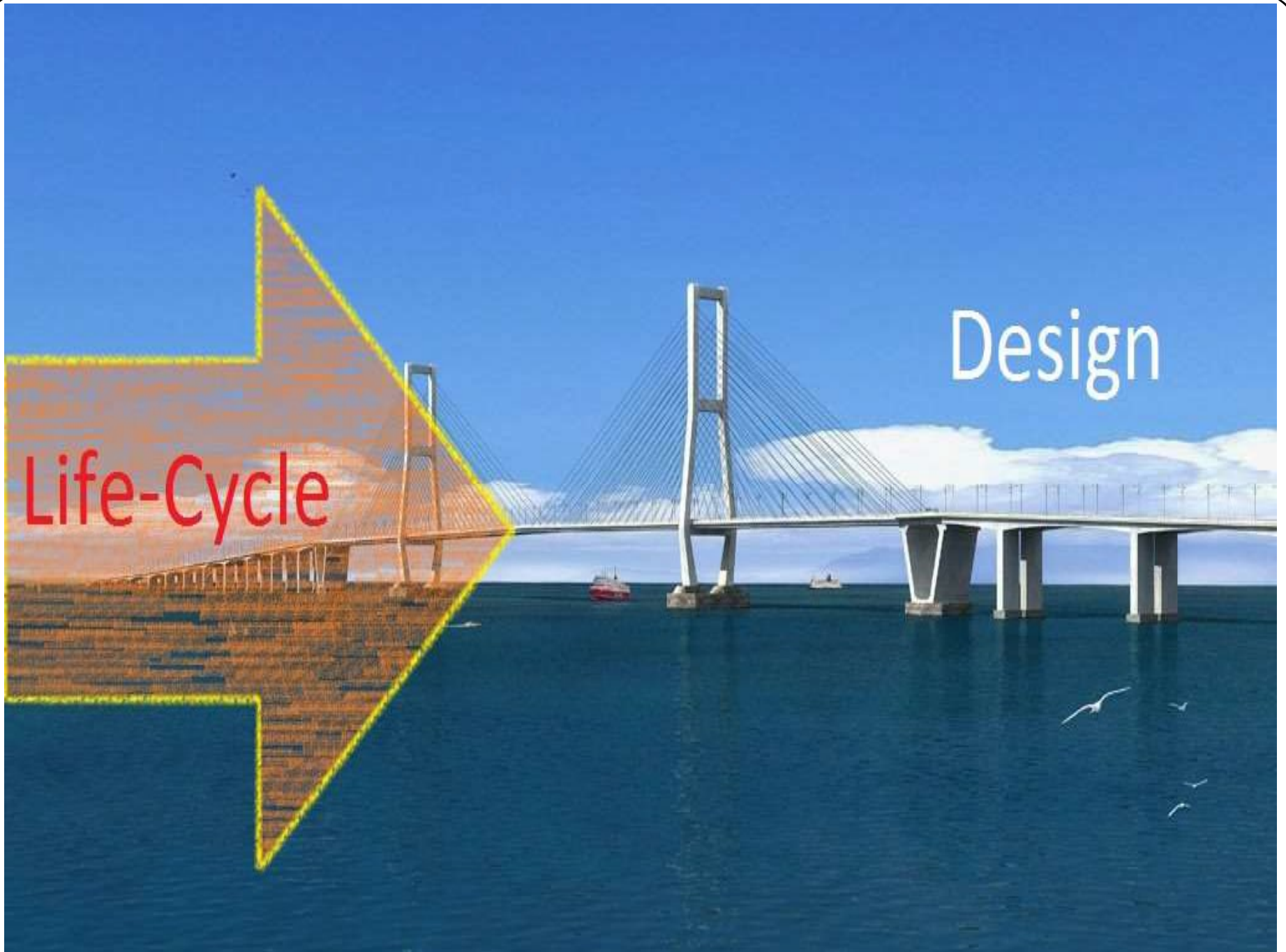# Department of Mechanical Engineering

NIT Srinagar

