Requirements Specifications Assignment

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A Requirements Specifications document serves many purposes. Its primary purpose, however, is to ensure that you are setting your sights correctly to develop a “solution” that appropriately addresses the problem you are dealing with. It sets the objectives of the project and provides a means to measure the performance of the final design. It also proves convenient in opening communication channels with your client in a structured, written form. From the developer's perspective, it should answer the question “how do I know when I am complete?”.

Developing a meaningful set of specifications involves understanding

- the client's needs and wants, and the boundary between the two;
- what practical and achievable specifications are;
- what set of specifications are required to characterize an outcome;
- the needs of those that will use the end-product (or objective); and
- the limitations/restrictions imposed on the design process and the resulting product or objective by way of
  - budget constraints;
  - existence of legacy products;
  - legal/regulatory bodies;
  - safety hazards; and
  - the client's firm's practices, etc.

Needs Assessment

Clients may have many things that they require of the project. Help the client differentiate between what they want and what they actually need. You will likely have the freedom to choose which of the wants you would like to address, although the client may have some priorities in place that may guide this process.

In the end, the trick is to phrase the needs such that they have 1:1 correlation with specifications. By finding this correlation, you are able to explain to the client how their needs have dictated specific, likely numeric, requirements.

Scope of Specifications

Determining a set of specifications that accurately and comprehensively define an end-objective (perhaps a product) is difficult. Experienced engineers are usually involved in this process right from the start in order to assist the process. Not defining the end-goals appropriately can cause trouble for all remaining steps.

Keep in mind that at this stage you are *not designing* the end product. Generally speaking, the less you clutter the objectives with design, the more freedom you will have (i.e. the more creativity you can have) in finding a design to achieve the objectives. For instance, if a project requires the measurement of temperature over a certain range with a certain accuracy, avoid including information about which sensor technology you will use: thermocouple, RTD, or an integrated solution, all of which may be valid. Avoid having redundant specifications, too, since these will limit your freedom, and certainly compromise conciseness.

Missing specifications can lead to conflicts with your client. You may deliver a system that meets all the requirements you have documented, but has not addressed a client need.

To find the set of specifications that define an outcome requires *research*. One trick is to look up existing systems or devices that do something similar to what you would like to do. These may come with a specification sheet that will help you define your goal.

Attributing Values to Specifications

Once you have a set of specifications that define the product or objective, the next step is to attach measurable, numerical values to those requiring it. This step, again, requires a great deal of experience or research to get right. Specifying too tightly will make your objectives difficult to achieve, and specifying too loosely will undermine the usefulness of your project. Specifying outside reasonable ranges can go so far as to affect your credibility.

As an example, suppose your project involves developing a digital motor control system for a milling machine axis. When developing a numerical value to assign to a 'control frequency' specification, a value of 1 Hz is far too low (causing many control problems), and a value of 1 GHz is far too high (leading to unnecessarily complex digital circuit design). Values of, say, 1 kHz to 10kHz are likely more appropriate: research would likely help you put these values into context if your learnings to date do not already suggest this.

Regulatory and Governing Information

Specifications are often associated with laws or standards that will influence how they are evaluated, developed, limited, etc.

It is imperative for engineers to understand that their designs, and even the development of these designs are subject to laws. It is not legal, for instance, to broadcast beyond a certain power on a licensed radio band. This would be governed by the CRTC in Canada, and by the FCC in the United States.

Standards often prove a convenient method for describing, in an abbreviated form, a feature or set of features that the design will offer. For example, if a project requires a serial link between it and a PC serial port, the EIA-232 standard contains a great deal of information that can help describe the functionality of this aspect of the device.

Finding the laws, regulations, and standards that will influence a design requires a great deal of research. Please note that the University of Alberta library provides on-line access to a standards database.

Correlation Matrix

A correlation matrix is a tool often used by designers to understand how various quantifiable specifications affect one-another. This tool also serves to help communicate with a client. You may be able to use this to explain, for instance, that the brightness of a project's display will affect battery life, or that the more precise a temperature-sensing circuit, the slower the device will operate. Generally speaking, the more tightly-controlled a specification, the more expensive this aspect of the product will be. It may also take more time to develop.

The axes of a correlation matrix are identical, and only half (upper or lower) is used as a result to avoid redundant entries. Include on these axes entries for all specifications that may have a range of tolerable values. You may also include specifications that you would like to discuss with the client, and thus be able to explain why the use of a backlit LCD (something that they are adamant to have) will reduce battery life or increase cost. Paraphrased, to have a client's wants (rather than needs) included in the matrix is appropriate.

Note that 'cost', 'time', and 'quality' (or some similar measures) are almost always relevant to a design, and thus a correlation matrix. This corresponds to the saying “fast, good, cheap: pick two”.

