

# ECE 411

## Engineering Practices

### “Needs Identification”

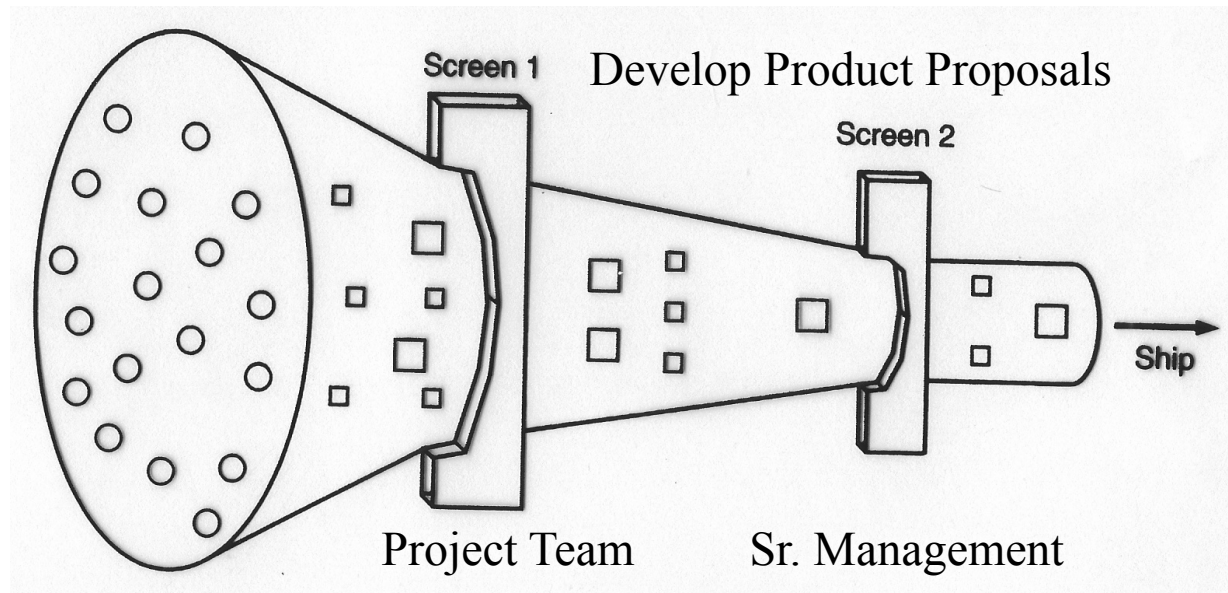
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# Outline

- Development funnel
- Types of Engineering Projects
- Sources of Product Ideas
- Importance of Need Identification
  - Rule of 10
- Methodology
  - Research
  - Requirements
  - Need identification and Questions to Ask for any Project
  - Research
  - Ranking
  - Decision-making
  - Need and Objective Statements
  - Problem Statement

# The Development Funnel



Product Ideas

Product Proposals to Sr. Management

# Process



# Types of Designs

## Creative Design

- Design for new product or category
- Palm Pilot PDA, First GPS
- Significant innovation

## Variant Design

- Variant of existing design (performance, features)
- Net book PC, low power microprocessor
- Less innovation, more constraints (compatibility)

## Routine Design

- Design where theory and practice well developed
- DC power supplies, filters, basic arithmetic circuits
- Optimizing trade-offs (price/power/performance)

## Research Projects

- Technology Evaluation
- Applied Research
- Fundamental Research

# Design Projects

- Variation of an existing product
  - Change a minor feature or operating parameter
  - Replace component (e.g. obsolescence)
- Improvement of an existing product
  - Reduce cost, cost of ownership
  - Improve quality
  - Meet competitive challenge
  - Improve performance
  - Incorporate new technology
- New product for low-volume
  - Manufacturing startup cost may be critical criteria
  - May indicate preference for off-the-shelf components
- New product for mass production
  - Emphasis on unit costs for manufacturing
  - Commonly: automobile, consumer electronics, PCs
- One-of-a-kind design
  - e.g. buildings, manufacturing and power, spacecraft, some S/W

