L2: Needs identification

Types of engineering design projects

Needs identification

Research survey

Needs and objective statements

Types of engineering design projects

Creative designs

- Represent new and innovative designs
- An example: the Palm Pilot
  - The idea had been around for a while (Apple's Newton), but had been unsuccessful, primarily b/c of poor handwritten recognition
  - Palm's creative idea: develop a simplified handwriting language: Graffiti

Variant designs

- Variations of existing design, where the goal is to improve performance or add new features
- Many engineering designs fall into this category
- An example: the iPhone 2 (as compared to the iPhone 1st gen)

Routine designs

- Designing devices for which theory and practice are well-developed
- An example: a DC power supply, a personal webpage

A different taxonomy

Systems engineering/integration projects

- Goal: synthesis of many subsystems into a larger system
- Unique challenges: typically large, involve many people and technologies

Experimental design projects

- Goal: design experimental procedures and apparatus to determine the characteristics of a system
- e.g., test a system under a variety of operating conditions

Analysis projects

- Goal: analyze some aspect of an existing system to improve it or correct it
- e.g., a system may be failing in the field, and the goal is to identify the source of the failure

Technology evaluation projects

- Goal: determine if a new technology can be used in a given application
- e.g., determine if the technology can improve an existing system

Research projects

- Goal: discover or create new technology
- Unlike other types of projects, its ultimate outcomes are unknown
  - Applied research
    - Create new technology/systems based on existing technology and theory
  - Fundamental research
    - Discover new scientific principles, without having an application in mind
    - Generally not part of design projects

Needs identification

Case study

- A client approaches you with the following problem
  - Traffic in front of campus is too congested. Design a new traffic lane for northbound traffic exiting at the intersection at the front of the college
- You design the lane and add it to the intersection
- Three months later, the traffic has decreased a bit, but is still a significant problem

What went wrong?

Needs identification

Case study

- A client approaches you with the following problem
  - Traffic in front of campus is too congested. Design a new traffic lane for northbound traffic exiting at the intersection at the front of the college
- You design the lane and add it to the intersection
- Three months later, the traffic has decreased a bit, but is still a significant problem

What went wrong?

- You were solving the wrong problem
- The real problem was to improve the flow of traffic at the entrance
- Adding a traffic lane was a solution, masked as the problem

Lesson

- Customers often come with the problem and the solution all wrapped up together
- Whenever this happens, your **design space** is significantly reduced, and so are your chances of success

To prevent this from happening, you must

- Challenge the customer's assumptions
- Ask clarifying questions
- Decouple the problem from the solution, then focus on the problem

Steps for identifying the need

Step 1: gather raw data from users

- Interviews with the client (supervisors, key users)
- Focus groups (for new products)
- Direct observation (e.g., IDEO shopping cart)
- Technology push vs. market pull

- **Example questions (from the textbook)**
  - When and why do you use this type of product?
  - Walk us through a typical session using the product
  - What do you like about the existing products?
  - What do you dislike about the existing products?
  - What issues do you consider when purchasing the products?
  - What improvements would you make to the product?

Step 2: interpret the raw data in terms of needs

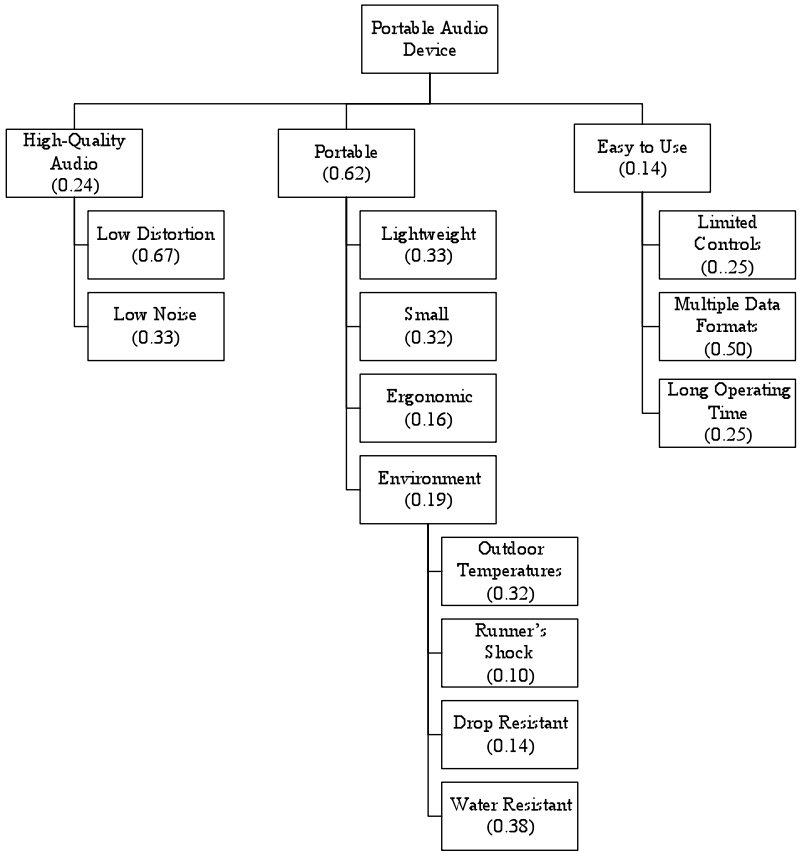
- Translate raw data into customer needs (using customer's language)
  - Statements of the customer needs are know as marketing requirements
- Express them in terms of what the product must do (a requirement), NOT how it should be achieved
- They should be short, action-oriented phrases
  - e.g. "*The system should have high quality audio*"

