**Design Theories and Methods**

**What are they?**

- An **organized system of techniques** found by experience to be useful
- A **checklist of items to consider** that increases the chances of creating a design with certain desirable characteristics

**Example:**

| Functional analysis | Evaluates the worth of a design in terms of issues like cost, appearance, usability, profitability, safety, marketability |


OU ME Sr. Design, Dr. Kremer, 2
Design methods are used for Cost Reduction & Quality Improvement

Purpose is to reduce total cost of the design
  » materials +
  » manufacturing (labor, equipment, …) +
  » assembly (labor, equipment, …) +
  » cost of quality control (conformance testing, scrap, rework,…) +
  » cost of failure + …
Design methods used for Cost Reduction & Quality

Reasons for unnecessary cost

[The Rational Manager, Kepner & Tregoe]

» Lack of an idea
» Lack of information
» Habitual thinking (mental roadblocks, natural resistance to change)
» Honest misconceptions
» Negative attitudes
» Shortage of time
» Changing technology (unaware or current capabilities or state-of-the-art technology)
» Outdated specifications
» Poor human relations (including faulty communications)
» Lack of understanding of the meaning of good value
Why do we need more than 1 design method?

“if the only tool you have is a hammer, every problem will look like a nail”

We need different design methods to deal with the many different design objectives & perspectives:

Maximize value and performance,
Minimize total life-cycle cost,
Minimize manufacturing cost,
Minimize assembly time,
Minimize environmental impact,
Minimize servicing / repair costs…
What are the most common design theories and methods

- Concurrent Engineering / Simultaneous Engineering (consider all aspects of the design early in the process)

- Value Engineering / Functional Analysis (focus on function, and eliminate any feature that doesn’t directly support a basic function of the system)

- DFX (Design for Manufacturability (DFM), Design for Assembly (DFA), Design for Simplicity (DFS) [developed by Hitachi and licensed by GE],…)

- FMEA (Failure Modes and Effects Analysis)
Example Design Method: Value, Function, and Value Engineering

Value: Most function for the least cost
($ spent per unit of function)

Function: Action that is desired & expected from a component or a system

» Basic function: the specific work that must be done to meet expectations and carry out the fundamental task

» Secondary function: other functions that
  a) are performed to support the basic function
  b) are inevitable but not necessarily desirable consequences of the basic function
  c) add esteem value (the delighters)
Example Design Method: Value, Function, and Value Engineering

All functions can be represented as a word pair consisting of an

Active verb + Quantifiable noun

» Verb answers the question: What does it do?
» Noun answers the question: What does it do it to?

Example: Computer monitor stand Product Design, Otto & Wood

Key functions include:
• adjusting height,
• locking height position,
• supporting the monitor forces, and
• receiving the monitor.
**Value Engineering / Functional Analysis**

**Value Engineering** (VE) is a design theory intended to produce designs with maximum value.

**Functional Analysis** is a design method or tool used within Value Engineering to maximize value.

» In VE, the “significant few” are identified based on the **Value Index (VI)**

» **VI=Price/Worth**, the larger the VI value the better the chance for improvement

» **Worth**: Least expensive method of performing the basic function
Value Engineering is defined as:

the systematic application of recognized techniques that
a) identify the function of a product or a service
b) establish a monetary value for that function, and
c) provide the necessary function reliably at the
   lowest overall cost

The Purpose of Value Engineering is

to identify and remove unnecessary costs without
compromising the quality and reliability of the design.

It can be applied during conceptual design (top down) or
design refinement (bottom up).
Value Engineering / Functional Analysis

A Part-level Value analysis answers the following questions:

[Engineering Design, Dieter]

» Can we do without the part?
» How much function is needed? (Does it do more than required?)
» Does the part cost more than it is worth?
» Is there something that does the job better?
» Is there a less costly way to make the part?
» Can a standard item be used in place of the part?
» Can an outside supplier provide the part at less cost without affecting dependability?

Value Engineering techniques simplify designs by eliminating parts that do not add value to the end product and reduce costs by searching for the least expensive method to reliably provide the necessary function.
Value Engineering

Flowchart for program-level value analysis as conducted in industry

Note especially the questions used at each stage

[Reference: Engineering Design, Dieter]
Function: provide air-flow.
Holes are the least expensive way to provide the function.
Worth is the cost of the hole making operation.
Value Engineering – Details & Examples

(Reference: Value Analysis, Hollis)

Function: attach fan to shaft
Extra parts provide unnecessary secondary functions & can be eliminated

Description — change from 5 separate pieces to 1 case piece for holding fan
Proposal Reduction — 45%
Net Savings — $33,000
Functional Analysis Tools

A top-down, system level functional flow chart is a good tool for
» Providing organizational structure to your thinking
» Communicating the system design to reviewers

The flow chart starts from the question:
What is the basic function of the entire system?
then
Shows how that answer affects system design and configuration

System level function and configuration

Part level functions and possible embodiments
(to support system function)
**Functional Flow Chart Example** - Computer monitor stand product development case study (Product Design, Otto & Wood)

**Key functions:**
- adjusting height
- locking position
- supporting the monitor forces
- and receiving the monitor.