ECEN 478: Senior Design

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Outline

Introductions

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- It is, in effect, the mission statement that drives all subsequent stages of development, and, when finished, should be

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  - Legal binding between you and customer

Learning Objectives

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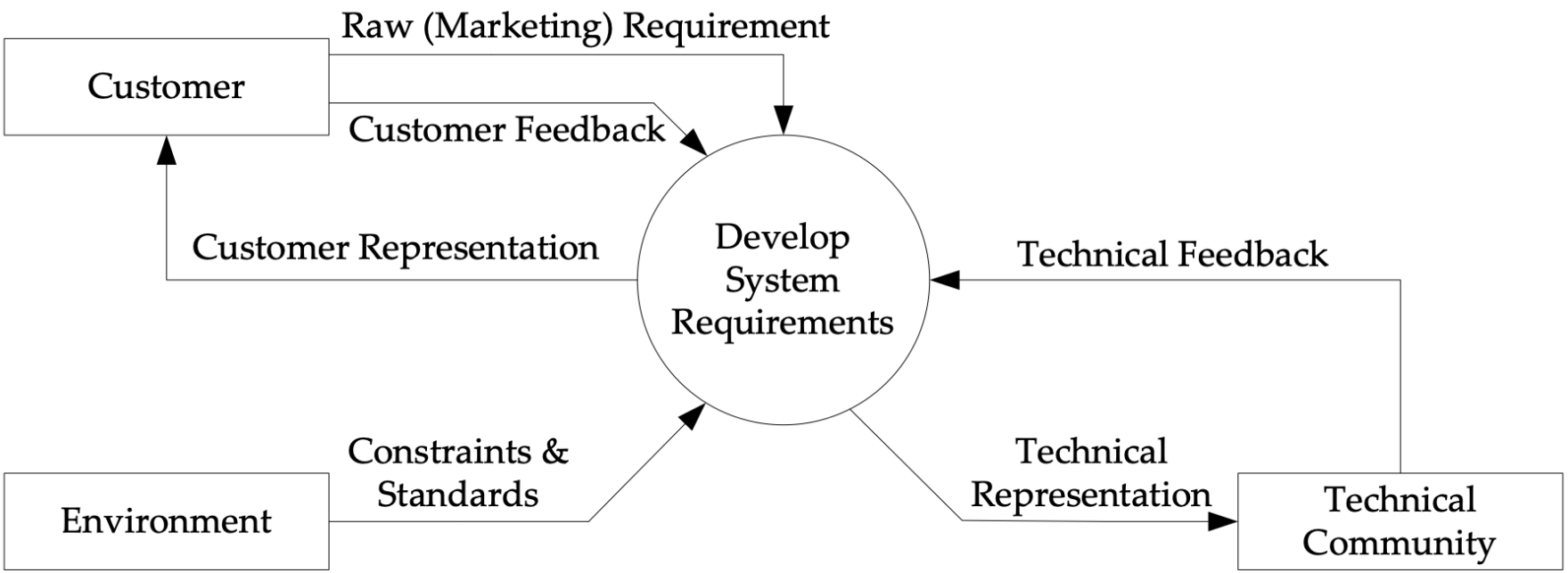
- Be able to conduct advanced requirements analysis to identify tradeoffs.

Overview of Process [IEEE-STD 1233]



From IEEE Guide for developing system requirements specifications

Definitions

1. Marketing requirements

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2. Engineering requirements

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2. Engineering requirements
3. Requirements Specification

Outline

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- Abstract.

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- Traceable.
  - Traceable to marketing to marketing requirements

Example

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A Fifth Property Realism

- IMPORTANT – Your requirements for your project must also be REALISTIC.

  robot should travel at speed of 1000,000 miles per hour!

- => You need to demonstrate that the target you have selected is technically feasible.
- How are you going to do this? (Violate abstractness for a moment- get feedback from engineering team)

Outline

Constraints

Constraint = design decision imposed by the environment or a stakeholder that impacts or limits the design. (see the original overview diagram).

Example

The system must use a PIC18F52 microcontroller to implement processing functions.

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  - User (e.g, standard communication protocol)
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  - Developer (e.g., code comments)
- Types: safety, testing, reliability, communication, data, documentation, design, ...

