DESIGN PROBLEMS AND PROCESSES

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WHAT IS ENGINEERING DESIGN?

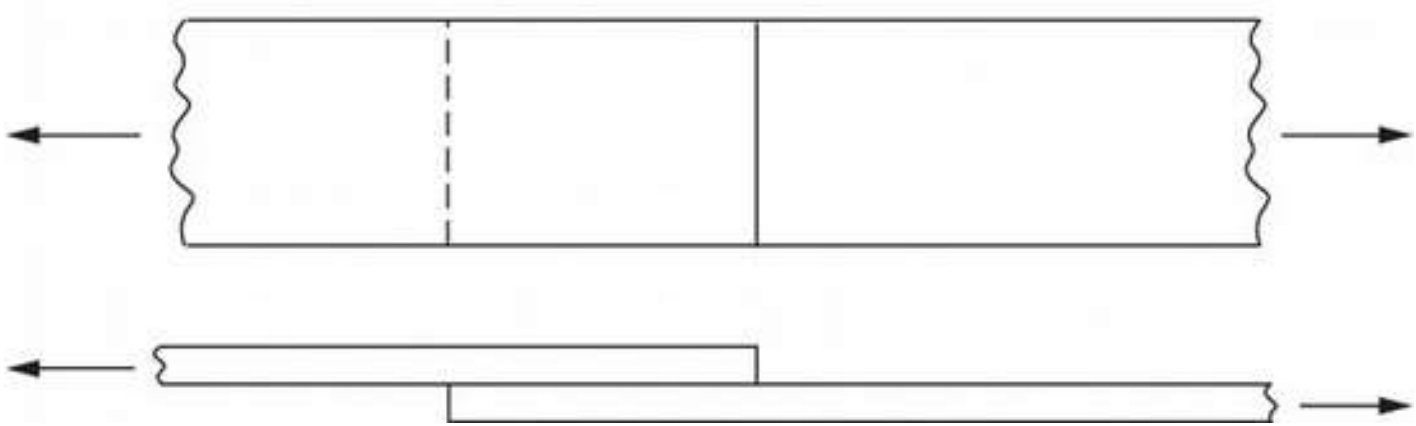
We can say the following:

Solving a problem that means:

- is not fully-defined in terms of its requirements
- has a multitude of satisfactory solutions
- requires creativity and engineering knowledge in generating and evaluating solutions (*iterative process)*
- usually results in a piece of working hardware

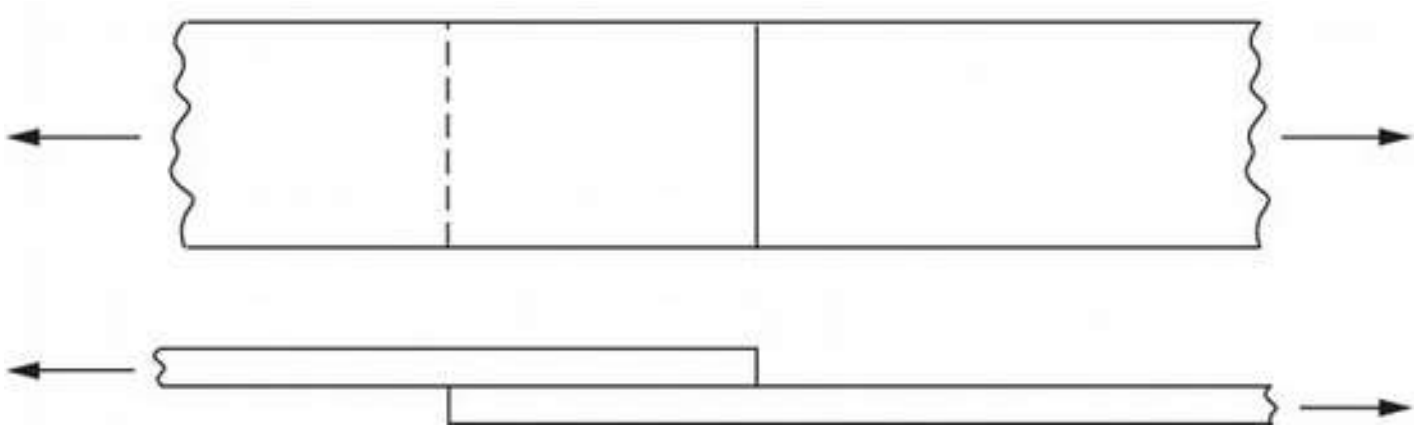
TEXTBOOK DESIGN VS. REAL DESIGN

Textbook design: “What size SAE grade 5 bolt is required to fasten two pieces of 1045 sheet steel, each 4 mm thick and 6 cm wide, which are lapped and loaded with 100 N?”

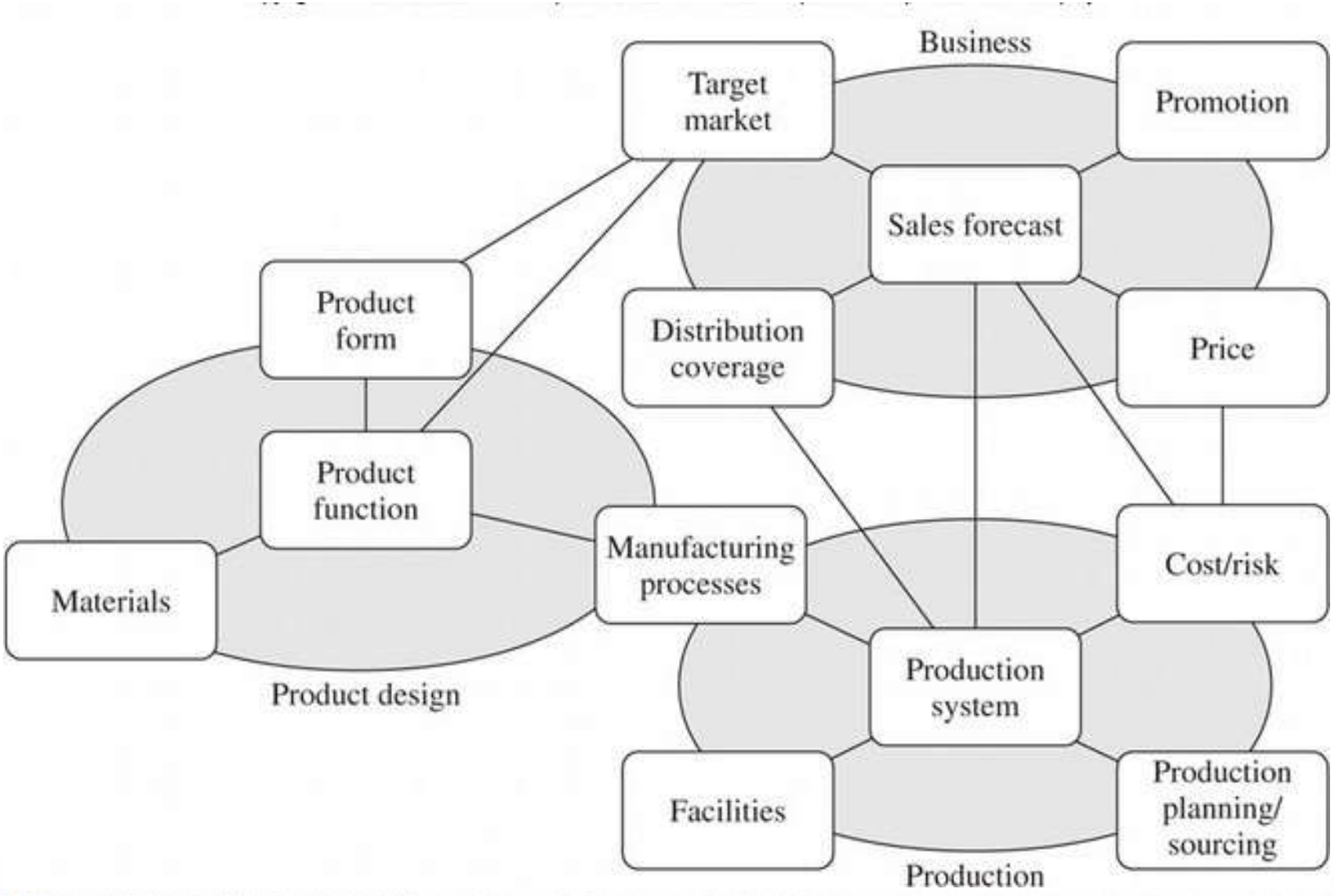


TEXTBOOK DESIGN VS. REAL DESIGN

Real design: “Design a joint to fasten two pieces of 1045 sheet steel, each 4 mm thick and 6 cm wide, which are lapped and loaded with 100 N.”