# Types of Projects

## Systems Engineering Integration

- Large scale, many people, coordination

## Testing

- Does system meet requirements?
- Determine parametrics

## Experimental Design

- Design experiment or apparatus

## Analysis

- Analyze/correct problem
- Recommend solution

# Where do product ideas come from?

- Customer feedback
  - Log calls to 800 number – collect/analyze the data!
  - Mine social media for keywords, references to products
  - Customer surveys, Sales/marketing visits, Focus groups
- Usability studies (“protocol analysis”)
  - Observe users while performing a task
  - Where are bottlenecks? Confusion? Errors?
- Field Service, Sales, Marketing

"You can observe a lot, just by watching people." -- Yogi Berra

"Errors are a gold mine" -- If you are watching people, and they make a mistake, it tells you a lot about what you need to improve. There was an amusing film clip of two men trying to make double-sided copies with an early version of a fancy Xerox machine. The manager watching it originally said "well, they're just stupid" -- until he found out that the two men were senior scientists at Xerox.

"Look for workarounds and hacks" -- If someone is using something for a purpose you didn't intend (or in a way you didn't plan), it tells you a lot about how you can improve things.

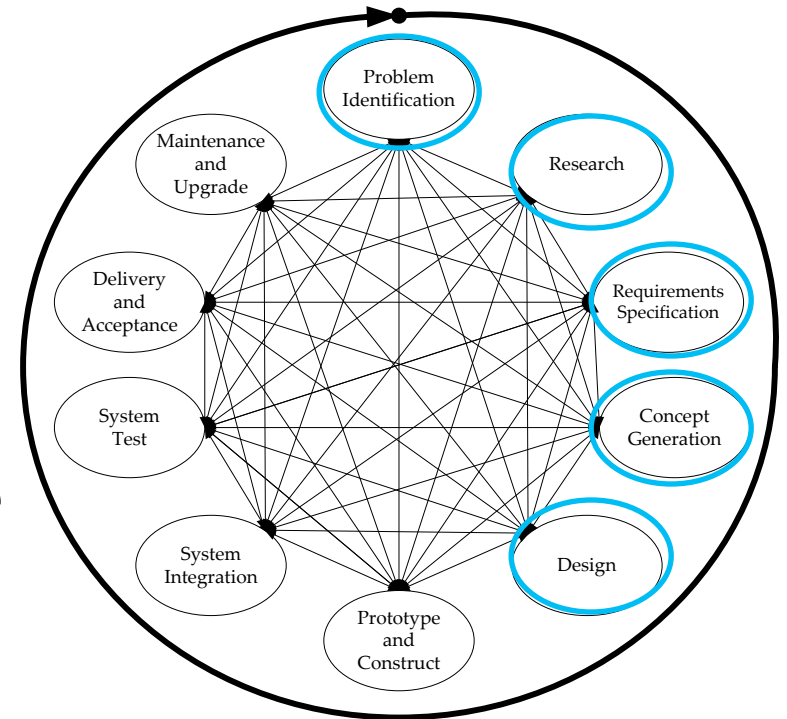


# Where do product ideas come from?

- Extrapolate from trends
  - Larger disk drives → better backup strategies
  - Aging population → ergonomic redesign of common items
- An engineer's idea/inspiration
- Brainstorming
- The Client
  - PSU ECE Capstone Project
  - Common in civil, mechanical engineering

