



Welcome to Engineering Design

- What is engineering design, really?
- Function to form
- Design process
- Phases of design
- Product realization process
- Roles for engineers
- Concurrent engineering
- Teamwork
- Summary



What is Design, really?

Which of the following is design and which is analysis?

A. Given that the customer wishes to fasten together two steel plates, select appropriate sizes for the bolt, nut and washer.

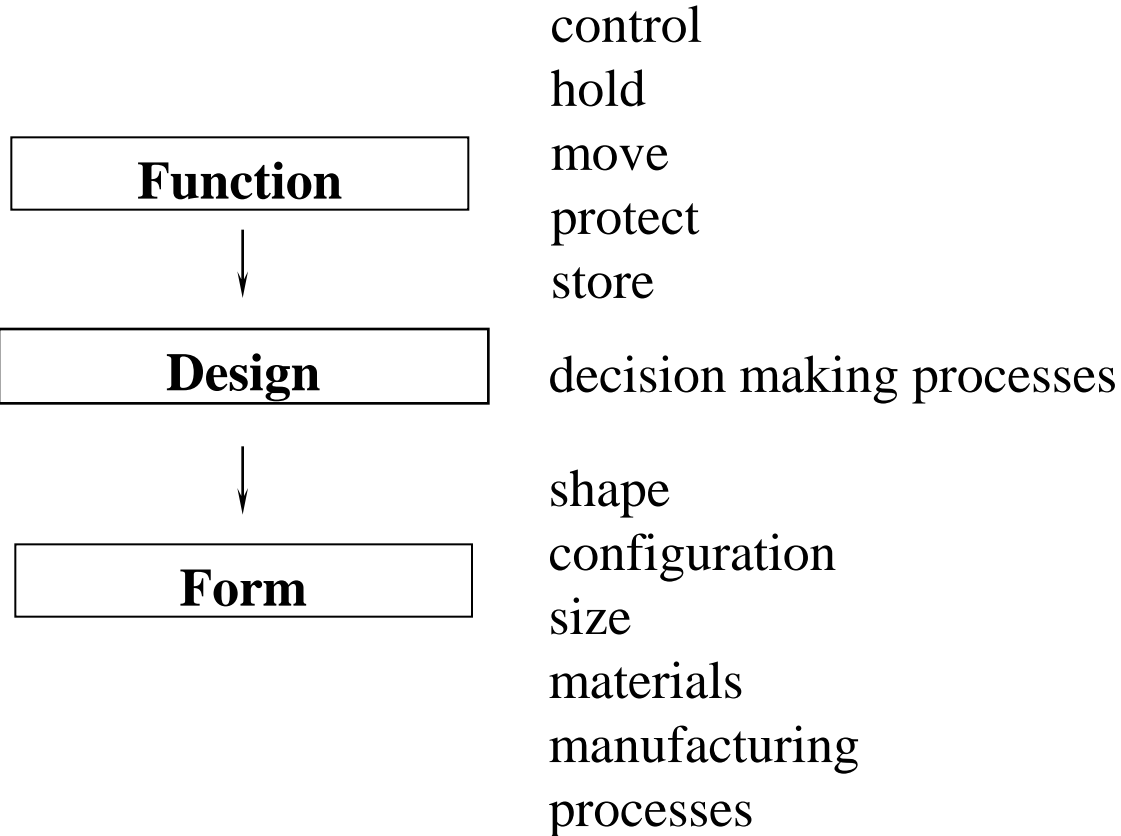
B. Given the cross-section geometry of a new airplane wing we determine the lift it produces by conducting wind tunnel experiments.

Design

Analysis

Form is the solution to a design problem.