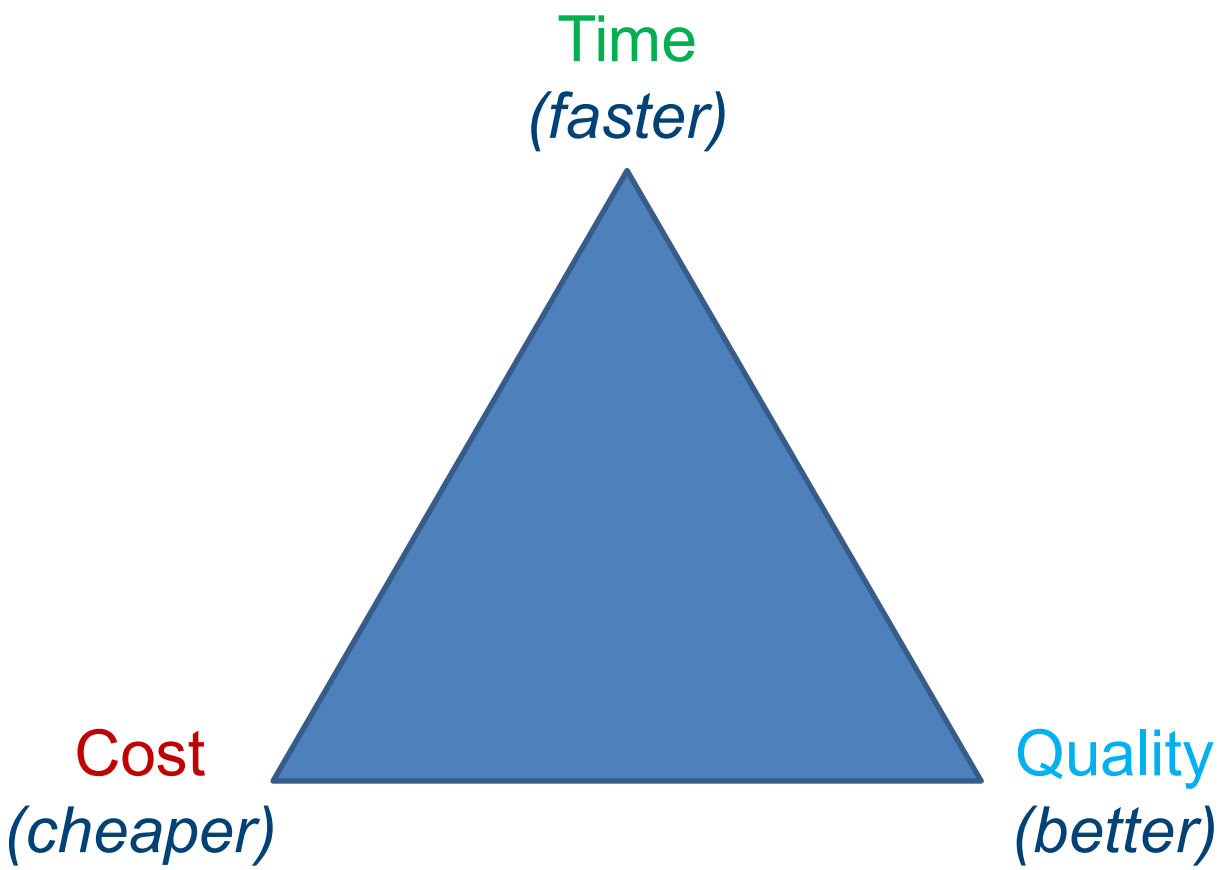


CONTROLLING VARIABLES IN PRODUCT DEVELOPMENT



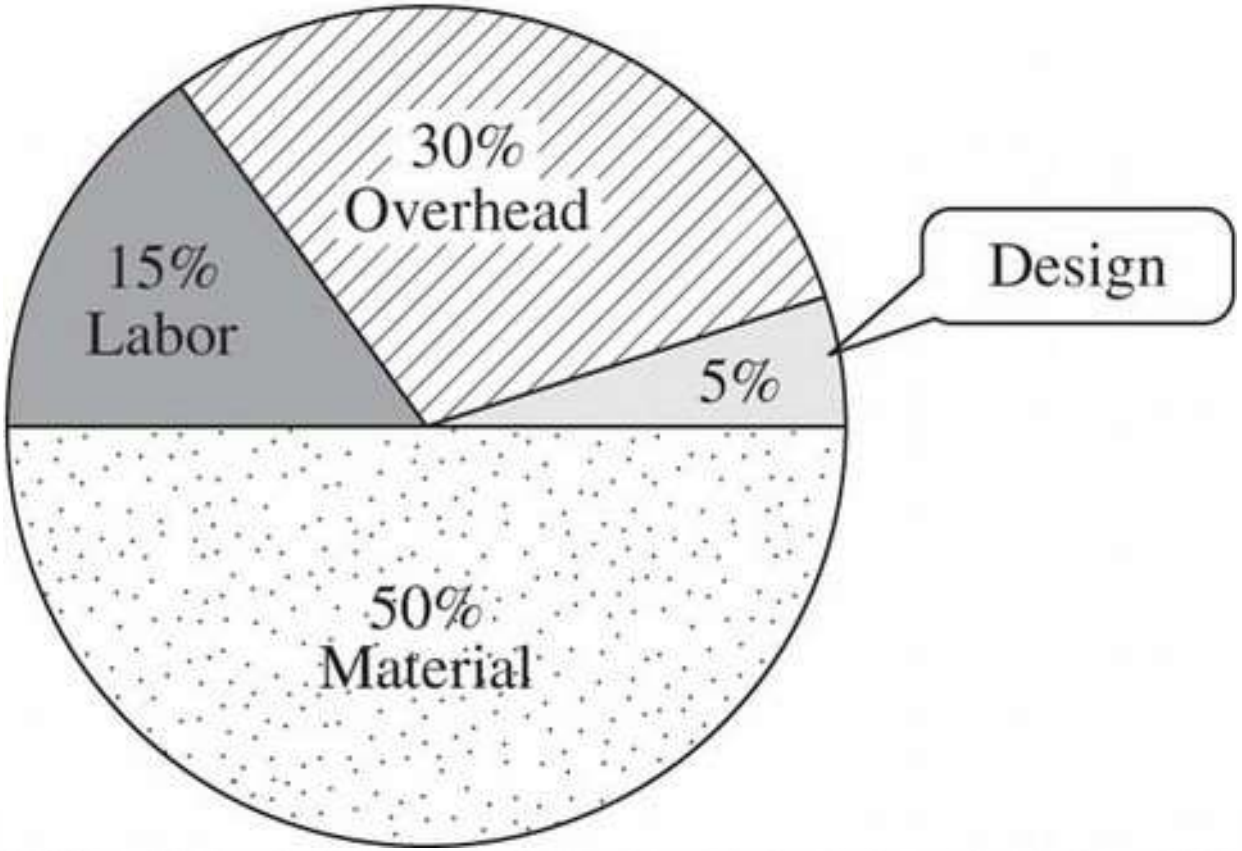
MEASURING EFFECTIVE DESIGN

(management always wants)



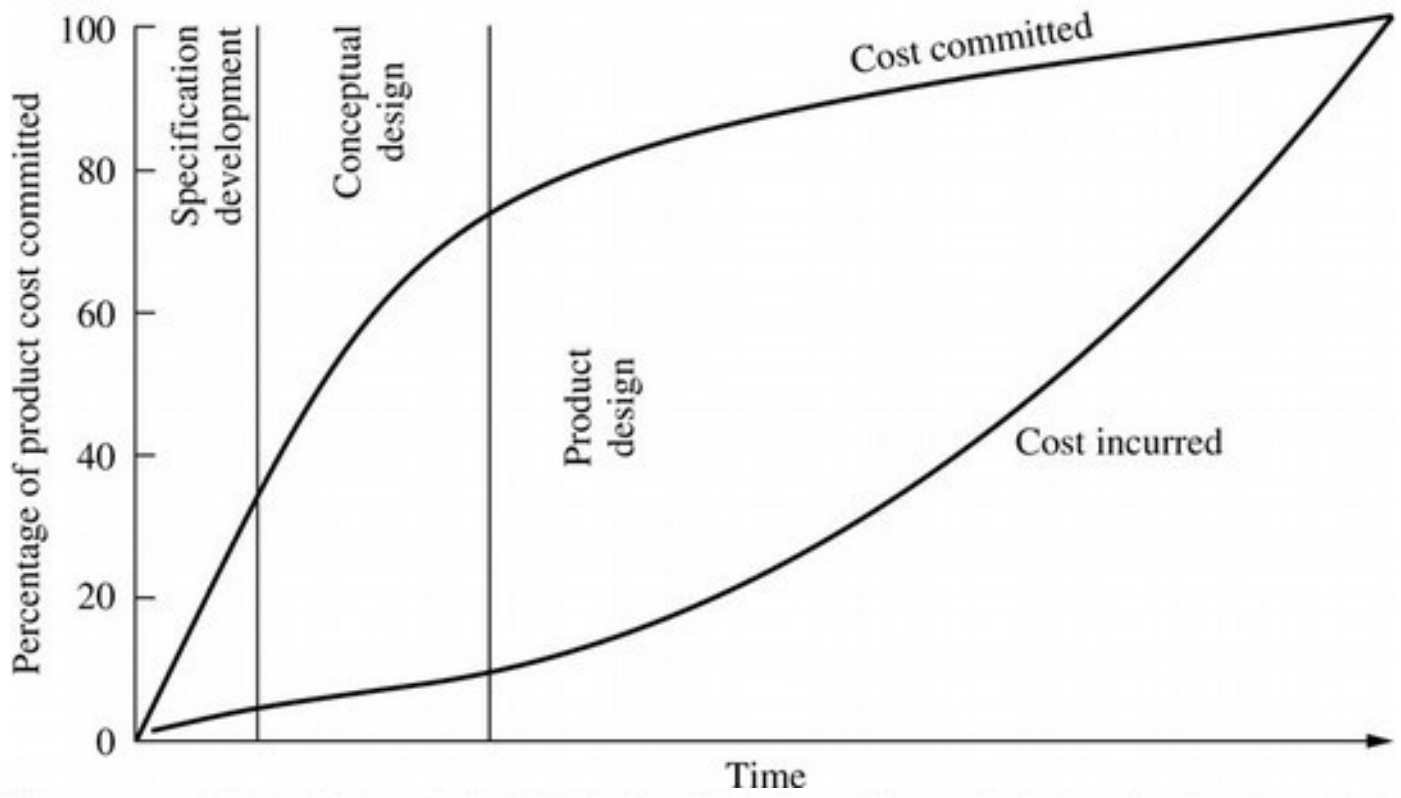
MEASURING EFFECTIVE DESIGN

Designers R&D costs are little, but their impact on product cost is great. (it is worth to be an engineer)



