ECEN 478: Senior Design

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Outline

Introduction

- Capstone design projects provide a great opportunity to gain experience in the management and execution of a project.
- One of the first and most important decisions encountered is selecting a project to pursue.
- The objective of this chapter is to provide some guidance in the project selection phase.

Learning Objectives

- Have an understanding of the types of projects that electrical and computer engineers undertake.
- Understand and be able to apply criteria for project selection.
- Know how to determine, document, and rank end-user needs.
- Be aware of resources available for conducting research surveys.
- Have selected a project concept and developed a problem statement.

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  - Creative designs represent new and innovative products.
  - Variant designs. Are variations of existing designs, where the intent is to improve performance or add features to an existing system.
  - Routine designs. represent the design of devices for which theory and practice are well developed. Examples are DC power supplies.

Types of projects

Within these three categories of design, there are many different types of projects.

- Systems engineering and integration projects: synthesis of many subsystems into a larger system. (They may be creative or variant designs)
- Testing projects Does the system meet the requirements.
- Experimental design projects: design experimental procedures and apparatus for determining the characteristics of a system. For example, an engineering team may test a system under a variety of operating conditions.
- Analysis projects. is to analyze some aspect of an existing system to improve or correct it. (Error detection systems i.e., FMEA)

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  - Applied research. research for to apply existing knowledge to solve a particular problem.
  - Fundamental research: research for the sake of knowledge.

Sources of project ideas

- Industry sponsorship
- Website: Engineers without Borders
- Website: www.FreeRandD.com
- Campus and local community
- Brainstorming

Project Fesability and Selection Criteria

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- What are the risks and payoffs? How much will it cost? How long will it take?
- What are the midterm and final exams' to check for success?

Project Fesability and Selection Criteria

- The project must be tied in the mission and vision of the organization.
- Must have payback. If the project will make a profit.
- Should have selection criteria. (AHP)
- Objectives of the Project slumld be SMART: specific,measumble, assignable, realistic, time— related

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AHB: Decision Making with Analytical Hierarchy Process

AHI is a flexible quantitative and qualitative method, applicable to many problems

- To apply AHP there must be a decision to be made, criteria against which the decision is based, and a set of competing decisions from which one must be selected.
- This process is encapsulated in a decision matrix

		Alternative 1	Alternative 2		Alternative n
Criteria 1	ω_1	α_{11}	α_{12}	$\cdots$	α_{1n}
Criteria 2	ω_2	α_{21}	α_{22}	$\cdots$	α_{2n}
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\cdots$	$\vdots$
Criteria m	ω_m	α_{m1}	α_{m2}	$\cdots$	α_{mn}
Score		$S_1 = \sum_{i=1}^{m} \omega_i \alpha_{i1}$	$S_2 = \sum_{i=1}^{m} \omega_i \alpha_{i2}$	$\cdots$	$S_n = \sum_{i=1}^{m} \omega_i \alpha_{in}$

Applying AHP for Car Selection

Steps for AHB:

1. Determine the selection criteria.
2. Determine the criteria weightings.
3. Identify and rate alternatives relative to the criteria.
4. Compute the scores for the alternatives
5. Review the decesion.

Lets apply the AHP for Car Selection

Step 1: Determine the Selection Criteria

Assume that the criteria determined are:

- Purchase cost
- Safety
- Design styling
- Brand-narne recognition

Step 2: Determine the Criteria Weightings

- Pairwise comparison is applied.

1 = equal, 3 = moderate, 5 = strong, 7 = very strong 9 = extreme.

	Purchase cost	Safety	Design	Brand name
Purchase cost	1	1	3	7
Safety	1	1	5	9
Design	1/3	1/5	1	3
Brand name	1/7	1/9	1/3	1

Step 2: Determine the Criteria Weightings

	Purchase cost	Safety	Design	Brand name	Geometric Mean	Weights
Purchase cost	1	1	3	7	2.1	0.37
Safety	1	1	5	9	2.6	0.46
Design	1/3	1/5	1	3	0.7	0.12
Brand name	1/7	1/9	1/3	1	0.3	0.05

$$\text{Geometric mean} = \sqrt[n]{a_1 a_2 \cdots a_n}.$$

$$\sum_i \omega_i = 1.$$

Step 3: Identify and Rate Alternatives Relative to the Criteria

The three competing alternatives to be evaluated are the Honda CR-V, Hyundai Tucson, and Toyota RAV4.