Presented By- Dr. Abhijit Dey
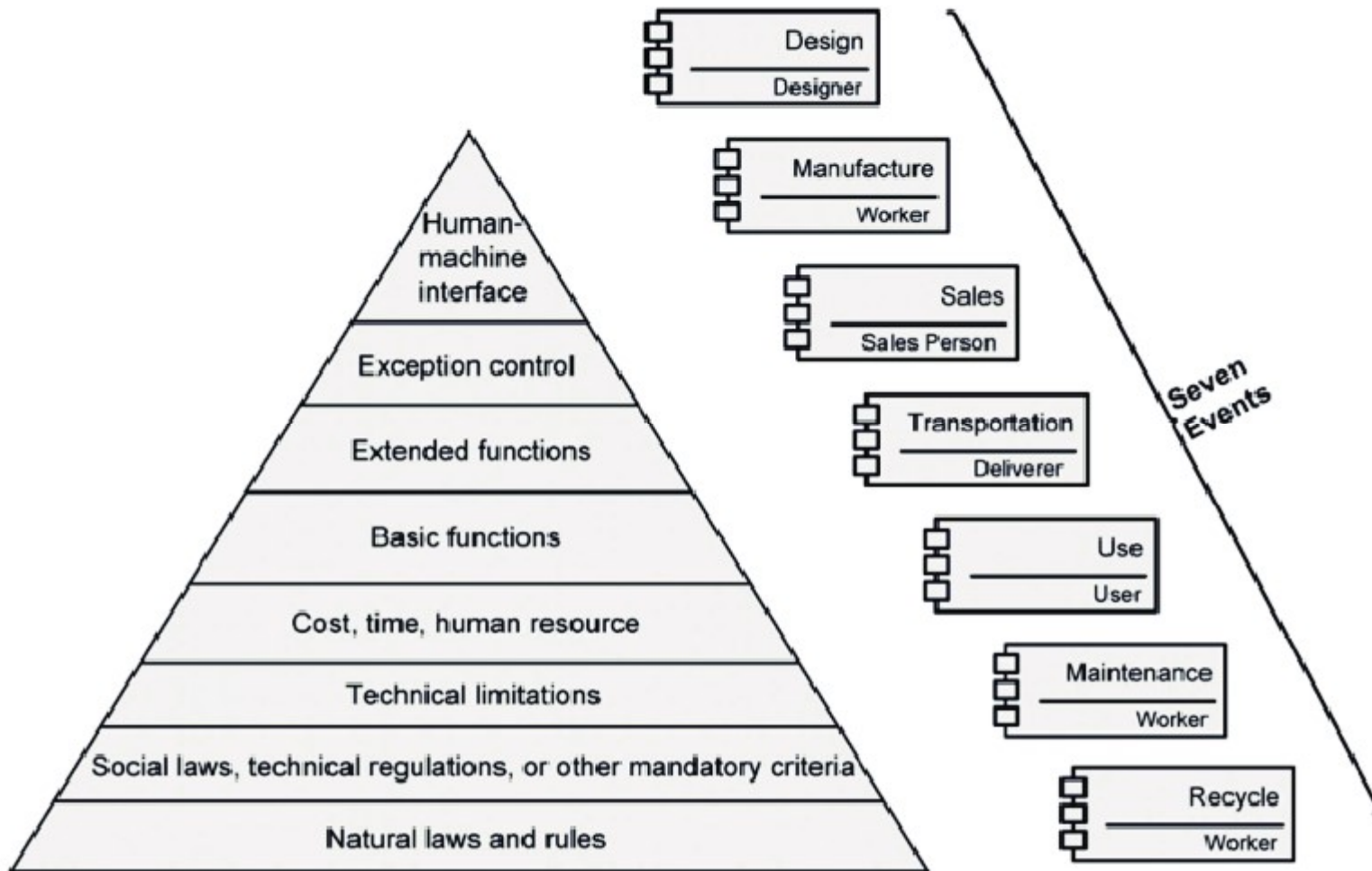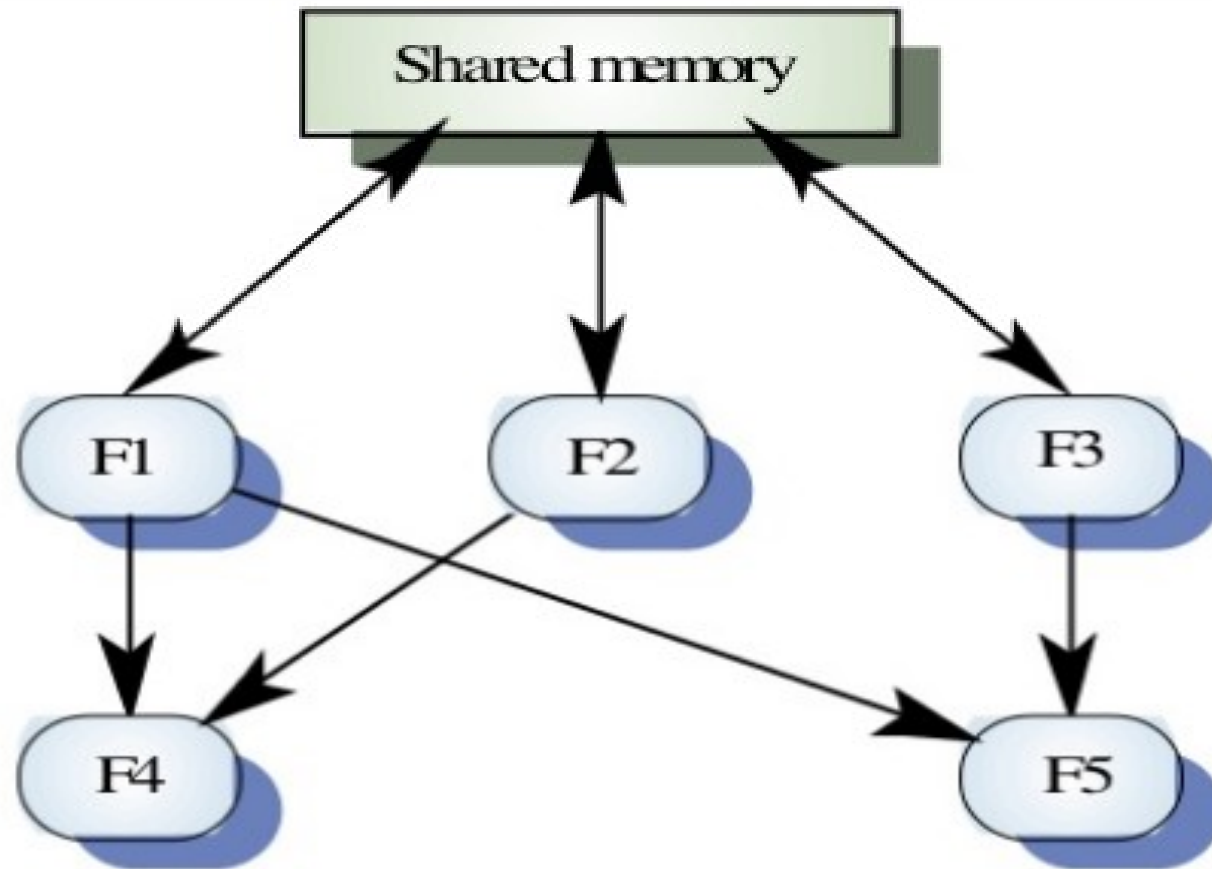
Content