How are Function and Form related



Form Ever Follows Function

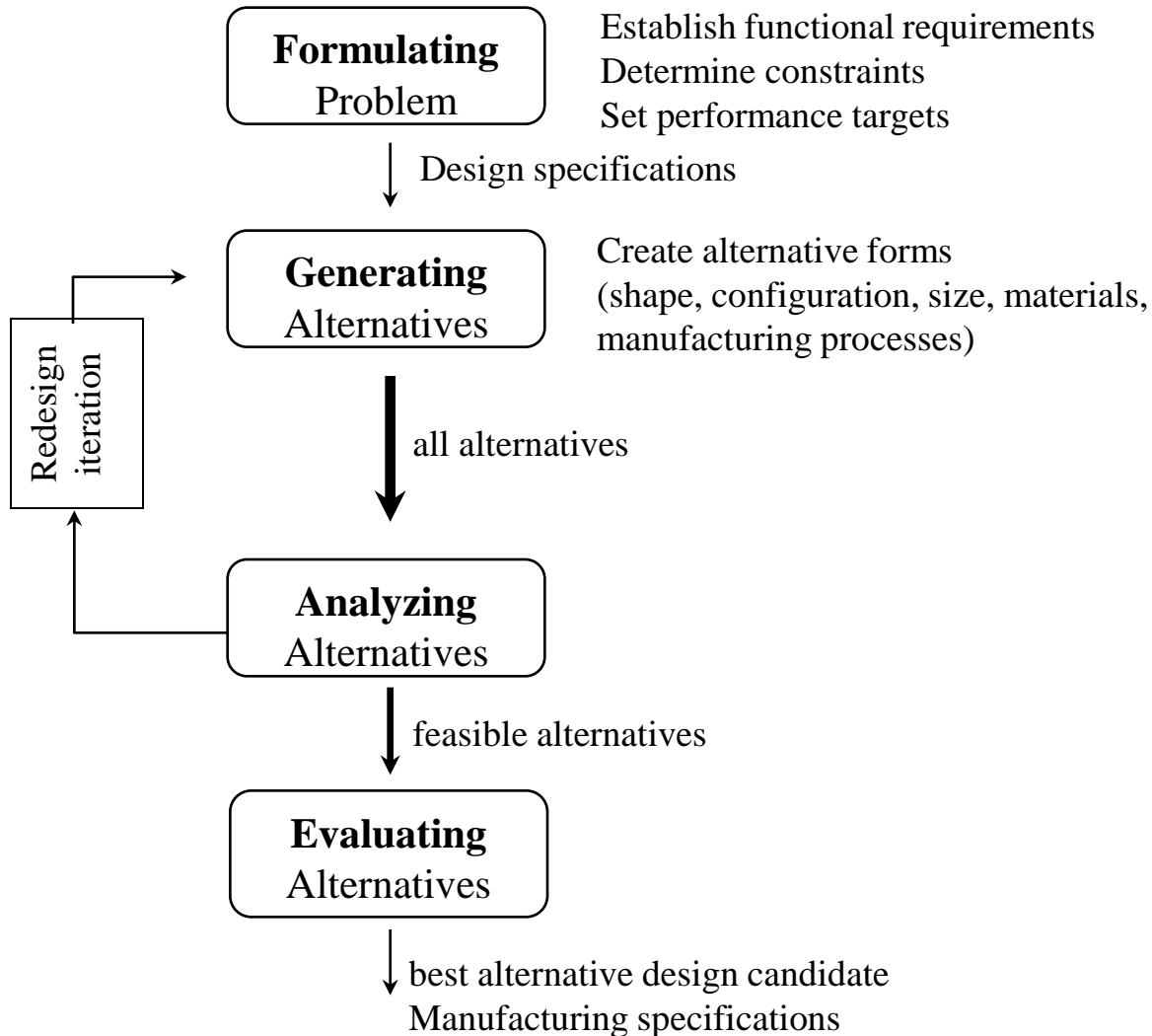
Louis Sullivan



Design – definition

Set of *decision making processes and activities* to determine the *form* of an object, given the customer's desired *function*.

Making Decisions? Use the *design process*





Are there “phases” of design?

How do design decisions change over time?

Is there a logical grouping of decisions?



Example design problem - Stop a spinning shaft

(8 inch diameter, 1000 lbs, steel, 3000 rpm)

Early in the design process, we decide upon the specifics of the function to be performed:

- Decide upon a satisfactory rate of deceleration
- Determine the length of the shaft
- Determine where it is supported
- Determine what actuating energy is available
- Decide to reverse engineer an existing product
- Choose to research brakes in the library

“Formulation” Phase



Decisions relating to concept?