- For fair comparison, it is important that the ratings relative to each criteria be normalized so that their sum is one. if not, the sum of ratings for each criterion will be different.

Lets compute α score for each criteria and each car.

Step 3: Identify and Rate Alternatives Relative to the Criteria (Cost)

The vehicle costs are \$21,026(Honda), \$18,183 (Hyundai), and \$21,989 (Toyota).

$$\alpha = \frac{\min[\text{cost}]}{cost}$$

The cost ratings are computed to be $\alpha 1$: 0.86, $\alpha 2 = 1$, and $\alpha 3 =$ 0.83.

The normalized values are $\alpha 1$: 0.32, $\alpha 2 =$ 0.37, and $\alpha 3 =$ 0.31.

Step 3: Identify and Rate Alternatives Relative to the Criteria (Safety)

According to US. National Highway Transportation Safety Association the average safety rating for each car on scale of 5-points is $\alpha 1 = 4.8$ (Honda), $\alpha 2$: 4.8 (Hyundai), and $\alpha 3$: 4.6 (Toyota)

The normalized values are computed to be $\alpha 1$: 0.34, $\alpha 2 = 0.34$, and $\alpha 3 =$ 0.32.

Step 3: Identify and Rate Alternatives Relative to the Criteria (Style)

It is subjective so we will return to pairwise comparison.

	Honda CRV	Hyundai Tucson	Toyota RAV4	Design Rating
Honda CRV	1	1/3	1/5	0.11
Hyundai Tucson	3	1	1/2	0.31
Toyota RAV4	5	2	1	0.58

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	Honda CRV	Hyundai Tucson	Toyota RAV4	Brand name Rating
Honda CRV	1	4	1	0.44
Hyundai Tucson	1/4	1	1/4	0.12
Toyota RAV4	1	4	1	0.44

Step 4: Compute Scores for the Alternatives

The decision matrix is built and the overall weighted scores for the alternatives are computed

		Honda CR-V	Hyundai Tucson	Toyota RAV4
Cost	0.37	0.32	0.37	0.31
Safety	0.46	0.34	0.34	0.32
Design styling	0.12	0.11	0.31	0.58
Brand name	0.05	0.44	0.12	0.44
Score		**0.31**	**0.34**	**0.35**

Step 5: Review the Decision

- if all work is done properly the final scores should sum to one.
- In this case there is not much difference between the scores, and a simple decision based upon the maximum value would lead to selection of the RAV4.

Outline

Needs Identification

The traffic at the front of campus is too congested. I would like you to design a new traffic lane near to the main entrance of the engineering building

What is the problem in this customer statement?

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What is the problem in this customer statement?

- It would be better if the client had simply asked to improve the traffic flow.
- Customers often come with the problems and solution all wrapped up together.

Needs ID Process

1. Gather raw data from users;
2. Translate need to market requirements;
3. Organize needs into a hierarchy;
4. Determine the relative importance of the needs
5. Review the outcomes and the process.

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- Market Trends

Translate needs to market requirements

- Statement of Customer Needs in language of customer.
- What the product should do, NOT how it should be achieved.
- Short, action-oriented phrases Example - “The system should have high quality audio.”

Example

In Video, the guy said, “these carts have been clocked going 35 mph”
what is the marketing requirement that goes with this statement?