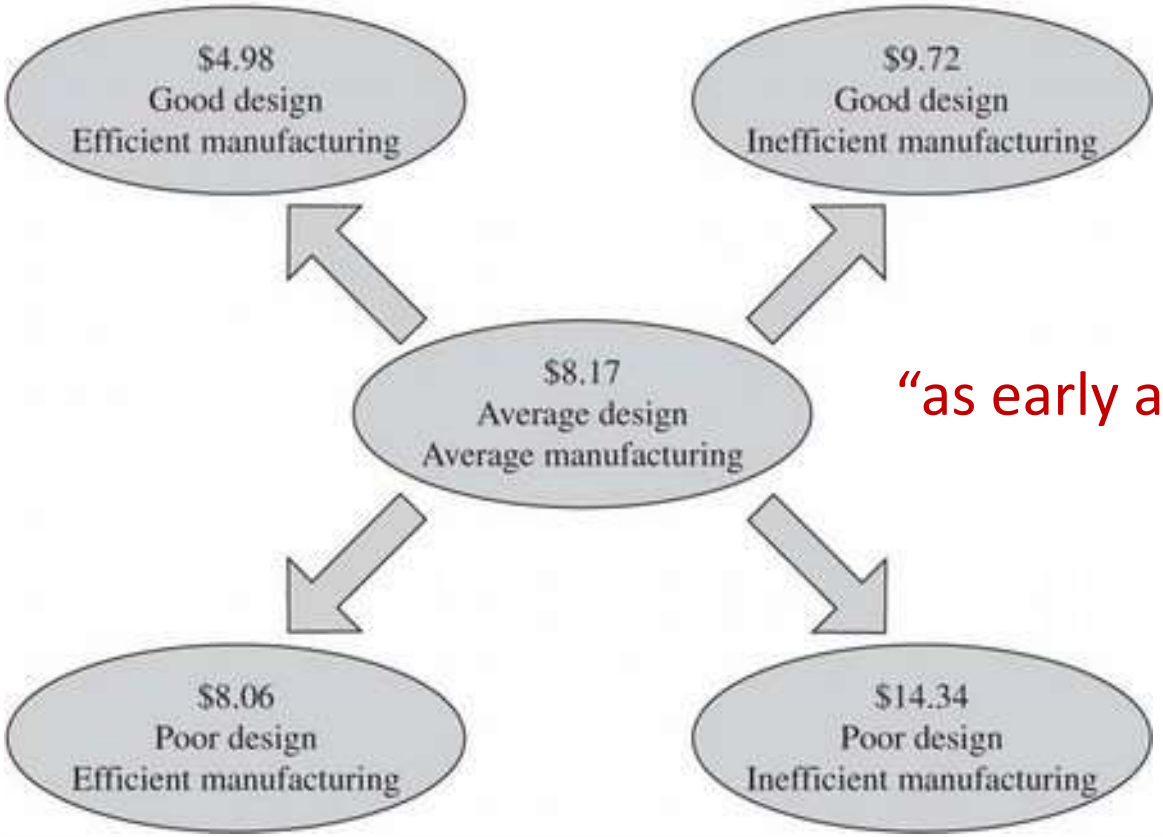
MEASURING EFFECTIVE DESIGN

The cost of designing is small but design has a large effect on manufacturing cost, overall product quality and time-to-market. Product cost is committed early in the design process and spent later.



MEASURING EFFECTIVE DESIGN

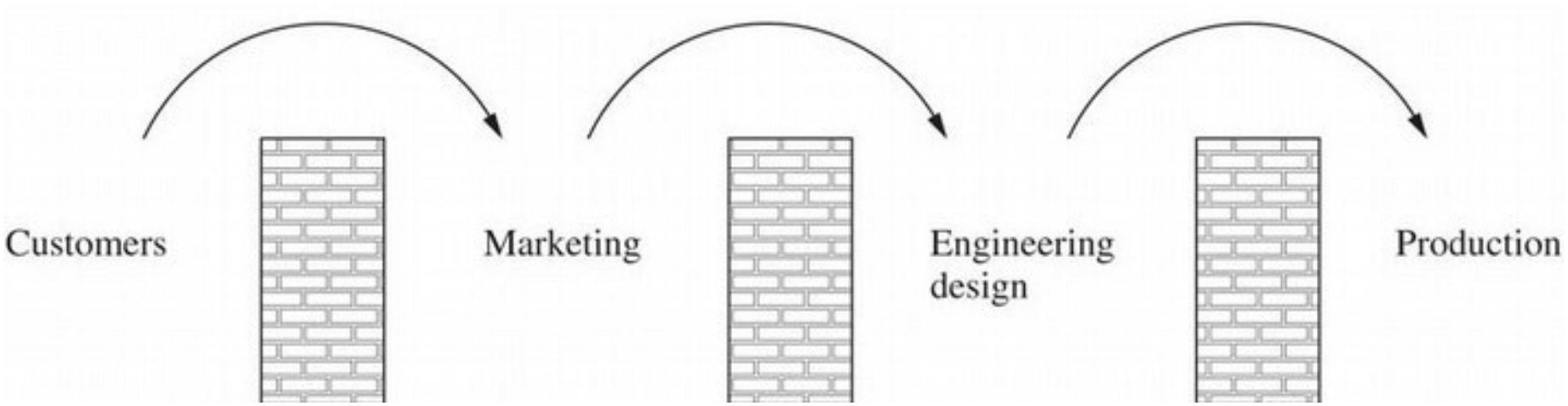
Changes made early in design process are more cost-effective than those made later



"as early as possible"

CONCURRENT DESIGN (simultanous engineering process)

Concurrent, or simultaneous, design has replaced the outdated “over-the-wall” design method



Because we do it parallel, not in sequence, we have no time at all…

CONCURRENT DESIGN

Most important feature: simultaneous development of product design and manufacturing process

Design for “X” (DFX techniques)

X = M (Manufacturability)

X = Q (Quality)

X = A (Assembly)

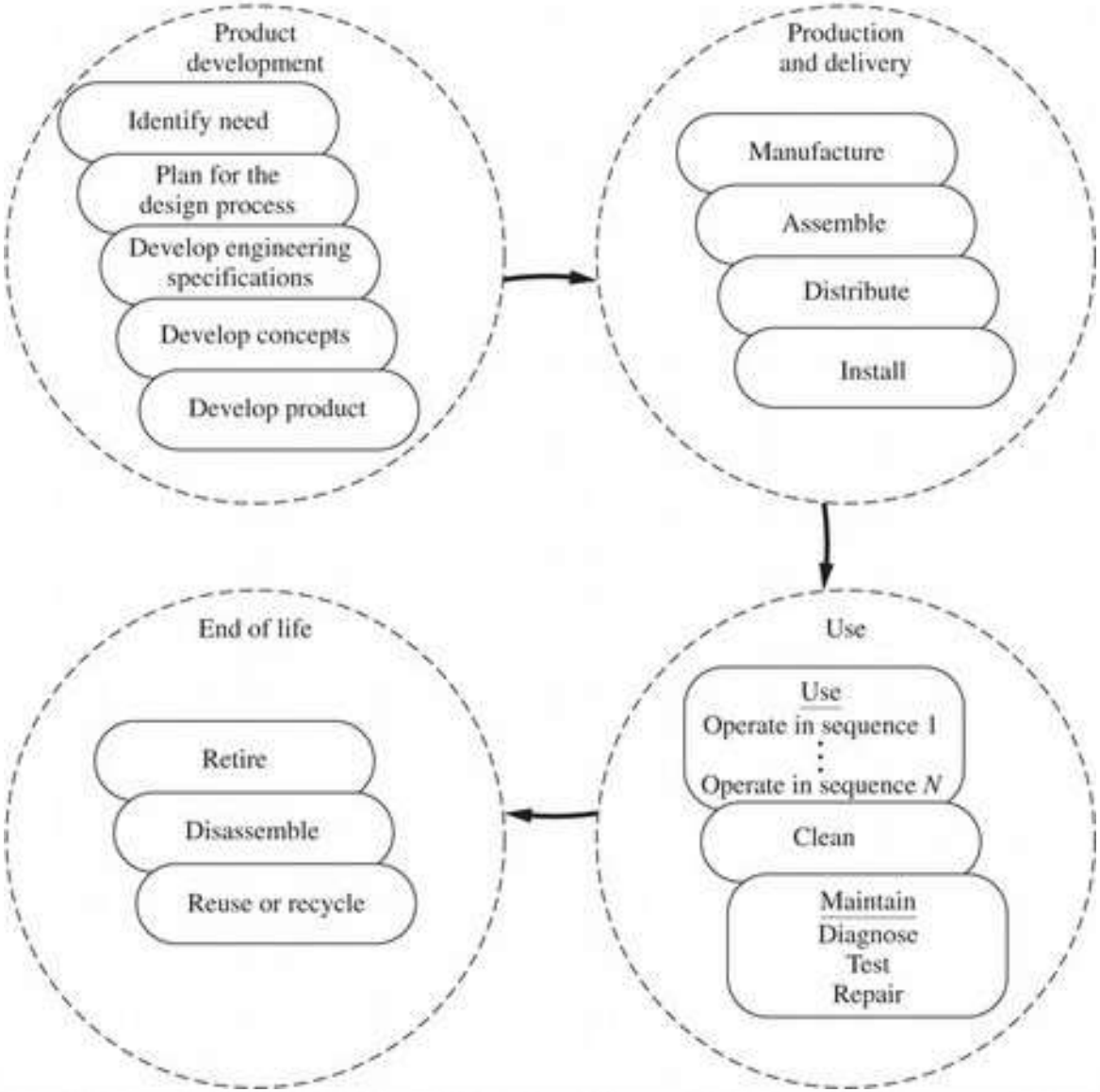
X = E (Environment)

