, table etc), then your requirement could be more abstract

—TPLT]
[The relationships between the parts of the document are show in the following figure —TPLT]


may ref
Theoretical Models
refined
may ref
General Definitions
refined
may ref
Instanced Models
may ref
may ref
may ref
may ref
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Likely Changes
Data Definitions
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Assumptions