L3: The requirements specification

Definitions

Overview of the process

Engineering requirements

Constraints and standards

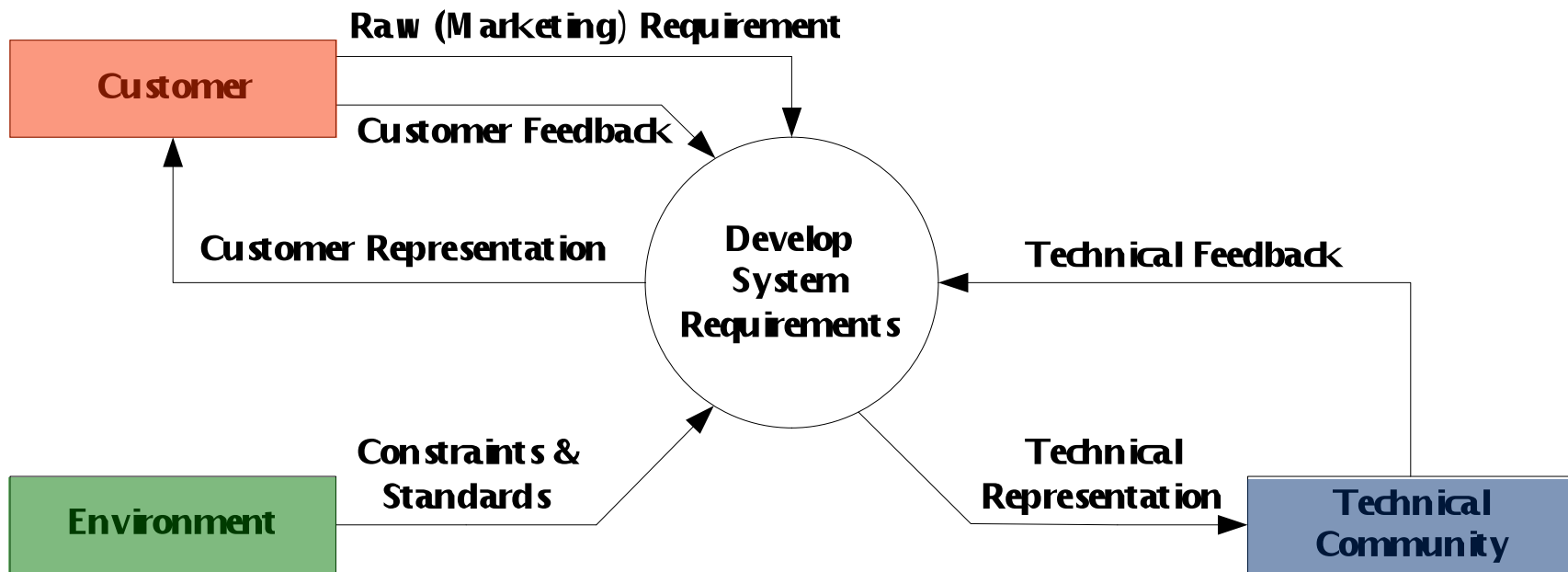**Examples of engineering requirements**

Introduction

What is the requirement specification?

- A collection of engineering and marketing requirements that a system must satisfy in order for it to meet the needs of the customer
- It should provide all important requirements yet provide flexibility for the design team to develop innovative solutions
- Also serves as a communication tool for everyone involved (engineering, marketing, client)
  - In some cases it becomes a legally binding agreement
- Admittedly, it is a bit of a "chicken or the egg" problem
  - It is hard to develop the requirements without already having solved the problem

- The process for creating the requirements specification is the purpose of this lecture

Overview of the process

Three input sources

– The customer (*marketing requirements*)

– The technical community (*engineering requirements*)

– The environment (*constraints and standards*)

Engineering requirements

What are they?

– Short statements that address a technical need of the design

– e.g. "the system should be able to supply 50 watts of power"

What are their properties?

– Abstract
  - Each requirement should specify <u>what</u> the system will do, not <u>how</u> it will be implemented

– Verifiable
  - There must be a way to demonstrate that the requirement is met
  - If something is not verifiable, then it cannot be a requirement

– Unambiguous
  - The meaning should be unambiguous
  - It should be stated with short complete sentences

– Traceable
  - Each requirement should be traceable to a marketing requirement

Example

Does the requirement below meet the four properties?

"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."

- **Abstract?**
- **Verifiable?**
- **Unambiguous?**
- **Traceable?**

Does the requirement below meet the four properties?

> *"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."*

- **Abstract?** Yes, it specifies what, not how
- **Verifiable?** Yes, speed and acceleration can be measured
- **Unambiguous?** It provides clear bounds for speed and acceleration
- **Traceable?** We'd have to look at the marketing requirements

Example

Does the requirement below meet the four properties?

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

- **Abstract?**

- **Verifiable?**
- **Unambiguous?**
- **Traceable?**

- A better version would be

> *"The robot must navigate autonomously, with the aid of only landmarks in the specified environment, for a period of at least 1 hour"*

Does the requirement below meet the four properties?

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

- **Abstract?** No, it specifies the type of sensor to be used, and that batteries must be used
- **Verifiable?** No, see below
- **Unambiguous?** No, what is meant by autonomous?
- **Traceable?** We'd have to look at the marketing requirements

- A better version would be

> *"The robot must navigate autonomously, with the aid of only landmarks in the specified environment, for a period of at least 1 hour"*

Environment requirements

Constraints

– Design decisions imposed by the environment or a stakeholder that limits the design

– e.g., "*The system must use a PIC18F52^{TM} micro-controller to implement processing functions*"

Standards

– Standards ensure products work together, also ensure the health and safety of the products we use daily

  • Think about the computing world if it weren't for standards

– A large number of standards exist

Safety	Testing	Reliability
Communications	Data formats	Documentation
Design methods	Connectors	Programming languages

– Question is, what standards are relevant to your project and how do you use them?

Examples of engineering requirements

Performance

Functionality

Economic

Energy

Environmental

Health and safety

Legal

Maintainability

Manufacturability

Operational

– The system will need to obtain FDA approval before it can be sold to

Reliability and availability

Social and cultural

Usability

Back to requirements specification

Properties of the requirements specification

- **Normalized** (orthogonal) set: no overlap between engineering requirements
- **Complete** set: addresses all the needs of the end user and needs for system implementation
  - Failure to define a complete set leads to <u>under-specificity</u>
- **Consistent**: Requirements are not self-contradictory
- **Bounded**: identify the scope of the requirements, such as a minimum acceptable bound for target values
  - Applying unnecessary bounds leads to <u>over-specificity</u>
- **Modifiable**: requirements are considered evolutionary, since there are many unknowns at the start of a project
  - The original requirements are known as <u>baseline requirements</u>

Steps to developing the requirements specification

- Identify requirements from
  - The customer (marketing requirements, previous lecture)
  - The technical community (engineering requirements)
  - The environment (constraints and standards)
- Ensure the engineering requirements are well formed
- Organize the requirements
- Validate the requirements

Case study: car audio amplifier

Marketing requirements	Engineering requirements	Justification
1, 2, 4	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	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	Should have an efficiency (η) >40 %.	Achievable with several different classes of power amplifiers.
3	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
1–4	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	*Production cost* should not exceed $100	This is based upon competitive market analysis and previous system designs
1–4	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

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.