X = R (Reliability)

X = S (Safety and Serviceability)

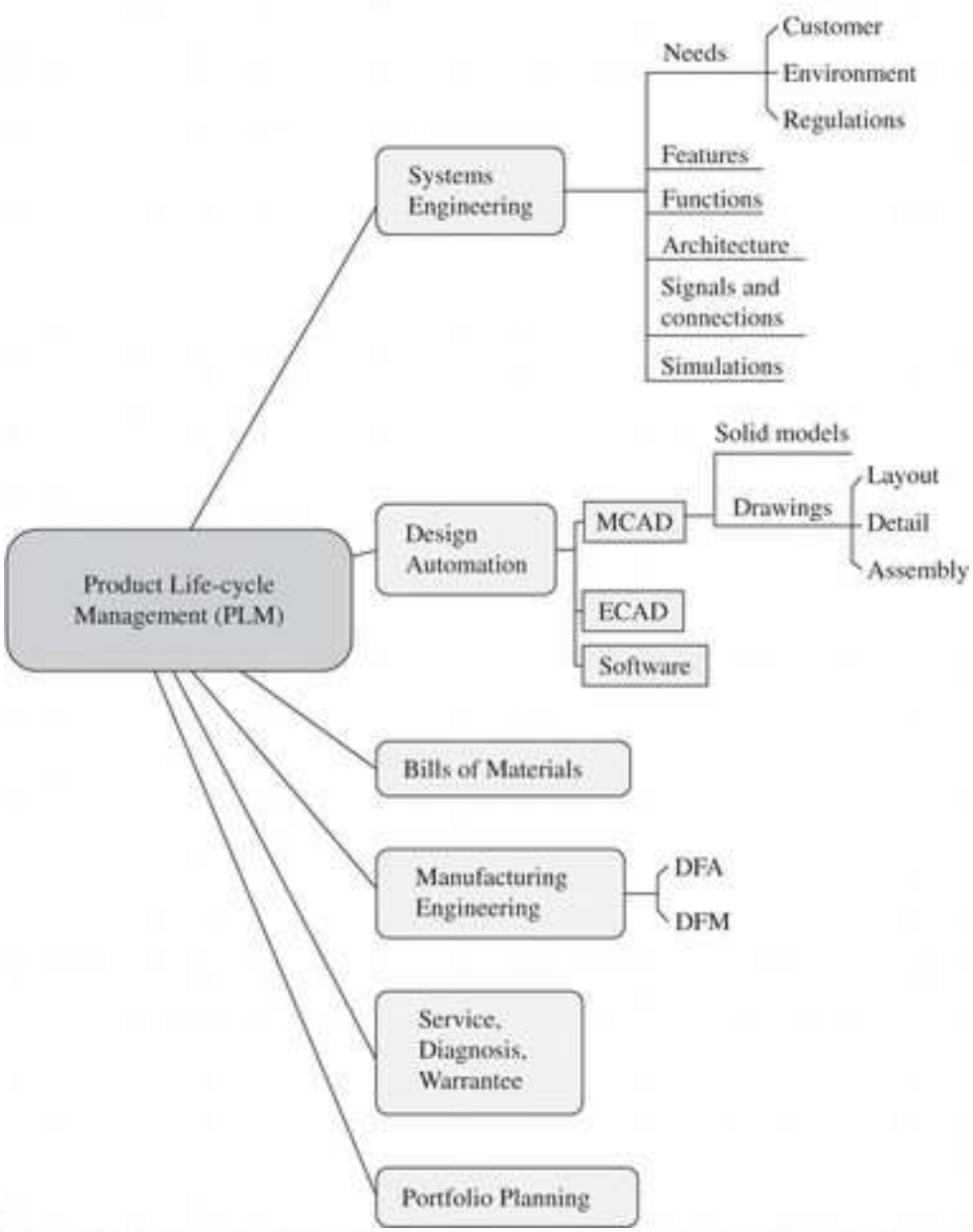
LIFE OF A PRODUCT

Engineering to be at every stage



LIFE OF A PRODUCT

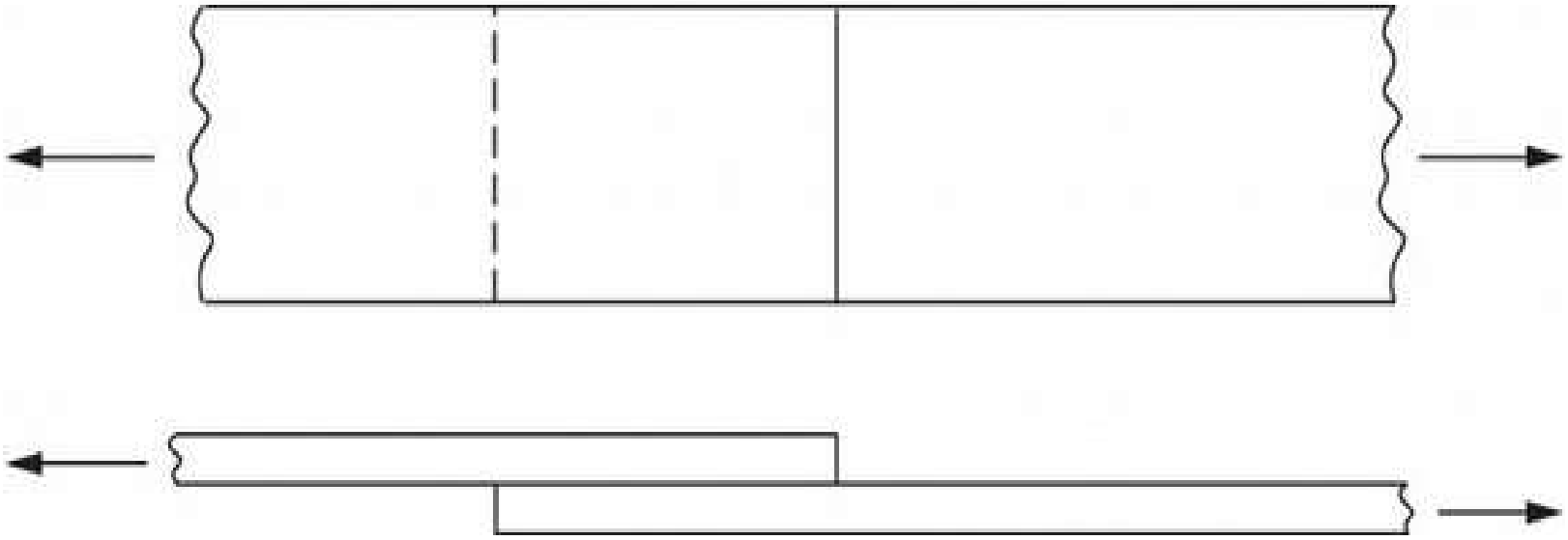
We have database PLM, Windchill, ENOVIA, etc which enables engineering to be at every stage.



THE "MANY" SOLUTIONS FOR DESIGN PROBLEMS

Design problems have many satisfactory solutions, but no (never) clear best solution

Sheet metal joint



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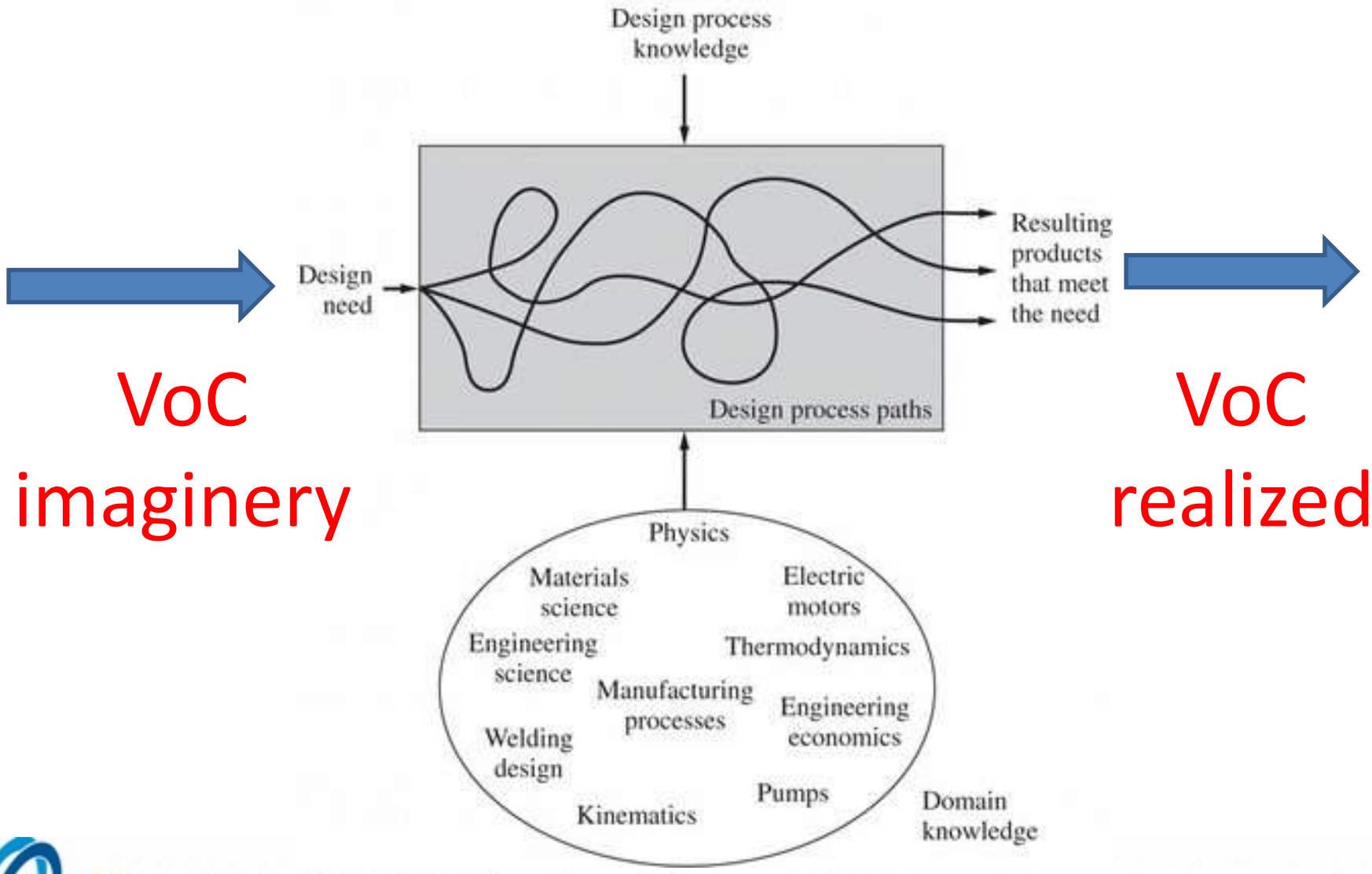