Decide *physical principles* that will perform the function

- 1. surface friction (e.g. drum brake, disk/caliper)
- 2. opposing magnetic fields (e.g. inverse motor)
- 3. air friction (e.g. fan blades)

Assume we decide on surface friction

“Concept Design Phase”



Decisions on configuring products and new components?

Decide upon **product** *components* & how they are arranged
Decide upon **part** *features* & how they are arranged

Product configuration:

disk/caliper, or drum, or band brake

location on shaft (right, left, middle)

(Assume we decide on a disk/caliper brake)

Part configuration:

relative size of hub to disk

relative size of rotor thickness to diameter

“Configuration Design” Phase



Values for Parameters?

Decide upon specific values for design variables

1. rotor diameter (outer)
2. rotor thickness
3. brake pad width
4. pad material
5. hydraulic pressure on piston

“Parametric Design” Phase



Completing the details

Decide upon the remaining manufacturing specifications

- machined rotor tolerances
- pad bonding resin
- assembly/testing procedure

“Detail Design” Phase



Final “Form” is the solution to a design problem

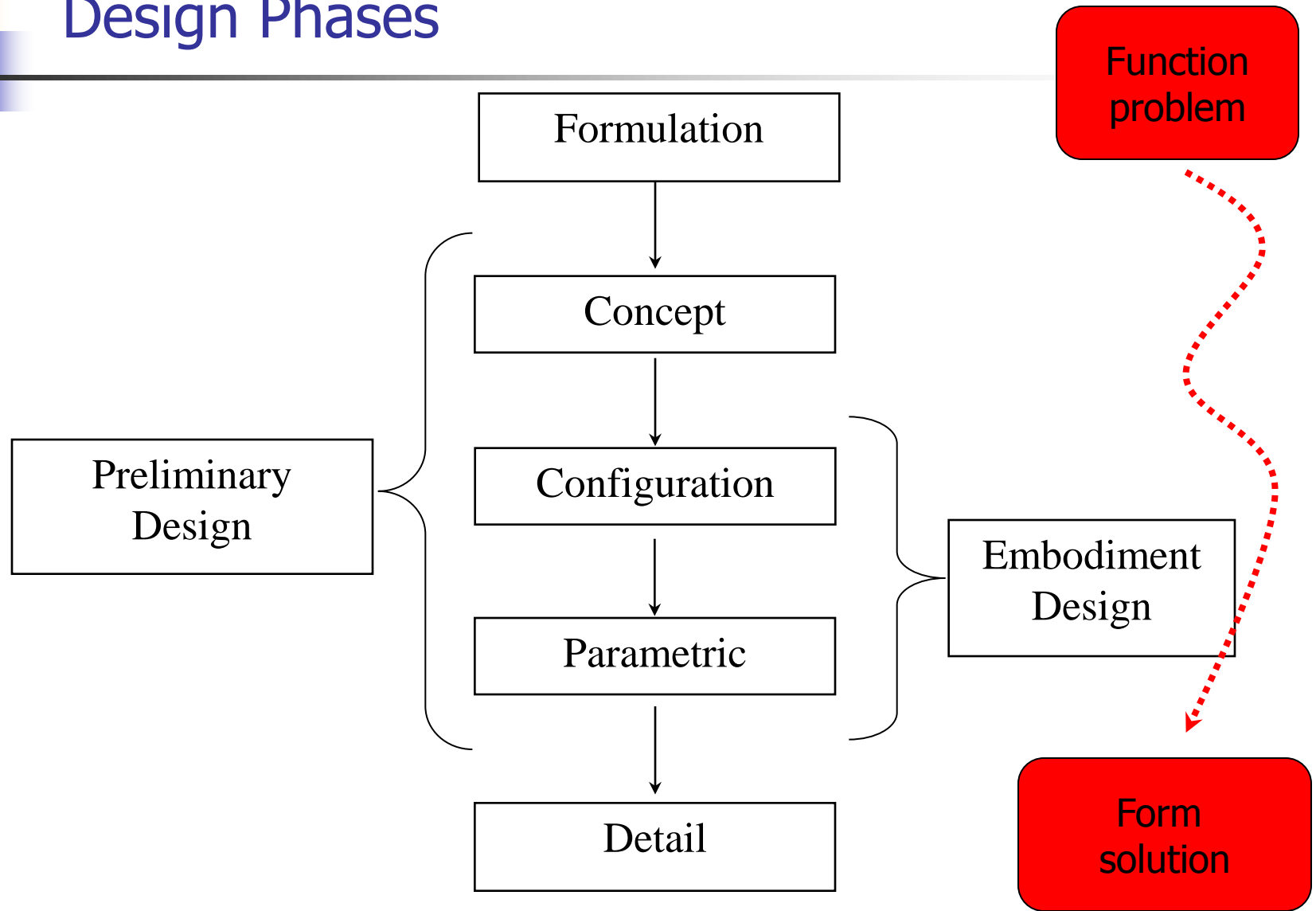
Function ---- stop a spinning shaft



Form

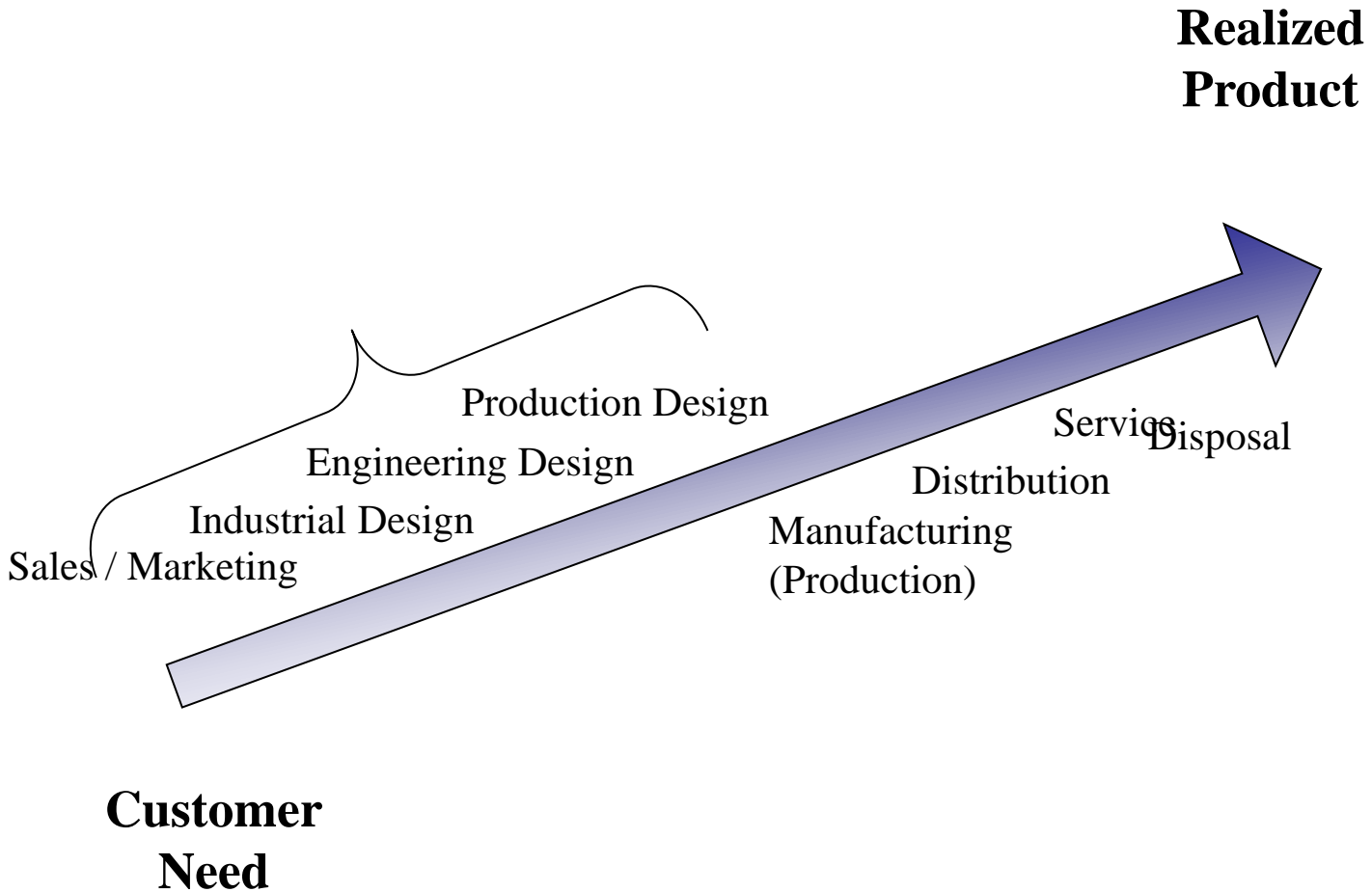
- rotor: 10 inch diameter, steel, 3/8-inch thick, cooling passages
- forged steel caliper/housing
- brake pads, 2 opposing, 4 sq. in., metal particles/epoxy matrix
- steel piston, 1-inch diameter, with elastomeric seals
- 100 psi hydraulic piston pressure