# Product Development Process

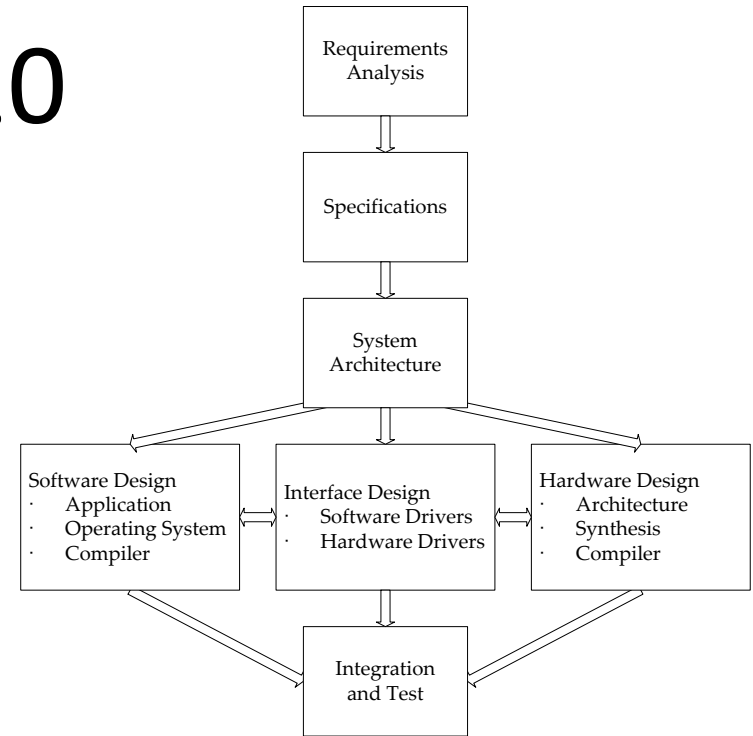
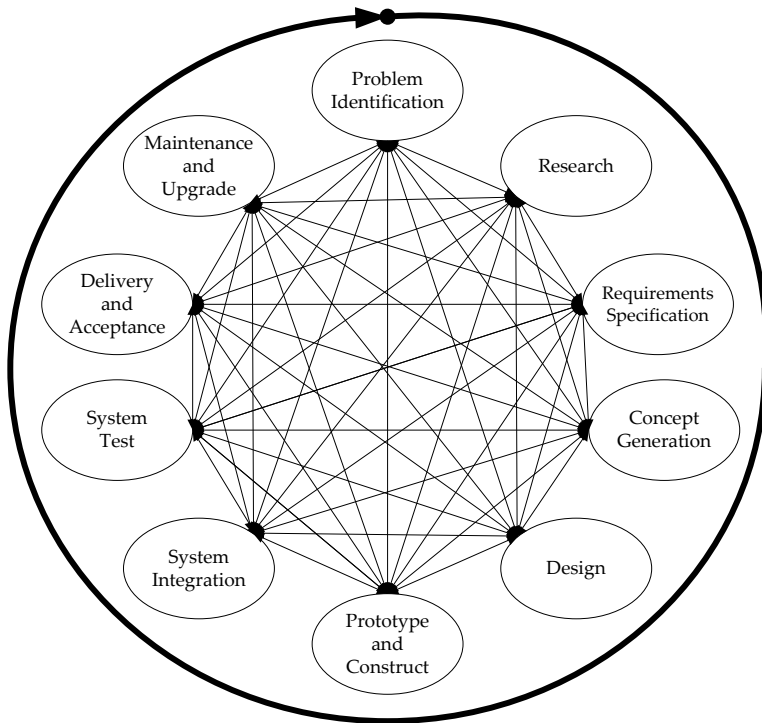
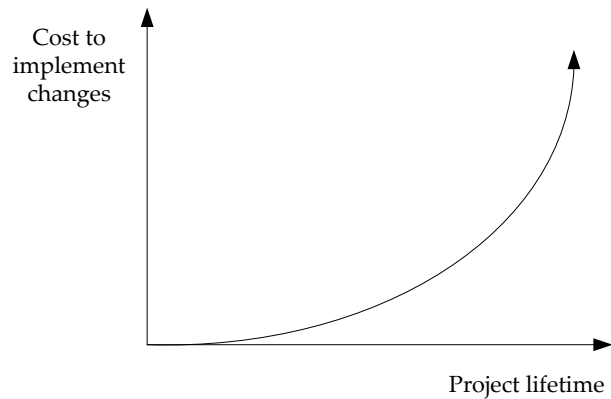
- Conceptual Design
- Preliminary Design
- Detailed Design
- Planning for Manufacture
- Planning for Distribution
- Planning for Use
- Planning for Product Retirement (End of Life)



# Product Development Process

- Conceptual Design
  - Identification of Customer Needs
  - Problem Definition
  - Gathering Information
  - Concept Generation
  - Concept Selection
  - Refinement of Product Design Specification (PDS)
  - Design Review