In the small correlation matrix shown in Fig. 1, the rationale for the entries, starting from the top left and proceeding horizontally, is as follows:

- As the size of the device increases, there is more room for batteries, and thus the battery life can be increased.
- As the size of the device increases, there is more room for a larger display.
- As the size of the device increases, it would be possible to include more room for power RF electronics and/or an antenna that could boost wireless transmission range.
- Battery life goes down as display size increases, since more power is needed.
- Battery life goes down as the wireless range is increased since it takes more power to broadcast further.
- Display size and wireless range are not really correlated, and so the cell is left blank.

	Size	Battery Life	Display Size	Wireless Range
Size		++	++	+
Battery Life			−−	−
Display Size				
Wireless Range				

++ Highly correlated positive
+ Moderately correlated positive
− Moderately correlated negative
−− Highly correlated negative

Figure 1 - A simple correlation matrix derived from work in [1].

Project Budget

Your design is going to be constrained by its budget. The Department of Electrical and Computer Engineering allocates no more than $100 per person in a group for projects. Whatever is purchased with this money becomes the property of the Department, and in particular the Capstone Design Course and *must be returned in working order*. Your client (including researchers at the University of Alberta) will not own the prototype at the end of the year, but are typically provided with the opportunity to purchase the prototype from the course.

Sometimes clients are able to provide their own funding for the project as either a complete replacement, or as something in addition to the course-procured amount. *Discuss this with your client.* Client-controlled budget is at their discretion, and not something that is handled by the course or its instruction personnel.

The dollar amount provided by the Department is set for its internal budgetary reasons and is not intended as a design constraint: if you feel so inclined, it is not 'against rules' to contribute your own funds to the project. Keep in mind, however, that you will likely be out-of-pocket for whatever you contribute. Although the course attempts to settle-up at the end of the year, there are situations where prototypes *must* end up with clients, or are retained for open-house displays, etc. If this is not the case, you are free to take away the components that you paid for.

Please do not make purchases on your own, expecting the Department budget to cover the expenses. The course attempts to minimize hidden fees such as shipping, customs, and brokerage fees, while attempting to get volume discounts by compiling large, course-wide, orders. This will happen a few times throughout the year. The first order will not occur until shortly after the Critical Design Reviews. *If you require parts for testing the viability of a design approach, please discuss this with course technician.*

Hazard Assessment

Sometimes pursuing a project means working with potentially dangerous technology, in a potentially dangerous environment, or toward a goal that poses some sort of risk. A partial categorization of hazards is as follows:

- Environment (working at a height, around equipment, around any other hazards, etc.)
- Chemicals (acids, bases, nanomaterials, carcinogens, etc.)
- Mechanical Systems (blades, gears, etc.)
- Radiation (UV light, microwaves, etc.)
- Electrical (excessive voltage, current)

It is important to ensure that everyone involved in a project knows about the hazards, how to safely handle them, and how to act in an emergency situation arising out of any of them.

Although a hazard assessment could be considered a separate submission, we choose to have you include it before you start the project in this requirements specifications stage. *Please discuss the hazards associated with your project with your client, your group-members, and your advisor.* Your client will often be well-versed in the risks, and may be able to offer you appropriate training to ensure you stay safe.

To address these hazards and be permitted to proceed with the project, you will need to research safe-work procedures associated with the project's hazards.

Requirements Specifications Contents

A full Requirements Specifications document is very lengthy. The submission expected here is abbreviated. In your submission please include the following information:

- your group number, and project title;
- a brief introduction to the project;
- a top-level block diagram to show inputs and outputs. This diagram will have a single block – your project. The inputs and outputs need not be exclusively electronic in nature;
- a table that presents the following on each row:
    - a client's need;

- the resulting requirements specification; and
- any and all regulations that govern the resulting specification.

An example row from this table follows. Note that the specification itself is typically something **quantifiable**. The regulatory information is found by research! On-line resources, including those offered by the University library prove to be invaluable for locating regulatory information.

Client's Need	Specification	Regulatory Information
Physically connect to existing data network.	Connection with 10BASE-T Ethernet physical layer.	IEEE 802.3

- a hazard assessment and associated safe-work procedures;
- a correlation matrix showing how a design's constraints are related, and how "wants" can affect the design;
- a sketch showing how you would like the resulting (physical) product or user interface to look;
- a brief description of operation (how the user will interact with your project); and
- a synopsis of your total budget (indicating the amount of money you have available to pursue your project, either via the course, your client, or both).

Although you could argue that a few of these items, above, involve some design, they are included more to allow you to understand the goals from differing perspectives, and, in particular, those of the installer and the end user. Again, the less design you do at this stage, the better.