Design Phases



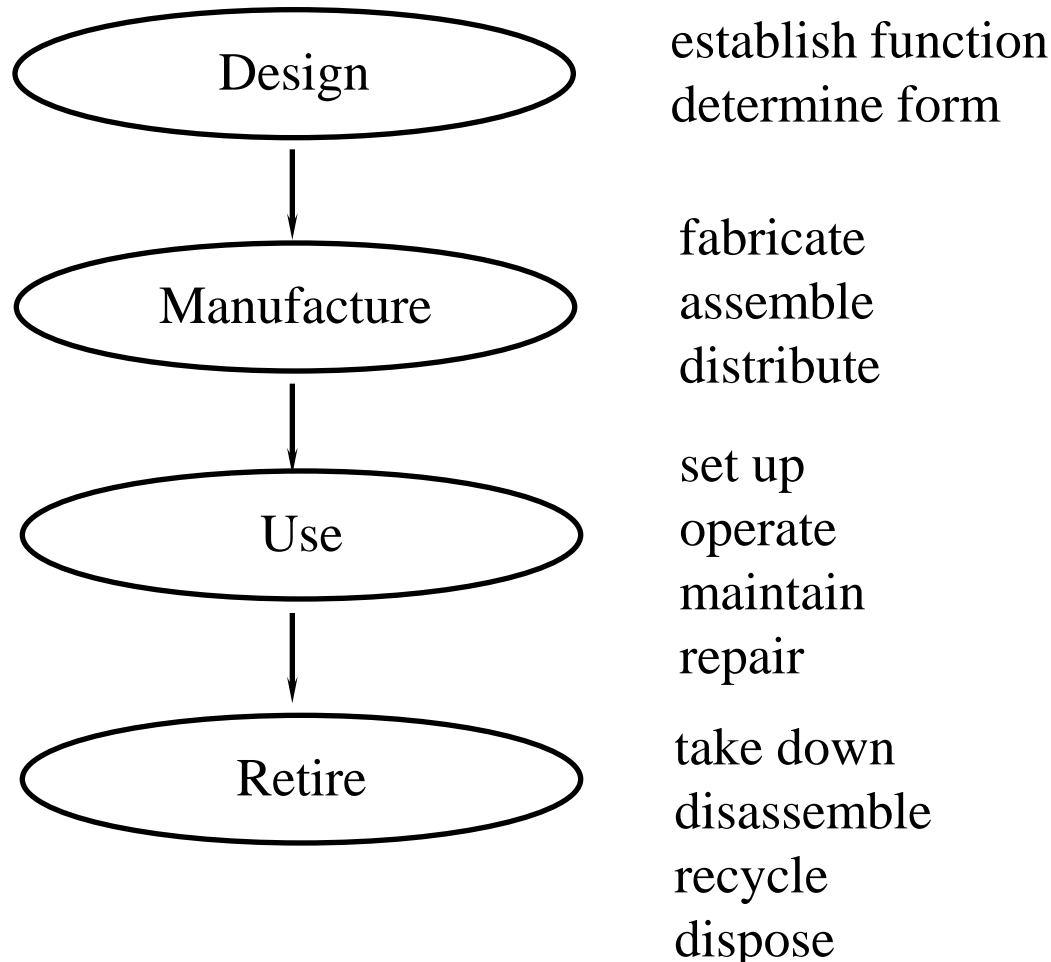


Design versus the *Product Realization Process*?