VoC imaginery

VoC realized

THE BASIC ACTIONS OF PROBLEM SOLVING

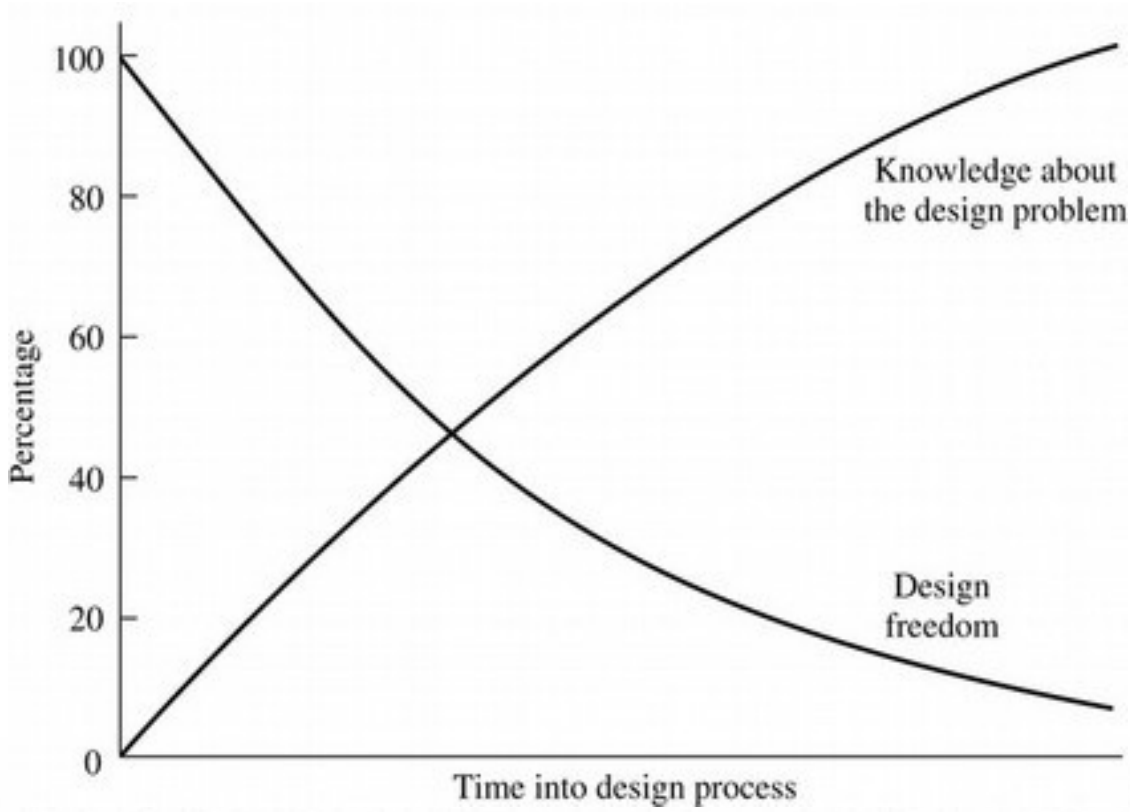
1. *Establish the need or realize that there is a problem to be solved*
2. *Plan how to solve the problem*
3. *Understand the problem by developing requirements and uncovering existing solutions for similar problems*
4. *Generate alternative solutions*
5. *Evaluate the alternatives by comparing them to the design requirements and to each other*
6. *Decide on acceptable solutions*
7. *Communicate the results*

THE DESIGN PARADOX

As the design process flows, you gain knowledge but you lose freedom to use what you know.

Time and cost normally drive the project, so there is rarely an opportunity to start over or to redo a design

To design something GOOD at first approach, otherwise COMPETITORS BREAK US



DIFFERENT TYPES OF MECHANICAL DESIGN PROBLEMS

Selection design

Configuration design (packaging)