Grading

This item is evaluated using the rubric appended to this document.

Submission

Please submit an electronic copy of a PDF version of this item by using the ECE Capstone Submission Facility (https://ee401imgsvr.ee.ualberta.ca/submission) by 4PM on the date noted in the syllabus. Any member of a group may submit on behalf of their entire group. Please be sure to review the PDF prior to submission, and also the copy that is returned to your group via email on successful submission.

References

[1] Salt, J.E. and Rothery, R., "Design for Electrical and Computer Engineers", John Wiley and Sons, 2002. ISBN 0-471-39146-8

Requirements Specifications Evaluation

Current Revision: **0.2** **Revision Date:** **September 27, 2011** **Academic Year:** **Group:**

Criteria	**N/A** **Score:**	**Limited** **0**	**Adequate** **1**	**Proficient** **2**	**Excellent** **3**	**Weighting**
			Level			
			Specifications			**0.5**
Scope		Key specifications are not included and/or there is an abundance of non-specifiable or redundant items included.	All key specifications are included. There are a number of missed or redundant non-key items.	All key specifications are included. There is either a redundant or missed non-key item.	The number and nature of specifications accurately corresponds to the design goals and the nature of the project.	
Regulations and Standards		The majority of governing regulations and standards are missed or incorrectly identified.	Obvious governing regulations or standards are missing or incorrectly identified.	A minor number of governing regulations or standards are missed or incorrectly identified.	Regulations (legal or otherwise) and/or standards governing specifications have been appropriately identified.	
Needs		Client's "wants" are confused with needs and/or there is a poor correlation between needs and specifications.	A number of client's "wants" are confused with needs and/or the needs are generally not specifiable.	A very limited number of client's "wants" are confused with needs. Needs are specifiable.	Client's needs have been separated from "wants" and correspond to specifiable design goals.	
Achievability		Specifications are unattainable with respect to time, budget, etc., or are so loosely constrained as to be almost meaningless.	Several specifications are not practically achievable or are loosely constrained to the point where project success is questionable.	Specifications are mostly achievable. A maximum of one specification is too tightly or loosely constrained.	Specifications are accurately linked to project objectives and are achievable considering time, budget, existing technology, etc.	
Correlation Matrix		Correlation is inaccurate and/or most important design constraints are missing.	Correlation is inaccurate for a number of items and/or multiple design constraints are missing.	Correlation for a single item is inaccurate and/or a maximum of one important design constraint is missing.	Matrix includes appropriate design constraints and accurately depicts the relation between these features.	
Budget		No budget figure is provided.			The budget available to the project is fully outlined.	
Hazard Assessment		An obvious hazard has not been identified.		Handling protocols are not identified.	All hazards are identified and characterized. Handling protocols are identified.	

Criteria	N/A Score:	Level Limited 0	Adequate 1	Proficient 2	Excellent 3	Weighting
		Supporting Information and Document Flow/Structure				**0.5**
Introduction		Introduction is missing overall purpose of the project and provides poor motivation.	Motivation and purpose are slightly lacking.	Motivation or purpose is slightly lacking.	Introduction provides a clear overview of the purpose and motivation of the design.	
Top-level Block Diagram		Several inputs or outputs are missing.	An important input and/or output is missing.	An input or output is missing.	Diagram clearly relates all inputs to- and outputs from the system.	
Operational Description		Operating method is unclear.	Description of operating method is clearly missing important steps, perhaps inaccurately accounting for the role of the user.	Operating method is mostly clear: the reader may have one or two minor questions remaining.	Clearly describes how a user will interact with the resulting design.	
Packaging Sketch / User Interface		Sketch is illegible or not in a form that would be presentable to the client.	External-world interfaces are not shown and/or major difficulties in the proposed packaging are evident.	Minor interfacing difficulties result from the proposed packaging and/or an interface to the external world is not shown.	Sketch clearly indicates the vision of the final product: user and other interfaces are shown. Professionally presented.	
Grammar		Grammatical errors compromise meaning. Extensive further document revision is recommended.	Grammar errors are distracting. Further proofing of document is recommended.	Minor grammatical improvement is possible.	No grammatical errors are found.	
Readability/Flow		Drastic modifications to document organization are deserved and/or figures are illegible.	Document flow could be improved and/or figures are missing captions or are unclear.	Minor improvements to document flow would help the reader and/or minor modification to a figure is desirable.	The document has excellent organization and is straight-forward to read and understand. All figures are clearly labelled, captioned, and are of appropriate size and clarity.	

Summary

Category	Score	Max	Percentage	Weighting	Contribution
Specifications		/		0.5	
Supporting Information and Document Flow/Structure		/		0.5	
				TOTAL:	%