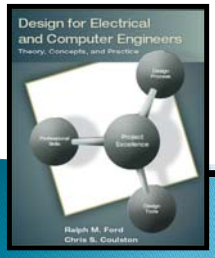
Chapter 3 – The Requirements Specification



Motivation – A Real Job Advertisement

Product Design Engineer (Electrical)

Duties and responsibilities of the position include: designing and developing new products and modifying/enhancing existing products to meet customer specification. This will be accomplished by communicating with internal and external customers to identify requirements; coordinating and implementing processes with manufacturing engineering based upon customer needs; and maintaining and/or creating supporting documentation

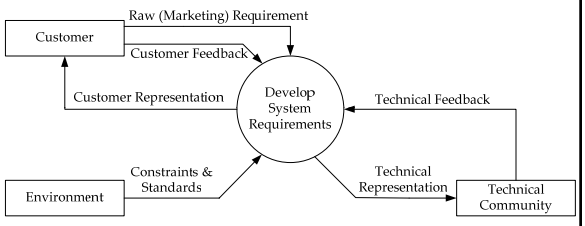
What came first?

Chapter 3 – Learning Objectives

By the end of this chapter, you should:

- Understand the properties of an engineering requirement and know how to develop well-formed requirements that meet the properties.
- Be familiar with engineering requirements that are commonly specified in electrical and computer systems.
- Understand the properties of the complete requirements specification, as well as knowing the steps to develop one.
- Be able to conduct advanced requirements analysis to identify tradeoffs.

3.1 Overview of Process [IEEE-STD 1233]



Definitions

Marketing Requirement

Engineering Requirement

Requirements Specification

3.2 Engineering Requirements

Engineering Requirement Properties

1) Abstract

2) Verifiable

Engineering Requirement Properties

3) Unambiguous

4) Traceable

Example

Does the following requirement meet the four desirable properties? (abstract, unambiguous, verifiable, traceable)

"The audio amplifier will have a total harmonic distortion that is less than 2%."

Example

Does the following requirement meet the four desirable properties? (abstract, verifiable, unambiguous, traceable)

"The robot must have an average forward speed of 0.5 feet/sec, a top speed of at least one foot/sec, and the ability to accelerate from standstill to the average speed in under one second."

Example

Does the following requirement meet the four desirable properties? (abstract, unambiguous, verifiable, traceable)

"The robot must employ IR sensors to sense its external environment and navigate autonomously with a battery life of one hour."

Example

Does the following requirement meet the four desirable properties? (abstract, unambiguous, verifiable, traceable)

"The system shall be easy to use by an intelligent 12 year old."

A Fifth Property – Realism

- IMPORTANT – Your requirements for your project must also be REALISTIC.
- => You need to demonstrate that the target you have selected is technically feasible.
- How are you going to do this?

Constraints

- Constraint = design decision imposed by the environment or a stakeholder that impacts or limits the design. (see the original overview diagram).
- Example contraint: *The system must use a PIC18F52 microcontroller to implement processing functions.*

Standards

- A standard is what?
- Question is, what standards are relevant to your project and how do you use them?
- Different levels of usage
  - User
  - Implementation
  - Developer
- Types: safety, testing, reliability, communication, data, documentation, design, …

Identifying Engineering Requirements

- Structured workshops and brainstorming
- Interviews and surveys
- Observation of processes and devices in use
- Benchmarking and market analysis
- Prototyping and simulation
- Research survey

Engineering Requirement Examples

- Need to know what type of requirement to select for a given system.
- These are but EXAMPLES – you must determine the correct ones for your system!
- Hint: don't just try to copy and paste them.

Engineering Requirement Examples

Performance

- *The system should detect 90% of all human faces in an image.*
- *The amplifier will have a total harmonic distortion less than 1%.*

Reliability & Availability

- *The system will have a reliability of 95% in five years.*
- *The system will be operational from 4AM to 10PM, 365 days a year.*

Engineering Requirement Examples

Energy

- *The system will operate for a minimum of three hours without needing*

Environmental

- *The system should be able to operate in the temperature range of 0°C to 75°C.*
- *The system must be waterproof and operate while submersed in water.*
- *to be recharged.*

Many more examples in the book.

3.3 The Requirements Specification

Requirements Specification

Definition

Properties of the *Requirements Specification*

- Normalized/Orthogonal
- Complete Set

Properties of the *Requirements Specification*

- Consistent
- Bounded

Validation

Validation =

How do you VALIDATE requirements?

- Ask the customer if the requirements meet their needs.
- Usually done in teams.
- For each *engineering requirement*
  - Traceable?
  - Verifiable?
  - Realistic & technical feasible?
- For the complete *Requirements Specification*
  - Orthogonal?
  - Complete?
  - Consistent?

Mapping (Audio Amplifier)

Marketing Requirement

Should have excellent sound quality.

Engineering Requirement

Total harmonic distortion should be ≤ 1%.

Justification

Based upon competitive benchmarking and existing amplifier technology. Class A, B, and AB amplifiers are able to obtain this level of THD.