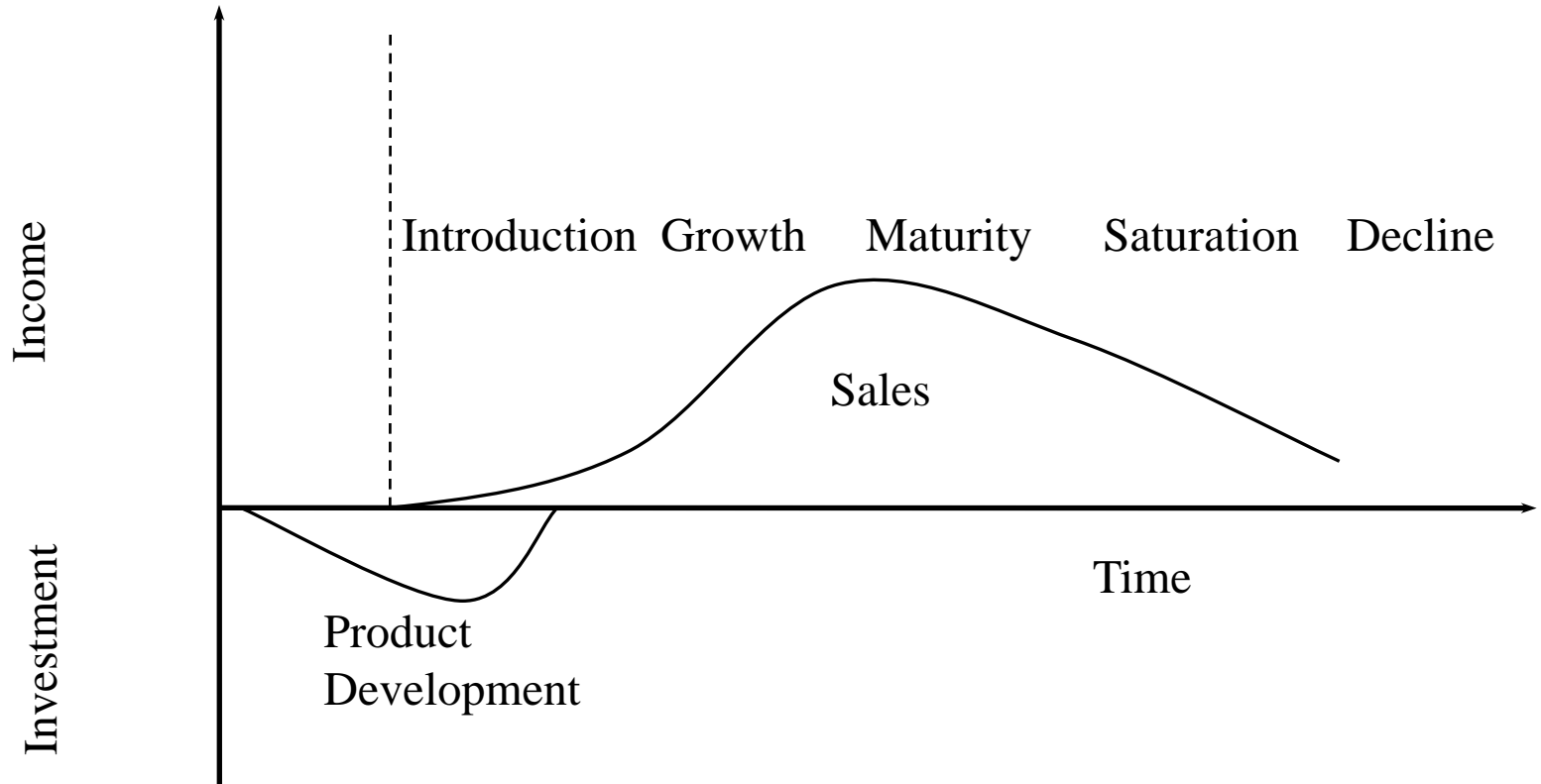
Phases in the life of a product



To satisfy the consumer...