Parametric design

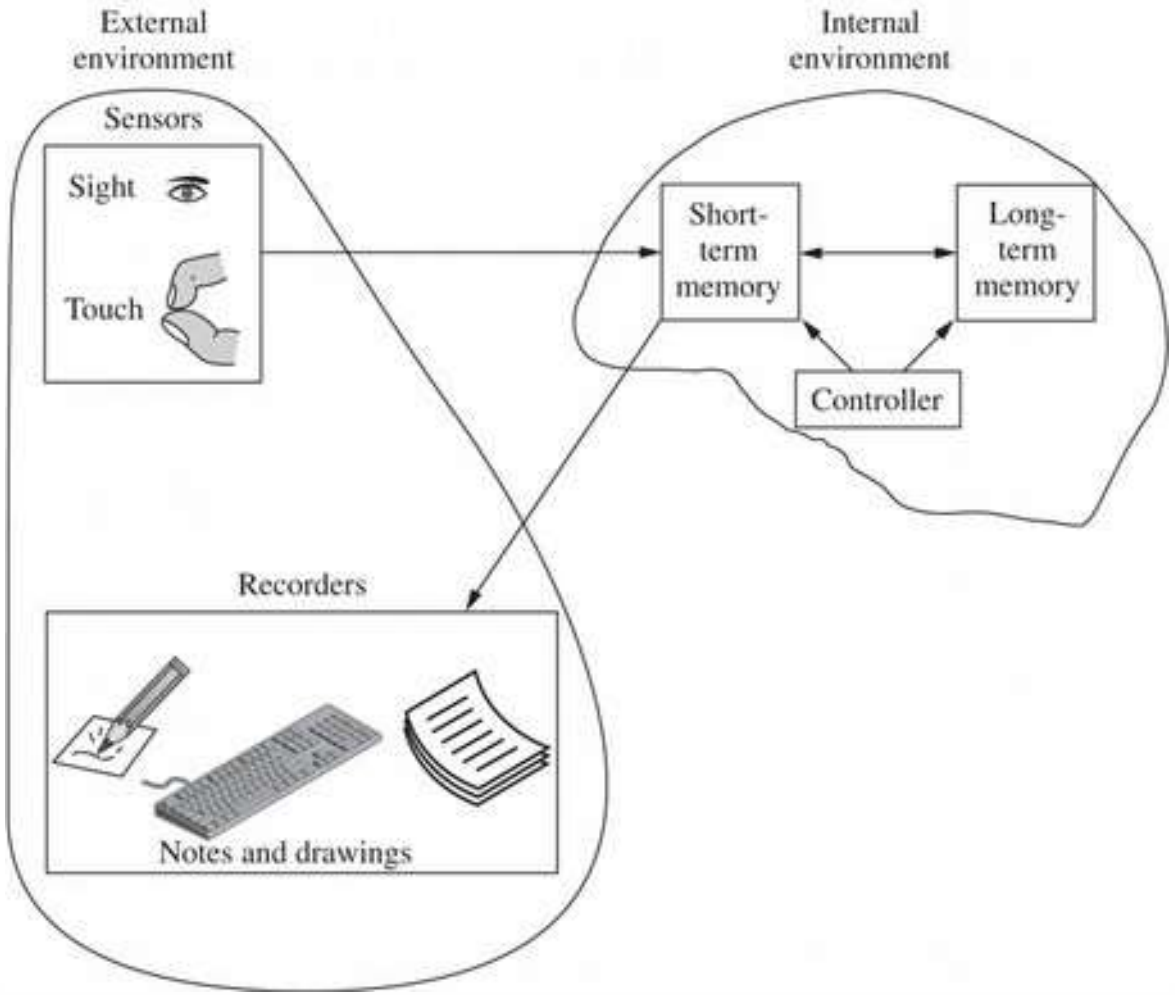
Original design

Redesign

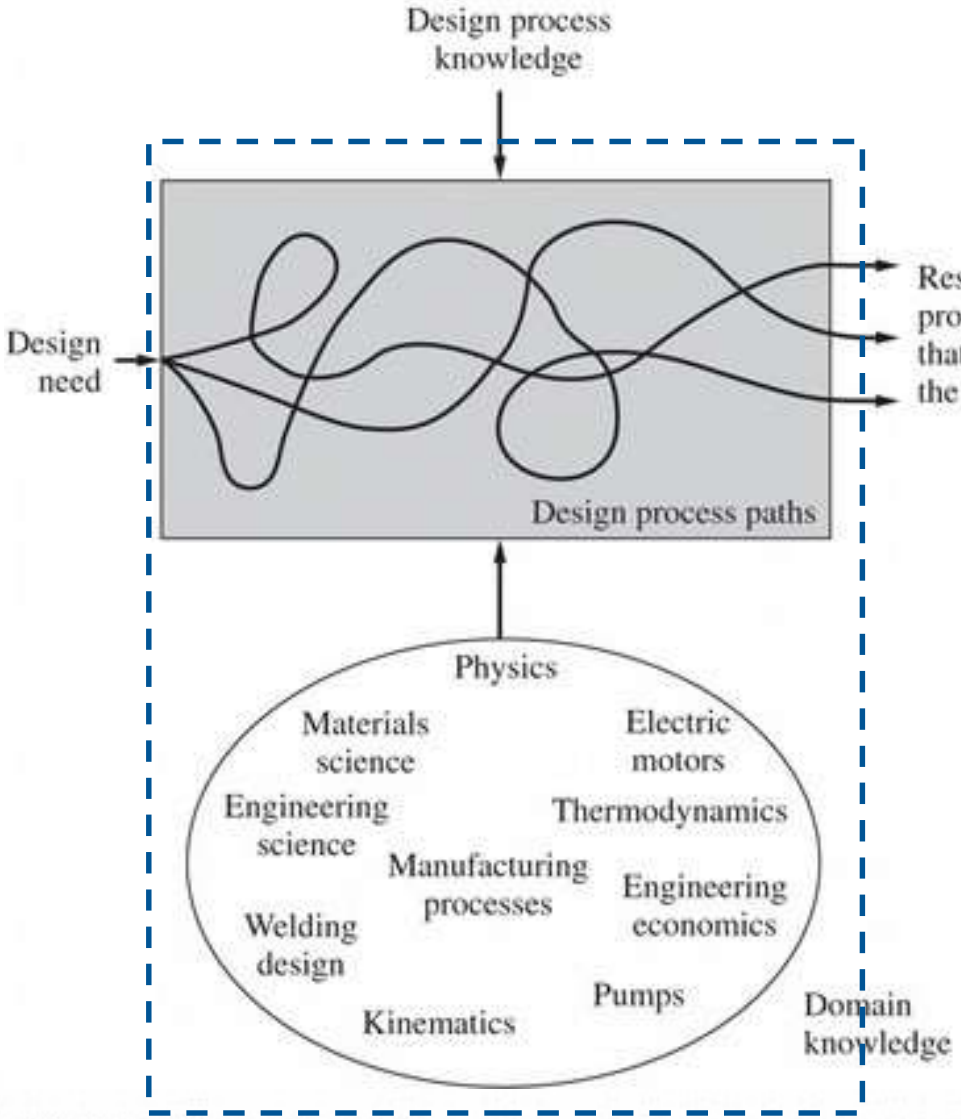
Variant design

Conceptual design and Product design

THE INDIVIDUAL DESIGNER –A MODEL OF HUMAN INFORMATION PROCESSING



THE INDIVIDUAL DESIGNER –TYPES OF KNOWLEDGE



Procedural knowledge

General knowledge

Domain specific knowledge

DESIGN TEAMS AND PERSONALITIES

- Extroverted vs. Introverted
- Fact vs. possibility-oriented
- Objective vs. Subjective
- Decisive vs. flexible

Teams should be heterogeneous

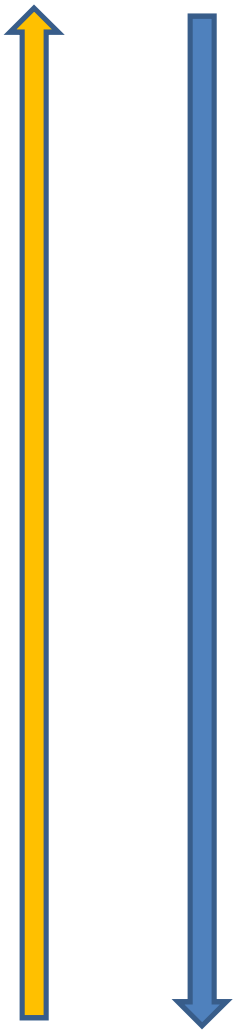
DESIGN TEAM GOAL

Solving a problem through 5C

- **C**ollaboration
- **C**ompromise
- **C**onsensus
- **C**ommunication
- **C**ommittment

MEMBERS OF DESIGN TEAMS (possible members)

We do it parallel



- Product design engineer
- Product manager
- Manufacturing engineer
- Designer
- Technician
- Materials specialist
- Quality control specialist
- Analyst
- Industrial designer
- Assembly manager
- Vendor’s or Supplier’s representative

THE MECHANICAL DESIGN PROCESS

Establish a need (Product discovery)