Mapping (Audio Amplifier)

Marketing Requirement

Should have excellent sound quality.

Engineering Requirement

Signal to Noise Ratio should be exceed 120dB.

Justification

More Mapping, cont'd

Marketing Requirement

Should have high output power.

Engineering Requirement

*Should be able to sustain an **output power** that averages ≥ 35 watts with a peak value of ≥ 70 watts.*

Justification

This power range provides more than adequate sound throughout the automobile compartment and is competitive in this price range.

Mapping, cont'd

Marketing Requirement

Should be easy to install.

Engineering Requirement

Average installation time *for the power and audio connections should not exceed 5 minutes.*

Justification

Past trials using standard audio and power jacks demonstrate that this is a reasonable installation time.

3.4 Case Study: Car Audio Amp

Marketing Requirements	Engineering Requirements	Justification
1, 2, 4	1. The *total harmonic distortion* should be <0.1%.	Based upon competitive benchmarking and existing amplifier technology. Class A, B, and AB amplifiers are able to obtain this level of THD.
1–4	1. Should be able to sustain an *output power* that averages ≥ 35 watts with a peak value of ≥ 70 watts.	This power range provides more than adequate sound throughout the automobile compartment. It is a sustainable output power for projected amplifier complexity.
2, 4	1. Should have an *efficiency (η)* >40 %.	Achievable with several different classes of power amplifiers.
3	1. *Average installation time* for the power and audio connections should not exceed 5 minutes.	Past trials using standard audio and power jacks demonstrate that this is a reasonable installation time.

Case Study, cont'd

1–4	1. The *dimensions* should not exceed 6″ x 8″x 3″.	Fits under a typical car seat. Prior models and estimates show that all components should fit within this package size.
1–4	1. *Production cost* should not exceed $100.	This is based upon competitive market analysis and previous system designs.

Marketing Requirements
1. The system should have excellent sound quality.
2. The system should have high output power.
3. The system should be easy to install.
4. The system should have low cost.

Case Study: iPod Hands Free

Marketing Requirements	Engineering Requirements	Justification
4, 6	1. System will *implement nine voice command* functions (menu, play/pause, previous, next, up, down, left, right and select) and respond appropriately according to each command.	These are the basic nine commands that are used to control an iPod and will provide all functionality needed.
1, 3, 4, 7	1. The *time to respond* to voice commands and provide audio feedback should not exceed 3 seconds.	The system needs to provide convenient use by responding to the user inputs within a short time period. Based on research it was determined that the response time for the iPod is less than 1 second and an average voice recognition system requires 2 seconds to recognize commands.
4, 6	1. The *accuracy* of the system in accepting voice commands will be between 95% and 98%.	Research demonstrates that this is a typical accuracy of voice recognition chips. Speaker independent systems can achieve 95% and speaker-dependent up to 98%.

Case Study, cont'd

5, 6	1. The system should be able to *operate* from a 12 V source and will draw a maximum of 150 mA.	The automobile provides 12V DC. A current draw budget estimate was developed with potential components and 150mA was an upper limit of current estimated.
5, 6, 7	1. The *dimensions* of the prototype should not exceed 6″ x 4″ x 1.5″.	This system must be able to fit in a car compartment, somewhere between the seats. Estimate is based upon a size budget calculation using typical parts.

Marketing Requirements

1. Should not minimize or slow down the functional quality of the iPod.
2. User should be able to search for songs and artists and receive feedback on selection.
3. System should provide clear understandable speech.
4. System should be able to understand voice commands from user.
5. Should be able to fit and operate in an automobile.
6. Should be easy to use.
7. Should be portable.

3.5 Advanced Requirements Analysis

Engineering–Marketing Matrix

		THD	Output Power	η, Efficiency	Install Time	Dimensions	Cost
		-	+	+	-	-	-
1) Sound Quality	+						
2) High Power	+						
3) Install Ease	+						
4) Cost	-						

Engineering Tradeoff Matrix

		THD	Output Power	η, Efficiency	Install Time	Dimensions	Cost
		-	+	+	-	-	-
THD	-						
Output Power	+						
η, Efficiency	+						
Install Time	-						
Dimensions	-						
Cost	-						

Competitive Benchmarks

	Apex Audio	Monster Amps	Our Design
THD	0.05%	0.15%	0.1%
Power	30W	50W	35W
Efficiency	70%	30%	40%
Cost	$250	$120	$100

3.6 Project Application: The Requirements Specification

A complete requirements document will contain:

- Needs, Objectives, and Background (See Chapter 2).
- Requirements.
  - marketing requirements
  - engineering requirements
    - Should be abstract, verifiable, and traceable
    - Some maybe constraints
    - Some may be standards
  - Advanced analysis
    - Engineering–marketing tradeoffs
    - Engineering–engineering tradeoffs
    - Benchmarks

3.7 Summary

- Properties of engineering requirements
- Examples of engineering requirements
- Properties of the Requirements Specification
- Advanced Requirements Analysis
  - Tradeoff matrices
  - Benchmarks