# Rule of 10

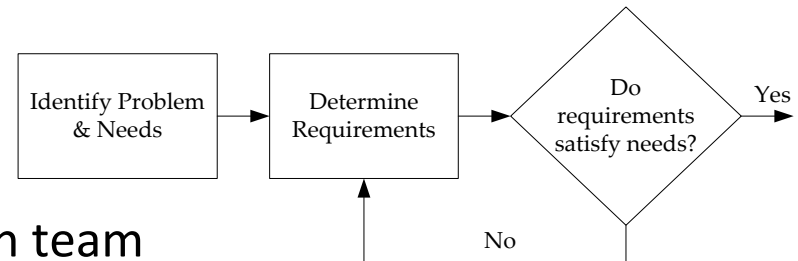


Objective	Key Spec	Plane
Economy COO	20% fuel savings	Boeing 787 Dreamliner
Capacity	555 Passengers	Airbus A380
Performance	Supersonic Speed	Concorde

# Conceptual Design

- Identify customer needs

- Understand customer needs
- Validate them
- Communicate them to the design team



- Define problem

- Create statement which describes what needs to be done to satisfy the customer needs
- Analyze of competitive products/solutions
- Create target specifications
- Identify constraints and trade-offs

- Gather information

- Determine size/extent of problem, value of solution
- Identify existing solutions
- Research patents
- Locate available technology
- Identify relevant standards

# Customer Needs

- Floppy Disk
  - Customer Input: “Floppy disks are too small”
  - Problem: “Increase storage capacity of floppy disk drive”
- Two solutions
  - Obvious: Improve storage capacity of floppy
  - Inspired: Maybe a better disk drive technology
- Better Still...

# Customer Needs

- What “needs” are satisfied by a floppy disk?
  - “Bootable” device
    - Zip drive
    - External Disk Drive
  - Backup/archival storage
    - FireWire or USB
    - CD R/W
    - Streaming tape
    - Internet backup (Mozy, Carbonite)
  - S/W distribution medium
    - CD, DVD
    - Internet download
  - File transfer
- What alternatives are there?
  - Ethernet
  - USB Flash Memory
  - IR port
  - WiFi
  - Bluetooth

Remember: A product can be a service (e.g. Podcasts, Photo storage and printing, Tivo, Netflix)

# Questions to Ask

1. What are you trying to do? Articulate your goals using absolutely no jargon.
2. How is it done today, and what are the limitations of current practice?
3. What is new in your approach, and why do you think it will be successful?
4. Who cares? If you are successful, what difference will it make?
5. What are the risks and payoffs?
6. How much will it cost? How long will it take?
7. What are the midterm and final “exams” to check for success?

Attributed to George Heilmeier, EE, Director of DARPA, CEO Bellcore



# Questions to Ask For Any Project

- Questions to define the design problem
  - What is the problem to be solved?
  - Why is there a problem?
  - What is my role in solving the problem?
- Questions to determine budget and schedule constraints
  - When is the solution needed?
  - What is the upper limit of cost to do the design?
  - What are your expectations of production cost, volumes?
- Questions of reliability and maintenance
  - What are the consequences of the system failing in operation?
  - What resources are available for maintenance?
    - Personnel, replacement parts, budget
- Questions of contract
  - How will it be determined when the design is complete?
  - How will it be determined that the design is acceptable?
  - How will I be paid?
  - Is the work that I am to do legal?

# Analytical Hierarchy Process

See Appendix B – Complete description of AHP

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

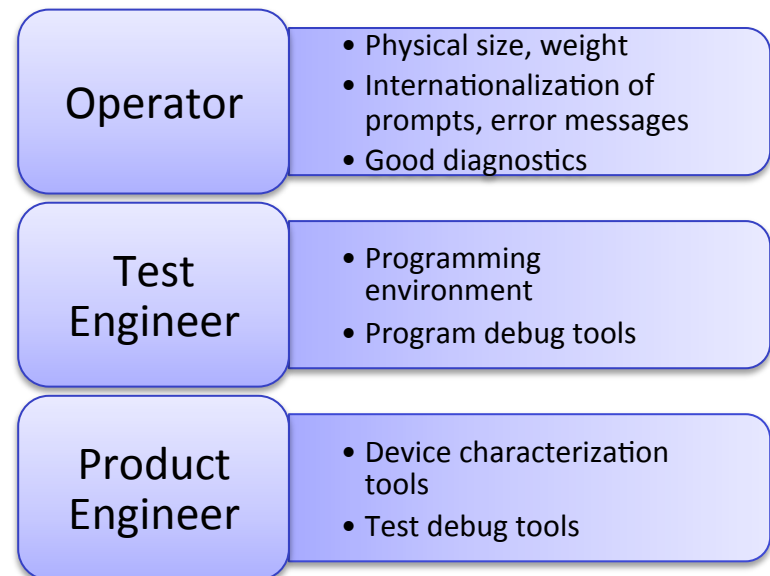
# Needs Identification Process

1. Gather raw data
2. Translate to marketing requirements
3. Organize the needs into a hierarchy
4. Rank the needs
5. Review the outcomes