Identifying Engineering Requirements

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- 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.
- Economic
  - Total cost of developing the system should not exceed $50,000

Engineering Requirement Examples

- Energy
  - The system will operate for a minimum of three hours without needing to recharge
- 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.
  - Health and Safety
    - The door should stop moving if a person or object is detected in the door path.

Engineering Requirement Examples

Social and Cultural

- The product shall provide help menus to the user in either English or Spanish.

Political

- This system will need in obtain FDA approval before it can he sold to medical users.

Outline

Requirements Specification

The requirements specification is the complete set (engineering and marketing) of all system requirements.

- Identify them from customer or environment.
- Ensure the engineering requirements are well formed
- Organize the requirements (Will show examples)
- Validate the requirements

Properties of the Requirements Specification

1. Normalized (orthogonal) set
   - No overlap or redundancy
2. Complete
   - Cover marketing requirements
3. Consistent
   - No conflict
4. Bounded
   - Within some range
5. Modifiable
   - Room for improvement

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  - Traceable?
  - Verifiable?
  - Realistic & technical feasible?
- For the complete Requirements Specification
  - Orthogonal?
  - Complete?
  - Consistent?

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: Car Audio Amp

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: iPod Hands Free

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.

Case Study: Gigabit Ethernet Card Testing

Marketing Requirements	Engineering Requirements	Justification
1	Must be able to measure the *optical power output* with an *accuracy* of ±0.5 dB.	This is based upon commercially available optical power measurement instruments.
2	Must be able to measure the *optical power output* from 10°C to 55°C.	This range simulates the operating environment, and 55°C is the maximum operating temperature of the card.
2	The system must maintain *temperature accuracy* to within ± 1°C during all tests.	Based upon accuracy of commercially available test chambers.
3	Must be able to measure optical power over a *frequency range* from 4 Hz to 33 Hz in increments of 1 Hz.	The frequencies encountered in actual operation will not exceed this range.
3	The *peak vibration amplitude* should be 0.01 inches.	The amplitude in the operating environment will not exceed this value.

Case Study: Gigabit Ethernet Card Testing

3	The card should be tested at a given frequency for a *duration* of 1 minute.	This exceeds the expected duration of vibration at given frequency that the system will encounter.
3	The vibration effects should be tested in *x*, *y*, and *z directions*.	The system will encounter vibrations in multiple directions. This will provide data on differences in directional variation due to vibration.
3	The experiment should determine *resonant frequency* to an accuracy of ±0.5 Hz.	This will provide data on worst-case vibration at the resonant frequency.
Marketing Requirements 1. The measurement of the optical power should be accurate. 2. It should measure the effects of temperature variations on optical power. 3. It should measure effects of vibration on the fiber optic connector and optical power output.		

Outline

The Engineering Marketing Tradeoff Matrix

Table 3.5 Engineering-marketing tradeoff matrix for the audio amplifier (↑ = positive correlation, ↑↑ = strong positive correlation, ↓ = negative correlation, ↓↓ = strong negative correlation).

		Engineering Requirements					
		THD	Output Power	η, Efficiency	Install Time	Dimensions	Cost
Polarity		-	+	+	-	-	-
Marketing Requirements	1) Sound Quality	+	↑↑	↓			↓↓	↓↓
	2) High Power	+	↓	↑↑	↑		↓↓	↓
	3) Install Ease	+		↓		↑↑	↑	↓
	4) Cost	-	↓↓	↓	↓		↓	↑↑

Correlations between Requirements

The Engineering Tradeoff Matrix

Table 3.6 The engineering tradeoff matrix for the audio amplifier (↑ = positive correlation, ↓ = negative correlation).

		THD	Output Power	η, Efficiency	Install Time	Dimensions	Cost
		−	+	+	−	−	−
THD	−		↓			↓	↓
Output Power	+			↑		↓	↓
η, Efficiency	+					↑	↓
Install Time	−					↓	
Dimensions	−						↓
Cost	−						

Competitive BenchMarks

Competitive benchmarking helps to select targets for the engineering requireme
by analyzing competing systems.

Table 3.7 Competitive benchmarks for the audio amplifier.

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

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

References

- Ford, Ralph Michael Coulston, Chris S - Design for electrical and computer engineers theory, concepts, and practice-McGraw-Hill (2008)

Questions