- Introduction

- Functions of design

- Structural Hierarchies

- Function based failure approach

- Cost of Design manufacturing

- Design Models

Functions of design

Human-machine interface
Exception control
Extended functions
Basic functions
Cost, time, human resource
Technical limitations
Social laws, technical regulations, or other mandatory criteria
Natural laws and rules

Design — Designer
Manufacture — Worker
Sales — Sales Person
Transportation — Deliverer
Use — User
Maintenance — Worker
Recycle — Worker

Seven Events

Design with functional units which transforms inputs to outputs

Functional design process

Data flow design

- Model the data processing in the system using data flow   diagram.

Structural decomposition

- Model how functions are decomposed to sub-functions using graphical functional chart.

Detailed design

- The entities in the design and their interfaces are described in details. These may be recorded in a data dictionary and the design expressed using a PDL.

Data flow diagrams

- Show how an input data item is functionally transformed by a system in to an output data item.

- Are an integral part of many design methods and are supported by many CASE system.

- May be translated into either a sequential or parallel design. In sequential design, processing elements are functions or procedures; in a parallel design, processing elements are tasks or processes.

DFD notation

- Rounded rectangle – functions or transform
- Rectangle – data store
- Circles – user interactions with the systems
- Arrows – show direction of data flow
- Keywords/ or – used to link data flow

Structural decomposition

- Structural decomposition is concerned with developing a model of the design which show the dynamic structure i.e function calls
- This is not the same as the static composition structure
- The aim of the designer should be derive design units which are highly cohesive and loosely coupled
- In essence, a data flow diagram is converted to a structural chart.