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Project planning

↓

Product (Specification) definition

↓

Conceptual design

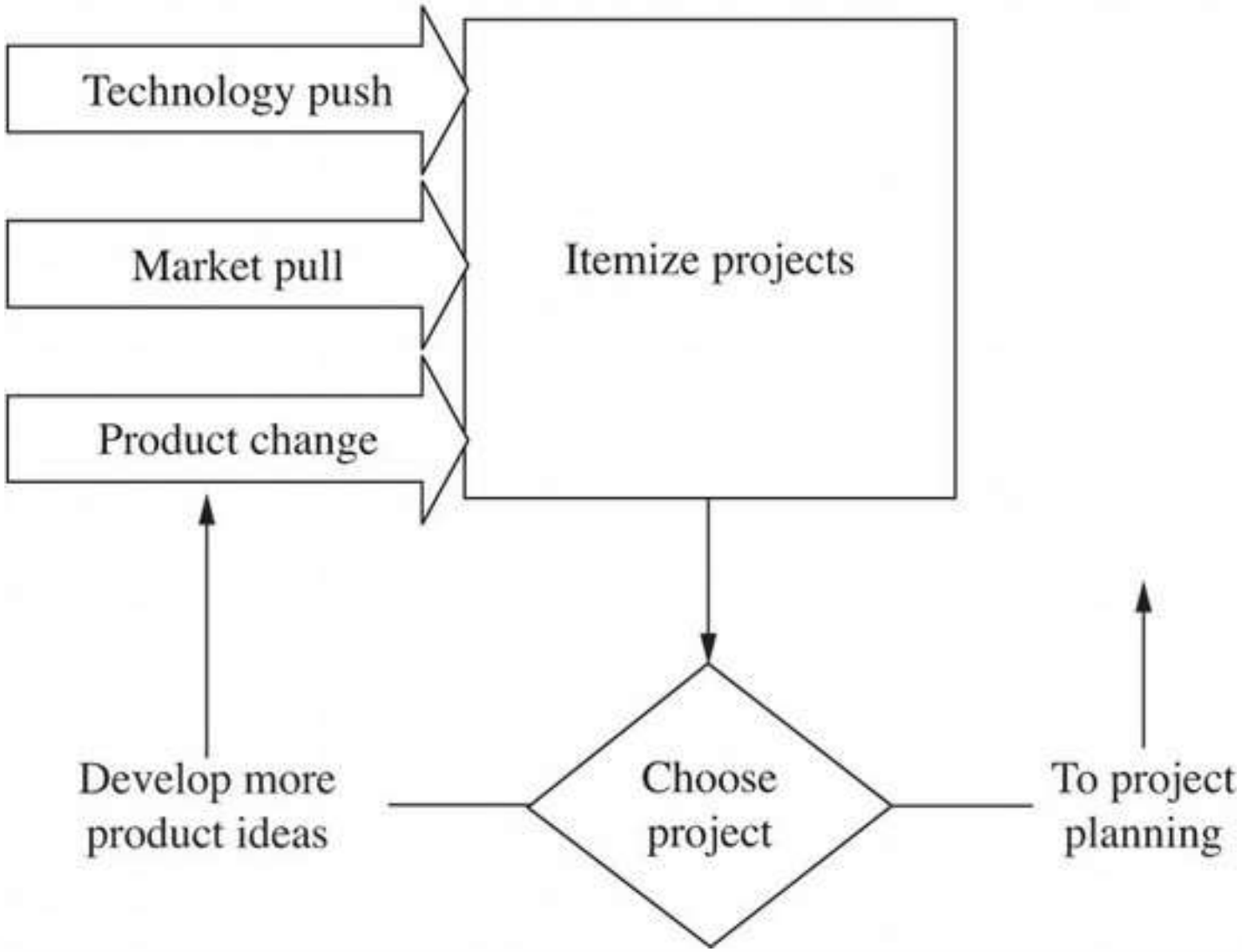
↓

Product development

↓

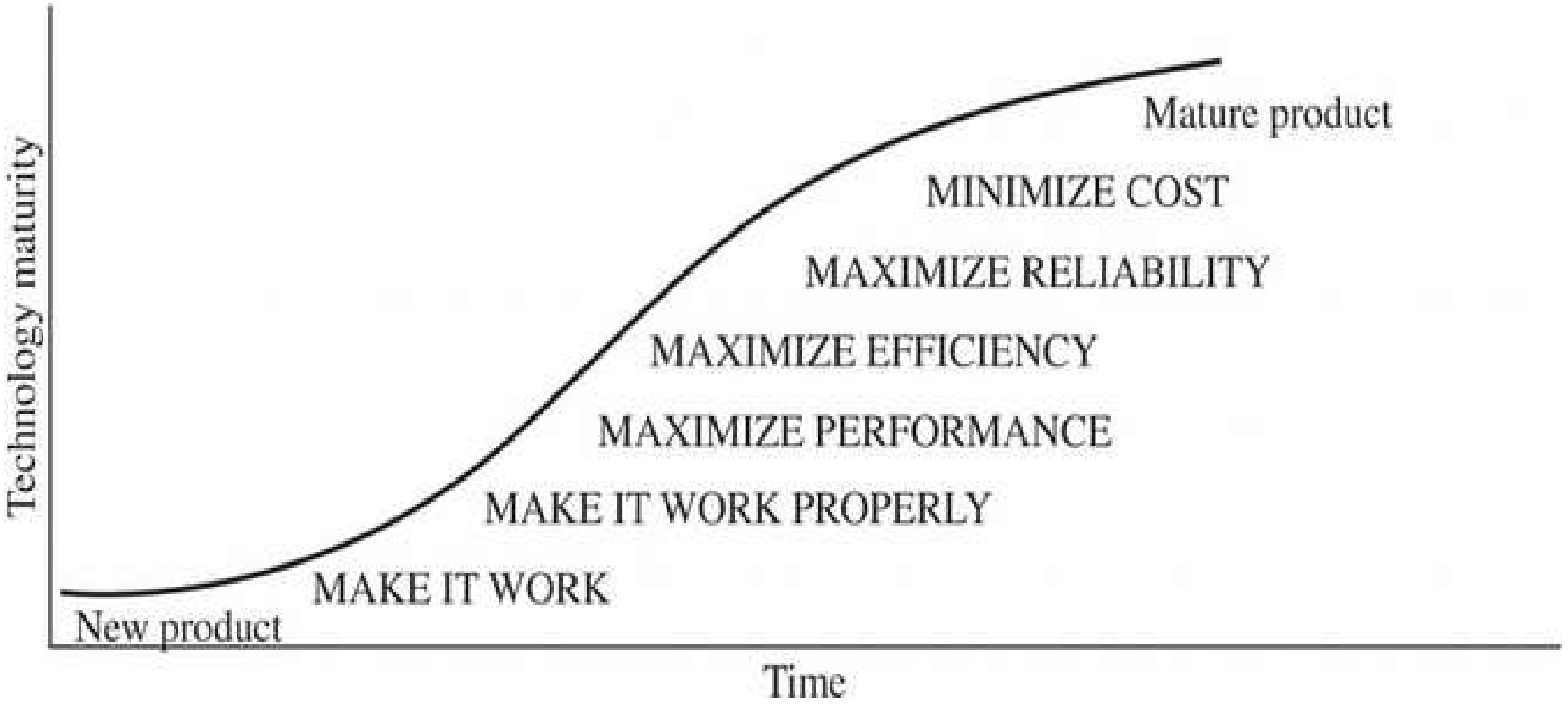
Product support

PRODUCT DISCOVERY



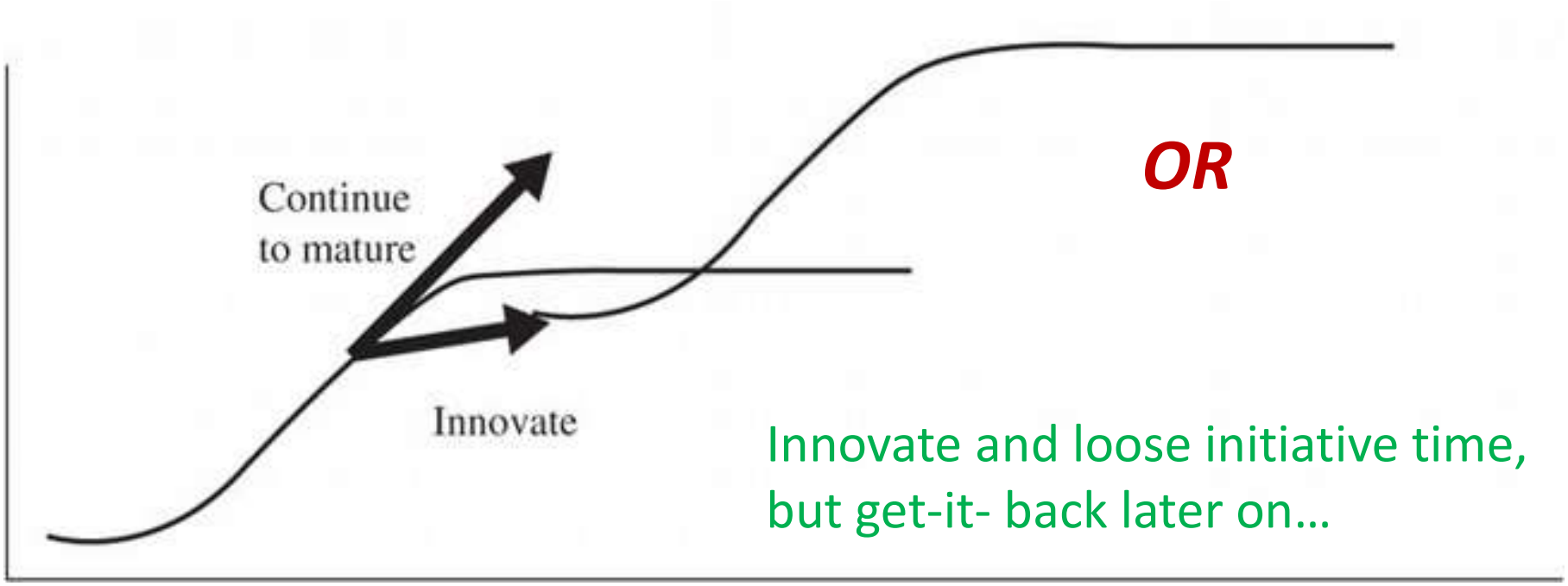
PRODUCT DISCOVERY

Product milestones and review gates



PRODUCT DISCOVERY

We always have this dilemma (standoff) either „do-it-further” for maturity



OR

Innovate and loose initiative time, but get-it- back later on…

PROJECT PLANNING

Planning precedes any commitment of resources

Identify types of Design project

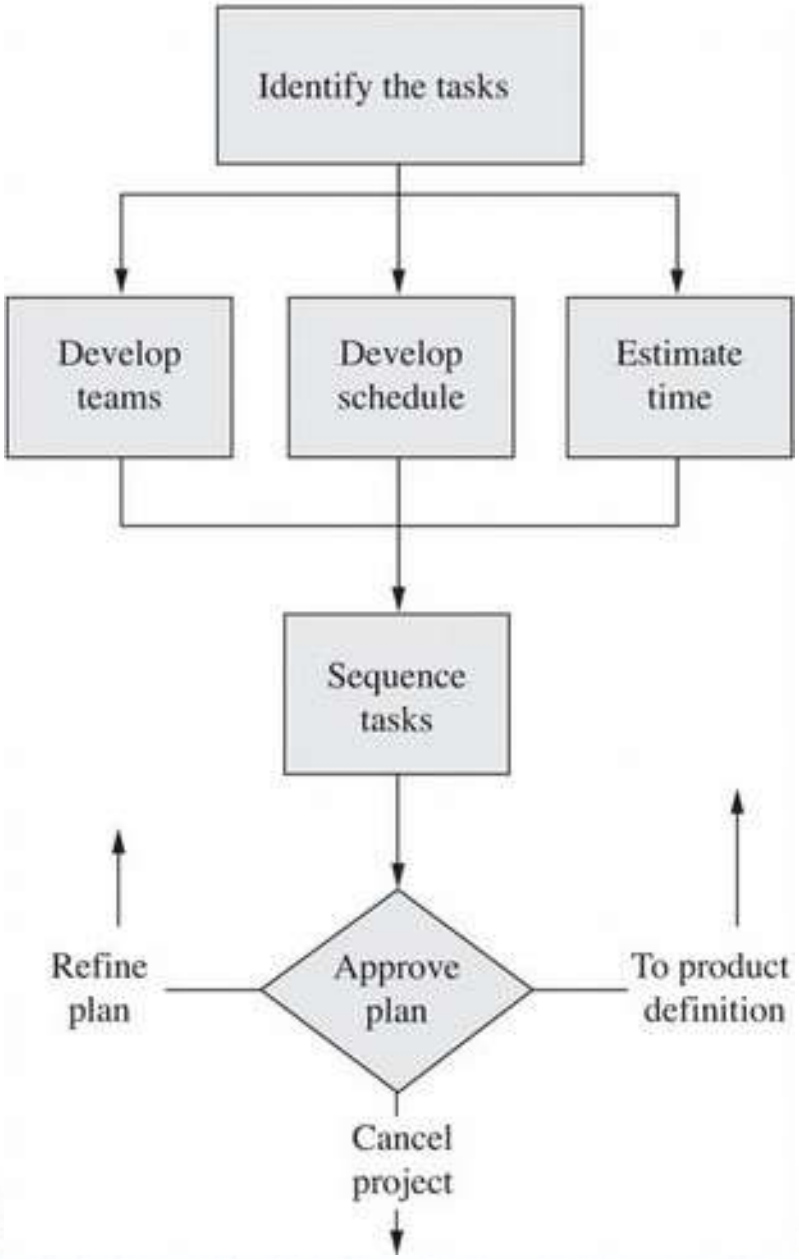
(a/ minor variation of an existing product, b/ improvement of existing product, c/ development of a new product

Form the design team

Generate the product development plan

- Research the market
- Determine and identify the tasks and objectives
- Estimate personnel, time, and other resources
- Develop a sequence for the tasks
- Forecast schedule and cost

PROJECT PLANNING



PRODUCT DEFINITION

Goal is to interprete and well describe the problem for a „common” understanding to all team members.