# Gather Raw Data

- Interviews
  - Your customer
  - The end user (if different from customer)
  - Can be multiple end-users with different needs
    - The user(s)
    - The installer
    - The maintainer
- Focus Groups
- Observation (Protocol Analysis)
- Trends
- Library, Web

## Example from ATE Industry



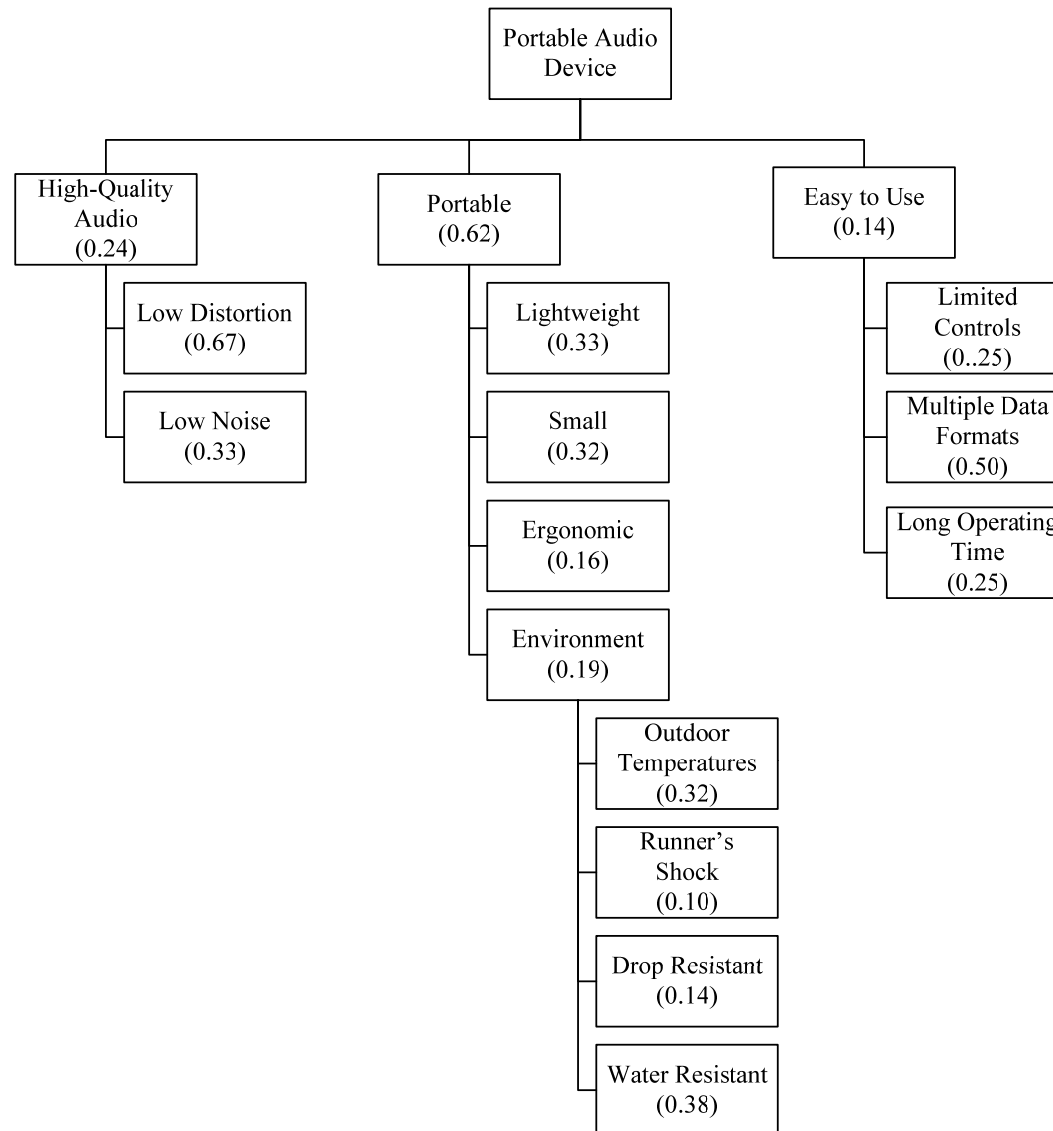
# Translate Needs into Marketing Requirements

- 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.”