- **Example of marketing requirements (from IDEO video)**
  - In the video, a supermarket employee says, "*these carts have been clocked going 35 mph*"
  - What is the marketing requirement that goes with this statement?
    - Cart should not move in wind
    - Cart should not exceed XX mph

Step 3: organize needs into a hierarchy

- Organize the needs into a hierarchy, from general to specific
- Organize by functional similarity, not importance (that's the next step)
- This is known as an objective tree

- **Example: portable audio device for runners (from the textbook)**
  - Weights represent the relative importance of each need (from the next step)



Step 4: determine the relative importance of needs

- Pairwise comparison (from appendix B in the textbook)
  - Systematically compare each need to all other needs at the same level in the hierarchy
  - Obtain the weights by adding row-wise

- **Example: from the portable audio device for runners**

Scale for pairwise comparison

How important?	Weight
Equal	1
Moderate	2
Strong	3
Extreme	4

Pairwise comparison matrix

	High-Q audio	Portable	Easy to use	Weight
High-Q audio	1	1/3	2	**0.24**
Portable	3	1	4	**0.62**
Easy-to-use	1/2	1/4	1	**0.14**

Step 5: review the outcomes and the process

- The above four steps represent just a process that embodies a good practice
- It is ultimately for making decisions about what is important to the end-user
- In the end ask yourself: “Does this make sense?” If not, you should make it so that it does or determine why not

Outcomes of the Needs Identification stage:

1) Marketing requirements (needs in the customer language)
2) Objective tree (hierarchical representation of those needs)
3) Ranking of the relative importance of those needs

The Problem Statement document

Need

- A statement that identifies the needs of the project

Objective

- Describes the concept proposed to meet the needs identified

Background (research survey)

- A summary of the research survey on relevant prior research and technologies and

Marketing requirements

- Short statements describing the user needs

Objective tree

- A hierarchical representation of the needs based on functional similarity with the relative weights of the needs identified

Need statement

- Identifies and motivates the need for the project, and it should
  - Briefly and clearly state the need to be met
  - Do not provide a solution to the problem
  - Provide supporting statistics or anecdotes
  - Describe current limitations
  - Describe any supporting processes

Need statement

- Identifies and motivates the need for the project, and it should
  - Briefly and clearly state the need to be met
  - Do not provide a solution to the problem
  - Provide supporting statistics or anecdotes
  - Describe current limitations
  - Describe any supporting processes

According to AppleInsider, approximately 10.3 million people owned iPods at the end of 2004 and many of the owners used them while operating their automobiles. The National Highway Traffic Safety Administration estimates that driver distraction is a contributing cause of 20 to 30 percent of all motor vehicle crashes – or 1.2 million accidents per year. One research study has estimated that driver inattention may cause as many as 10,000 deaths each year and approximately $40 billion in damages. iPods can present a distraction to drivers that is similar to cell phones in that the driver's attention is divided between controlling the steering wheel, watching the road, and navigating controls on the iPod. A system is needed to allow users to navigate among the music selections of their iPod without distracting their attention from the road.

From the iPod hands-free device design report by Al-Busaidi, Bellavia, and Roseborough [Alb07]

Objective statement

- Typically ranges from one or two sentences to one or two paragraphs, and it should
  - Summarize what is being proposed to meet the need
  - Provide some preliminary design objectives (no detailed requirements)
  - Provide a preliminary description of the technical solution, avoiding implementation details
    - The complete solution is posted after requirements are fully determined

Objective statement

- Typically ranges from one or two sentences to one or two paragraphs, and it should
  - Summarize what is being proposed to meet the need
  - Provide some preliminary design objectives (no detailed requirements)
  - Provide a preliminary description of the technical solution, avoiding implementation details
    - The complete solution is posted after requirements are fully determined

The objective of this project is to design and prototype a device that will make the iPod safer to use while driving an automobile, by allowing hands-free control of the iPod. The device will interact with the user using spoken English commands. The user will be able to issue simple voice commands to the device to control the operation of the iPod. In turn, the device will communicate information verbally, such as song titles that are displayed on the iPod screen, to the user.

From the iPod Hands-Free Device Design Report by Al-Busaidi, Bellavia, and Roseborough [Alb07].

Research survey

- Why conduct a research survey?
  - Because you need to become the experts on the problem and state-of-the-art in the particular area of your project
    - If you don't, then you re-invent the wheel
    - If you don't, then you don't look too smart
- Some questions to be answered in the research survey:
  - What is the basic theory behind the concept?
  - How is it currently being done?
  - What are the limitations of the current designs or technology?
  - What are the similarities/differences between your concept and current systems?
  - Are there existing or patented systems that are relevant to the design?

Research resources

- Internet resources
  - Assess the credibility of the information: is it a subjective opinion or a commercial for a product?
  - Use Google Scholar (the higher the citation, the better)
- Government resources
  - US Bureau of Labor Statistics
  - US Patent Office
- Journal and conference papers
  - ACM Digital Library
  - IEEE Xplore
  - Elsevier ScienceDirect

Lecture summary

- Determine the true user needs
- Outcomes of the needs elicitation process
  - Marketing requirements
  - Objective Tree
  - Ranking of the needs
- Conduct research survey
- Problem Statement
  - Needs
  - Objectives