Decomposition guidelines

- For business applications, the top level structure chart may have four functions namely inputs, process, master file update and output

- Data validation functions should be subordinate to an input function

- Coordination and control should be the responsibility of function near the top of the hierarchy

Process steps

- Identify system processing transformations
- Identify input transformations
- Identify output transformations

Initial structure chart
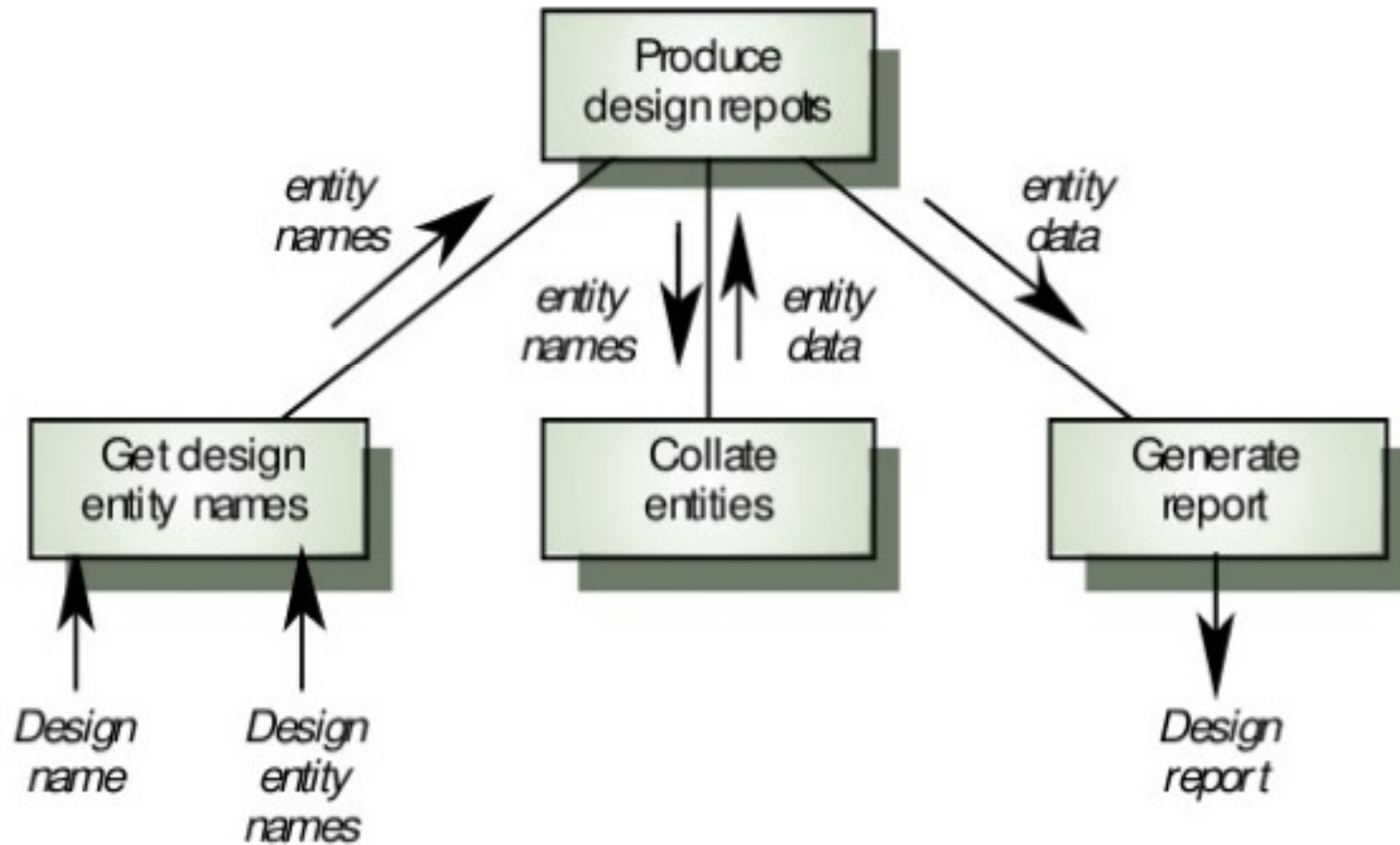
Expanded structure chart

