06. Conceptual Design
NASA ESMD Capstone Design

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System Level Conceptual Design

Phase A: Design Problem Analysis

Diagram showing the steps involved in Phase A, including:
1. Design Concept Keys
2. Technology Readiness Assessment
3. Pugh Evaluation
4. QFD
5. Best System Concept Proposal
6. Design Evaluation Plan
7. Concept Sketches
8. Conceptual Benchmarks
9. Functional Description
Project Tools Covered

◆ Concept Benchmarks and Design Concept Keys
  – A quantitative comparison of existing products and prototypes with respect to requirements. A brief description of the results should accompany it.

◆ Functional Description
  – A function diagram showing the flow of mass, energy, and information in your product with descriptions of each function.

Project Tools Covered

◆ Concept Sketches
  – Pictures/sketches and descriptions of the various concepts you have for meeting individual functions or entire product ideas.
Functional Description

◆ A function diagram showing the flow of mass, energy, and information in your product with descriptions of each function

Functional Design

◆ Beginning of conceptual design
◆ Function descriptions
  – Active verb and a quantifiable noun
  – Use list of function classes to help
  – Sub-functions by asking “How?”
  – Go to basic functions
  – Useful in many other methods
  – Remember to include energy, material, and signal (information) “movement”
  – A function has an input and an output
Functional Classes

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<th>Operational Step</th>
<th>Core Function</th>
<th>Key Objective</th>
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<td>Initial</td>
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- More complete functional analysis
- Map all flows concurrently (material, energy, and information)
- Keep track of what is flowing
Use Subtract and Operate to insure a complete function structure

Maintain energy, material, and information structure for later use

Subtract and Operate
- Operate function with each component missing individually
- List all functions missing
Function Map – Mechanical Pencil

- Let’s try it out
  - Energy first
  - Material second
  - Skip information

Concepts

- Pictures/sketches and descriptions of the various concepts you have for meeting individual functions or entire product ideas
- Must be feasible
Conceptual Designs

- They are outline solutions to the design problem, where rough sizes and structural relationships among major parts are given.
- This phase places the greatest demands on designers for creative thinking, and innovation can originate here.
- Decisions are made on how each major function will be performed - but consider many alternatives of how this could be achieved.

(Lumsdaine et al., 2006)

Conceptual Designs

- Conceptual designs are worked out in some detail to allow estimates of cost, weight, overall dimensions, and assessment of feasibility.
- Each initial concept should be worked out to about the same level of detail and format, to allow fair evaluation.

(Lumsdaine et al., 2006)
**Alternative Concept Sketches**

- Documentation in the form of sketches serves to
  - Communicate ideas among the team members
  - Documentation of the process to establish credibility in the design product
  - For example, structure or operating mechanism of the concept for mechanical products

(Lumsdaine et al., 2006)

**Alternative Concept Sketches**

- Concept Sketches should be clearly drawn and unambiguous but should not be formal drawings
- Each design concept in each of the Pugh matrices should be succinctly summarized in words
  - For example, “The Slider”: Door opens 90 Deg; slides back; lunch compartment; bottom grid shelf for boots; umbrella hook.

(Lumsdaine et al., 2006)
Concept Generation

- Brainstorming around an idea or not
- Ownership
- Sources
  - Patents, journals, references, experts
- Sketches as final concepts

Mental Blocks

- Defining problem too narrowly
- Attacking symptoms, not problem
- Assuming only one right answer
- Getting “hooked” on first solution that comes to mind
- Getting “hooked” on a solution that “almost” works
- Being distracted by irrelevant information
- Getting frustrated by lack of success
- Being too anxious to finish
- Defining the problem ambiguously
Adding New Ideas

- **Adapt?**
  - How can idea be used as is? What other uses could it be adapted to?

- **Modify?**
  - Change the meaning, material, color, shape, etc.

- **Magnify?**
  - Add new ingredient? Make longer, lower, shorter?

- **Minify?**
  - Split up? Take something out? Make lighter, lower, shorter?

- **Substitute?**
  - Who else? What else? Where else? Other material or approach?

- **Rearrange?**
  - Interchange parts? Other patterns, layouts? Reverse roles?

- **Combine?**
  - Combine parts, ideas? Blend? Compromise?

Other Techniques

- **Other people’s views**
  - Team owner
  - Fans
  - Short players
  - Tall players

- **Random stimulation words**
  - albatross, air, animals
  - bean, bear, bump
  - control, cape, cannon
  - needle, notice, next
  - quack, rage, run, rigid
  - wedge, zone, zoo
Function-Structure Mapping

- Understand how components in your concepts achieve the necessary functions
  - Check for unaccomplished functions
  - Look for integration opportunities
  - Reuse/combine concept pieces by function to create new concepts
Design Concept Keys

- A way for discussion and brainstorming of concepts that reaps the marvelous power of team synergy in this conceptual stage of design
- Each team member is assigned the task of inventing a complete design concept that embodies all the best features that can be imagined
- Each team member produces a complete design concept, with all major decisions and features clearly noted as keys to design concepts
- Enables comparison of the concepts with each other

(Lumsdaine et al., 2006)
Design Concept Drawing