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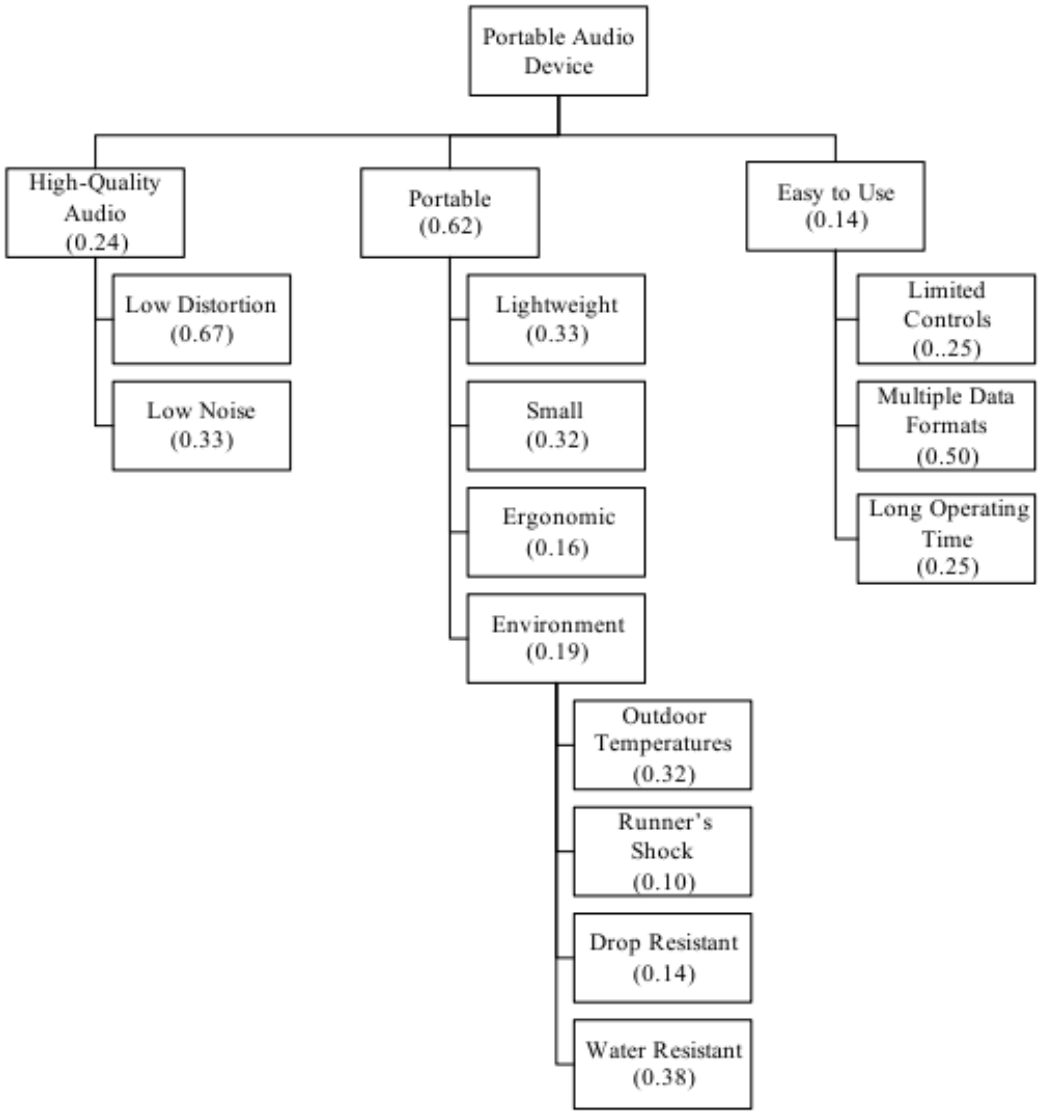
Answer(s):

- Cart should not move in wind.
- Cart should not exceed XX mph.

Step 3: Organize Needs into a Hierarchy

- Organize needs by functional similarity, not by importance!
- Start from the most general to the most specific in successive levels of detail as required by the problem.
- What is functional similarity?
  - Group the features under high level statements (known as marketing requirements)
  - Marketig requirements are the 1st level in the objective tree

Step 3: Organize Needs into a Hierarchy



Step 4: Determine the relative importance of the needs

- Ranking can be based on pairwise comparison
- Systematically compare each need to all other needs

	High-Quality Audio	Portable	Easy-to-Use	Weight
High-Quality 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

- In the end ask yourself "Does this make sense?" If not, you should make it so that it does or determine why not.
- There is a certain amount of subjecivity and judgment that goes into it; the end result should be reviewed to determine if it makes sense.
- The outcomes are
  - Marketing requirements
  - Hierarchical representation of the needs
  - Ranking of the relative importance of needs

Outline

Research Survey

- Research is driven the nature of the survey by project.
- Failure to do a research translate into time and money
- Do not reinvent the wheel !!