# Organize Needs into Hierarchy

- Organize needs by **functional similarity**, not by importance!
- What is **functional similarity**?

# Objective Tree



# Rank the Needs

- Rank the needs to determine the relative importance of each of the needs
- Systematically compare each need to all other needs
- Who should do this?

	High-Quality Audio	Portable	Easy To Use	Score
High-Quality Audio				
Portable				
Easy-to-Use				



# Review Outcomes

- This is 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

# Review Needs Identification Process

1. Gather raw data
  - Customers
  - End-users
  - Additional research
2. Translate into Marketing Requirements
3. Organize need into hierarchy (Functional Similarity)
4. Rank Needs (Pairwise comparison – at each level)
5. Review the outcomes

**YES** – you will apply this to your design project!

# The Research Survey

- You need to become the experts on the problem and state-of-the-art in this area
  - If you don't then you re-invent the wheel
  - If you don't then you don't look too smart
- What is the basic theory behind the concept?
- How is it currently being done?
- What are the limitations of 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

- Problem domain background
- Patents
- Regulatory or Legal Climate and Requirements
- Relevant Technology
- Standards
- Related Products
  - Competitive
  - Complementary
- Possible Vendors
- Possible Partners

“Everything that can be invented has been invented.”

--Charles H. Duell, Commissioner, U.S. Office of Patents, 1899.

# Resources

**EE Product Center**

*[www.EEProductCenter.com](http://www.EEProductCenter.com)*

Web site for locating components and their manufacturers. Tree structure and search capability. Articles.

**Circuit Cellar**

*[www.CircuitCellar.com](http://www.CircuitCellar.com)*

Good reference for designers. Emphasis on embedded systems and electronics projects. Tutorials and project ideas.

**Datasheet Catalog**

*[www.DatasheetCatalog.com](http://www.DatasheetCatalog.com)*

Datasheet source for electronic components and semiconductors

**Dr. Dobbs**

*[www.ddj.com](http://www.ddj.com)*

Primarily for software developers. Tips and tutorials.

**EE Times**

*[www.EETimes.com](http://www.EETimes.com)*

Industry newspaper for EE. Articles on current technology.

**Electronic Design Magazine**

*[www.EDNmag.com](http://www.EDNmag.com)*

Free magazine. Good technical resources, design ideas

# Resources

**On Semiconductor**

[www.OnSemi.com](http://www.OnSemi.com)

Semiconductor supplier with broad range of ICs, particularly power management. Searchable DB of components, guidelines for component selection.

**The Thomas Register**

[www.ThomasRegister.com](http://www.ThomasRegister.com)

On-line version of famous Thomas Register for identifying companies and products in North America. Provides profiles of companies and products they make.

**DigiKey**

[www.DigiKey.com](http://www.DigiKey.com)

One of the major component distributors. Everything from ICs to connectors to enclosures.

**U.S. Bureau of Labor Statistics**

[www.bls.gov](http://www.bls.gov)

Information on consumer spending, profiles of industries, employment forecasts.

**U.S. Patent Office**

[www.uspto.gov](http://www.uspto.gov)

Searchable DB of all patents back to 1790. Full text back to 1976.

**Portland State University Library**

[www.Library.PDX.edu](http://www.Library.PDX.edu)

Access to indexes. Excellent portal to Compendex, ACM, IEEE. Full text available for many articles.

# Need Statements

- Briefly and clearly state the need to be met
- 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

- Summarize what is being proposed to meet the need
- Provide some preliminary design objectives
- Provide a preliminary description of the technical solution, avoiding a detailed description of the implementation

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].



# The Problem Statement

## Problem Statement Contents

- Need
- Objective
- Background (Research Survey)
- Marketing Requirements
- Objective Tree

# Summary

- Apply sound project selection criteria
- 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