We must consider all the phases in the life of a product

Product realization begins the *Product Life Cycle*



How do we participate in the Product Realization Process?





Where do engineers work?

Employer		Thousands	%
Manufacturing		732	50
Engineering Services		401	27
Government (Federal, State & Local)		179	12
Self-employed		43	3
Other		110	8
Total		1465	100

(U.S. Department of Labor, 2000).



Engineering Roles in Design & Manufacturing

	Job Title	Description
Sales & Marketing	Sales Engineer	Meets customers, determines needs, presents product offerings
	Applications Engineer	Assists sales & marketing solving technical issues with respect to the use of product
	Field Service Engineer	Installs, maintains and repairs equipment at customers' sites
Research & Development	Industrial Designer	Establishes essential product appearance, human factors
	Design Engineer	Decides part or product form including: shape, size, configuration, materials, and manufacturing processes
	Materials Engineer	Investigates and develops improved materials
	Test Engineer	Designs and conducts performance and safety tests



Engineering Roles in Design & Mfg

Manufacturing

Industrial Engineer

Designs fabrication, assembly and warehousing systems

Manufacturing Engineer

Develops manufacturing tools and fixtures

Quality Control Engineer

Establishes and maintains raw materials and finished goods quality controls

Processing / Operations

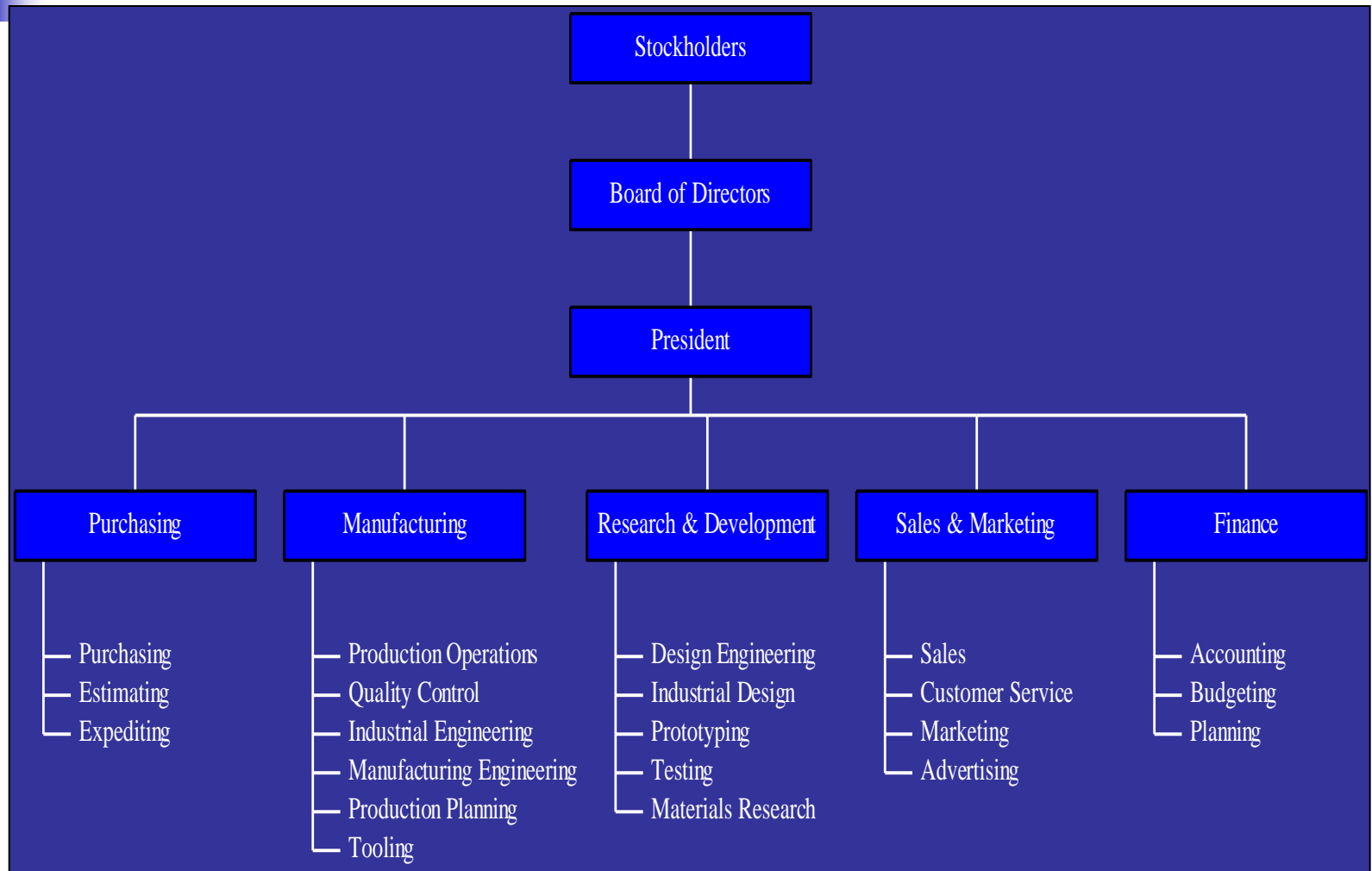
Plant Engineer

Designs and maintains processing plant facilities

Project Engineer

Coordinates project work tasks, budgets and schedules

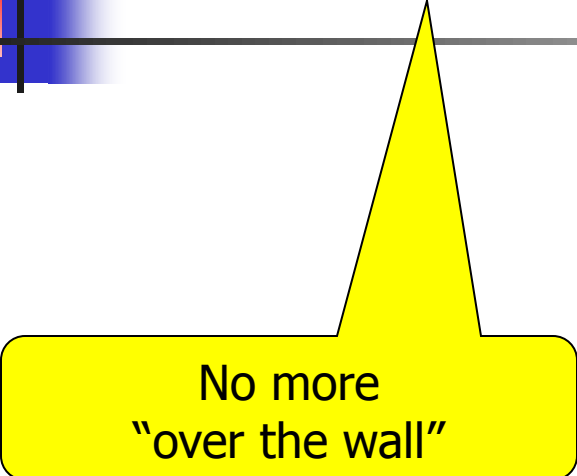
“Functional” organization chart



typical manufacturing company

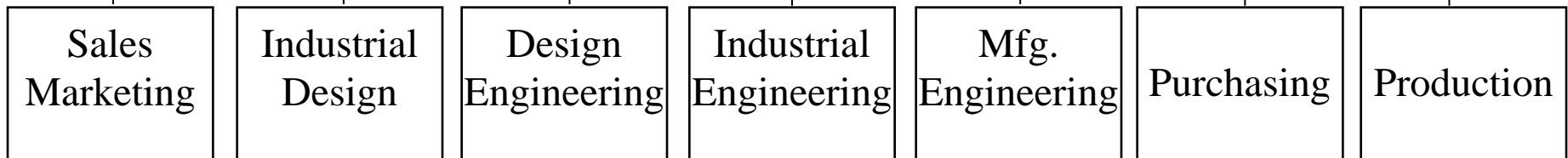


Concurrent engineering design team



No more
"over the wall"

Product
Manager





Engineering products is a **team** sport!

Professional Team	Industry
Competitors	Companies
Team owners	Investors
Coaches	Managers
Referees, umpires	Lawyers, judges
Communication	Coordination
Fumbles, injuries	Mistakes, losses
Individual skills	Specialized jobs
Team skills	"People" skills



Summary

- Engineering Design is “decision” making
- Design process requires formulating, generating, analyzing, evaluating, refining
- Form follows function
- PRP includes engineering design
- Big “M” manufacturing = PRP
- Most engineers work for or with “manufacturers”
- Many different jobs & responsibilities
- Organization charts describe “chain of command”
- Similar job “functions” are grouped for hiring, training and development.
- Product realization requires TEAMWORK