Questions to be asked

- What is the basic theory behind the concept?
- How is currently being done?
- What are the limitations of current designs technology?
- What are the similarities and differences between your concept and existing solutions?
- Are there existing patented technologies that may be relevant to the design?

Internet Searching

- Google it!
- Ensure credibility of information!
- Cite information.

Electrical and computer engineering resources

- https://www.digikey.com/ (electronic components and dataseets)
- https://circuitcellar.com/ (Embedded systems and electronics)
- https://www.drdobbs.com/ (Software development resources)
- http://www.datasheetcatalog.com/
- https://www.eetimes.com/ (Industry newspaper)
- https://www.edn.com/ (Magazine for electrical engineers)
- https://www.onsemi.com/(Supplier of semiconductors)
- https://www.thomasnet.com/ (Search for products and companies)

Government Resources

- US. of Labor Bureau Statistics, Consumer Spending `https://www.bls.gov/`
- All Government resources https://www.usa.gov/
- US patent office `https://www.uspto.gov/`

Journal and Conferences

- IEEE explore
- ACM
- Springer
- Elsevier

Outline

Needs and Objective Statements

Two parts of any problem statement Needs and Objectives

Needs

- Briefly and clearly state the need
- No solution
- Supporting information
- Current limitations

Objective

- What is being proposed to address need
- Some preliminary design objective
- Describtion of the technical solution (input and output behaviour)

Example 1

Example 2.2 iPod Hands-Free Device Needs and Objectives. *Abstracted from the iPod Hands-Free Device Design Report by Al-Busaidi, Bellavia, and Roseborough [Alb07].*

Need: 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 that of 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.

Objective: 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 statements. 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.

Example 2

Example 2.3 Experimental Design Problem Needs and Objectives. *Abstracted from the Intel Pro 1000XF Server Testing Design Report by Esek, Hunt, and Lewis. [Ese03].*

Need: Our industry sponsor is investigating the performance of commercial-grade gigabit Ethernet fiber optic equipment for computer data communications in a military environment. The proposed system will utilize an Intel Pro1000 XF server card. This is a harsh operating environment and its effects on the performance and lifetime of the equipment are unknown. The client wishes to understand how the military environment affects the optical power margin of the Intel Pro 1000 XF card and associated connectors and cabling.

Objective: The goal of this project is to design the experimental equipment and test procedures to determine the effects of temperature variations and vibration on the optical power margin and the operating lifespan of the system.

Example 3

Example 2.4 Portable Aerial Surveillance Needs and Objectives. *Abstracted from the PASS Design Report by Andre, Kolb, and Thaler [And07].*

Need: Emergencies happen all across the world, all of the time. There are nearly 2,000,000 reported fires in the United States every year, and over 90 tactical activations of Pennsylvania's Special Emergency Response Team, which handles barricaded suspects and hostage situations. There have been over 100 documented riots in the United States in the past century, with the Los Angeles Riot alone causing $1 billion in damage. Having an aerial view of these situations would be a great benefit to the emergency workers on the ground. For example, police may have to monitor a large crowd or a hostage situation where aerial surveillance would allow them to observe the situation from a safe distance and use the footage as evidence in court. Firefighters could use aerial surveillance to examine fire-damaged buildings and search for victims through the windows of high-rise buildings. In large cities, emergency organizations often employ helicopters for aerial surveillance. However, in smaller rural towns, helicopters either take too long to reach the scene from a nearby city or they are too expensive to afford. The least expensive two-seat helicopters cost over $400,000, while new helicopters cost well over a million dollars with average operating costs of $400–$1000 per hour. There is a need for a low-cost aerial device that can provide emergency workers with overhead surveillance of emergency situations.

Objective: The objective of this project is to design a device that will provide emergency workers with a live aerial view of a situation at a cost that small municipalities can afford. The device will deploy rapidly and record and log video. The camera will also include pan and zoom functionality to make identification of victims and suspects easier.

References

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

Questions