Final structure chart
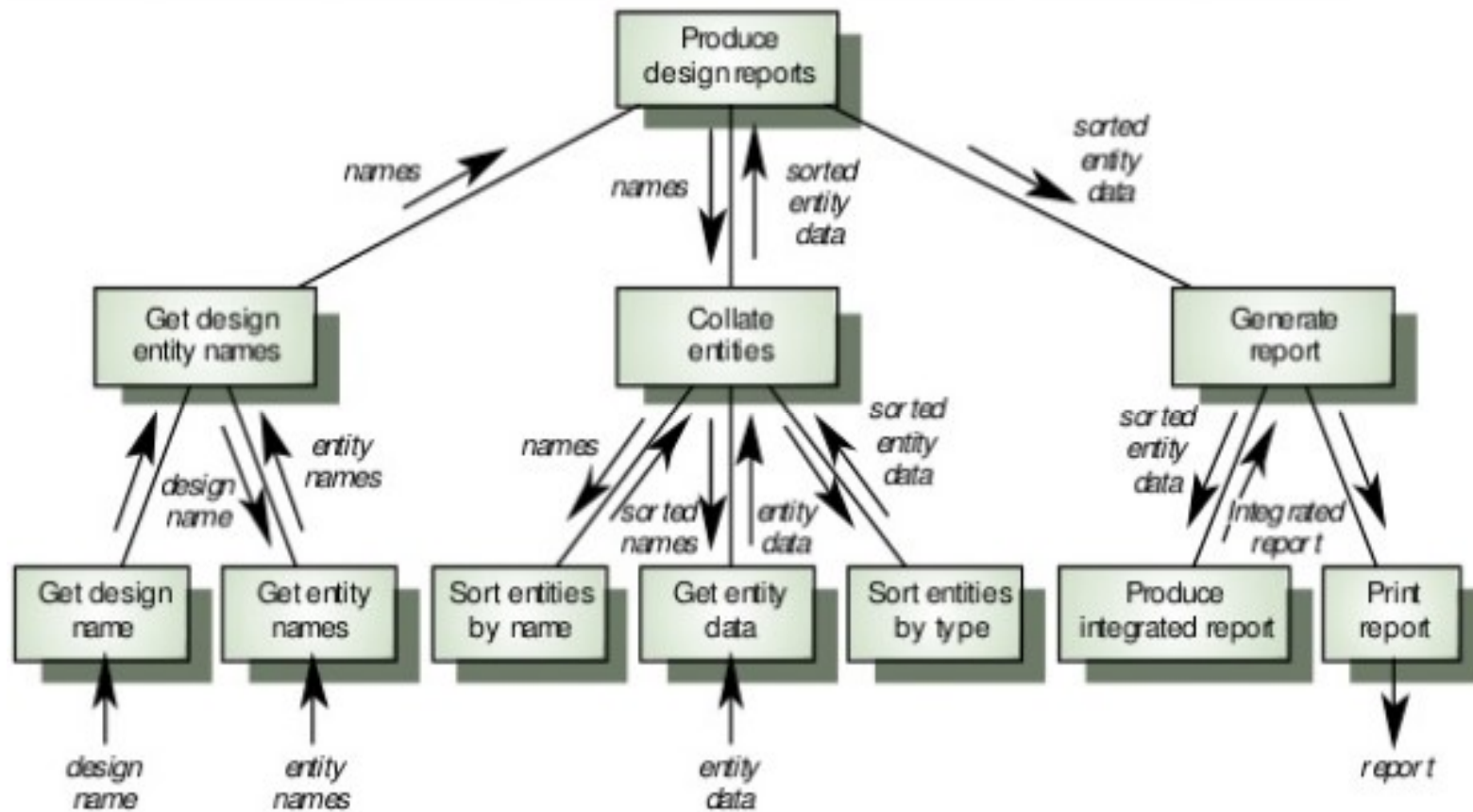
Detailed design

- Concerned with producing a short design specifications of each functions. This should be describe the processing, inputs and outputs

- These descriptions should be managed in a data dictionary

- From these description, detailed design description, expressed in PDL or programming language, can be produced