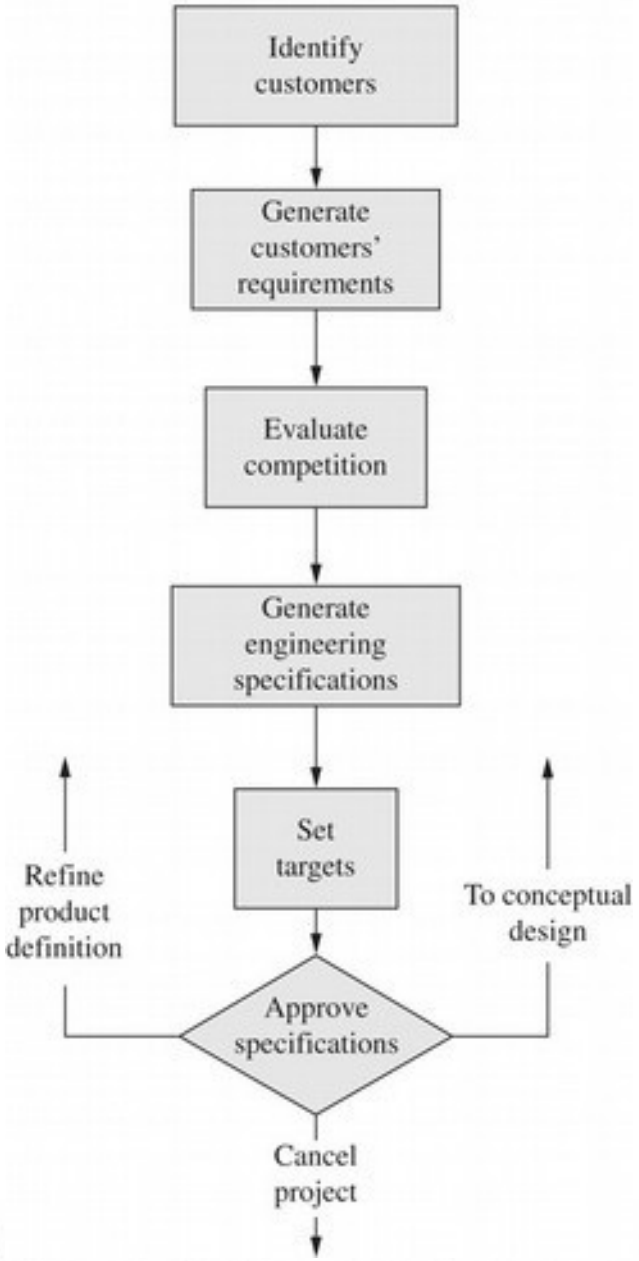
- Identify the customers
- Developing customer requirements
- Determine relative importance of needs
- Understanding the design problem
- Assess the competition and current customer satisfaction
- Convert customer requirements to engineering specifications
- Establish the engineering targets(target values)

  - The above activities determine how the problem is decomposed into smaller more manageable design sub problems.

  - Culminates with a Specifications approval. (agreement)

PRODUCT DEFINITION

As a flow, and an iteration circle…



CONCEPTUAL DESIGN

Generating concepts

- Functional decomposition
- Generate concepts for each function

Evaluate concepts

- Compare concepts generated with earlier developed requirements
- Judging feasibility
- Assessing technology readiness
- Go/no go screening
- Using decision matrices

Document and communicate to the right people at the right time

Culminates with a Design review.

PRODUCT DEVELOPMENT

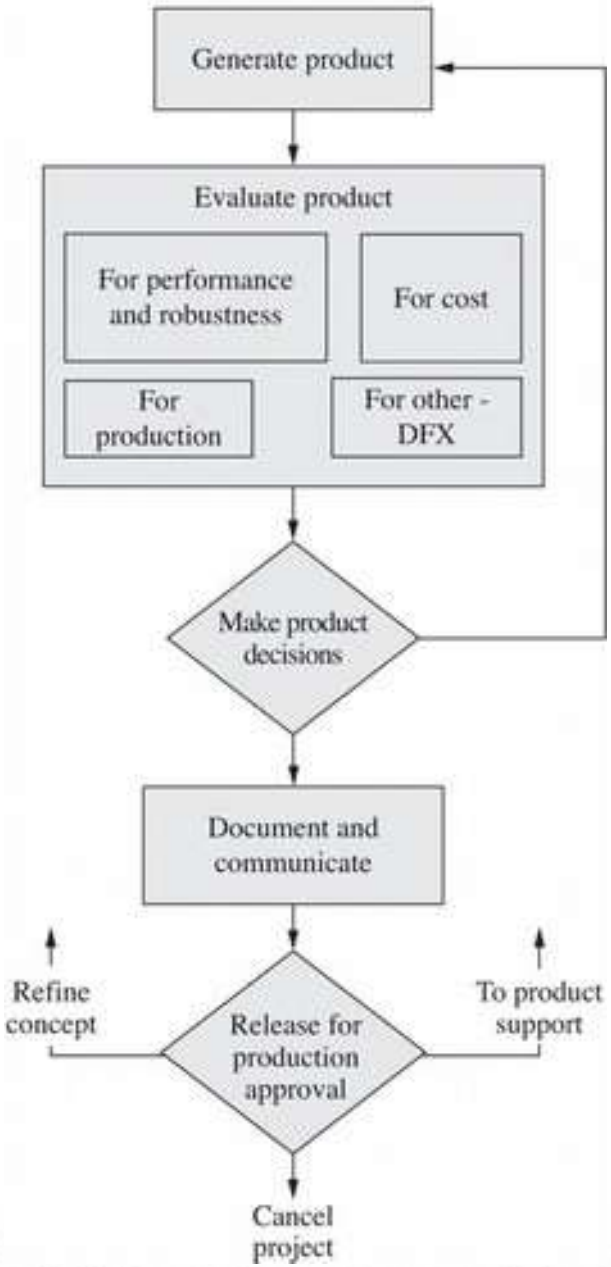
Generating the product (components) –based upon spatial, strength, power, thermal, temporal, acoustic, etc. Constraints

- Form generation from function
- Material and process(fabrication)selection
- Modelling and simulation
- Prepare drawings

Evaluating the product

- Evaluating functional changes
- Evaluating performance
- Sensitivity analysis
- Tolerance analysis
- Robustness of design
- Design for cost
- Value engineering
- Design for manufacture
- Design for assembly
- Design for reliability
- Design for the environment

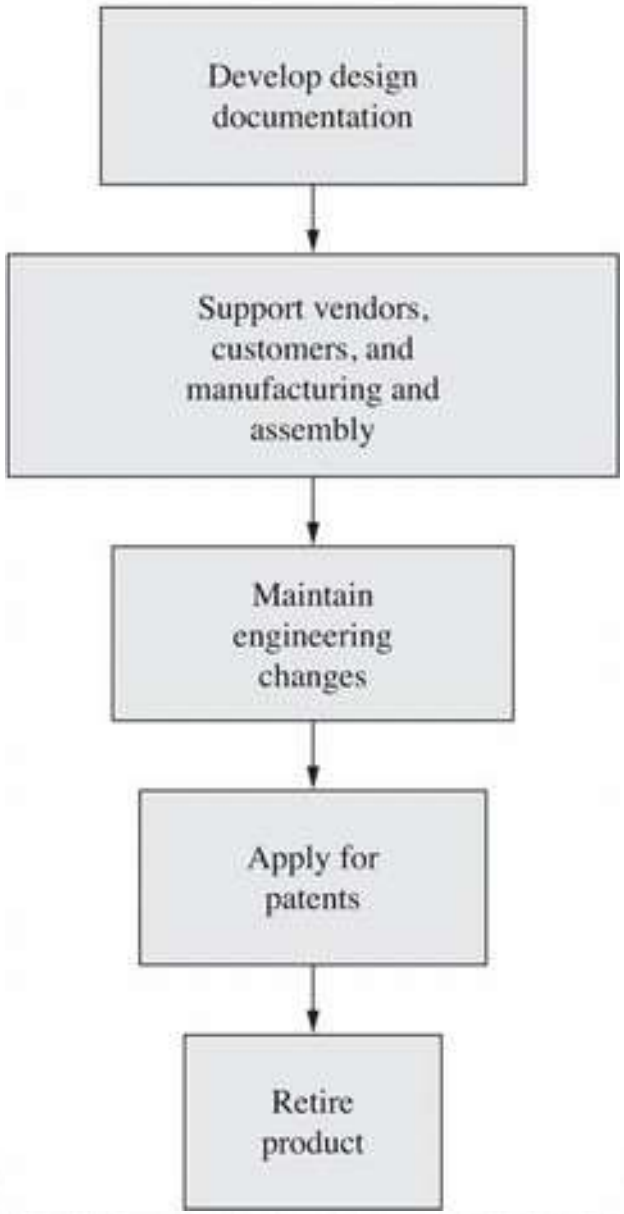
PRODUCT DEVELOPMENT



PRODUCT SUPPORT

- Vendor support
- Customer support
- Manufacturing and assembly support
- Maintain engineering change
- Patents
- Product retirement (recycling)

PRODUCT SUPPORT



THANK YOU FOR YOUR ATTENTION!