Data dictionary entries

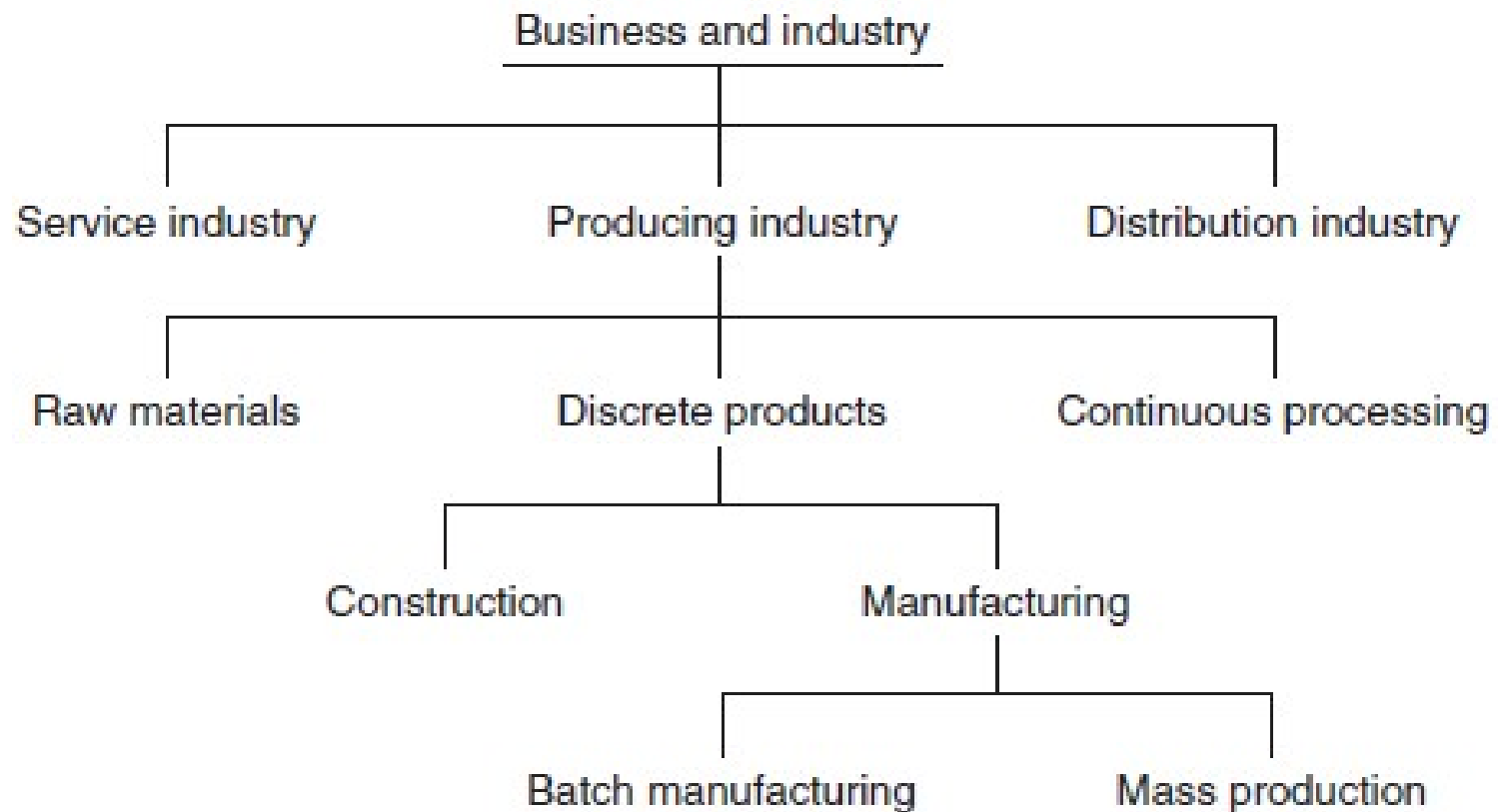| Entity name	Type	Description
Design name	STRING	The name of the design assigned by the design engineer.
Get design name	FUNCTION	*Input*: Design name *Function*: This function communicates with the user to get the name of a design that has been entered in the design database. *Output*: Design name
Get entity names	FUNCTION	*Input*: Design name *Function*: Given a design name, this function accesses the design database to find the names of the entities (nodes and links) in that design. *Output*: Entity names
Sorted names	ARRAY of STRING	A list of the names of the entities in a design held in ascending alphabetical order.

Structural Hierarchies

```
                          Business and industry
                                   |
         ┌─────────────────────────┼─────────────────────────┐
   Service industry          Producing industry        Distribution industry
                                   |
              ┌────────────────────┼────────────────────┐
        Raw materials        Discrete products      Continuous processing
                                   |
                    ┌──────────────┴──────────────┐
              Construction                   Manufacturing
                                                  |
                                 ┌────────────────┴────────────────┐
                          Batch manufacturing              Mass production
```

Function based failure approach

The product life cycle is made of three successive stages and the possible causal routes are represented by three solid arrows. The arrows can originate from any stage, but they invariably point, as the localization of failure, to the utilization stage
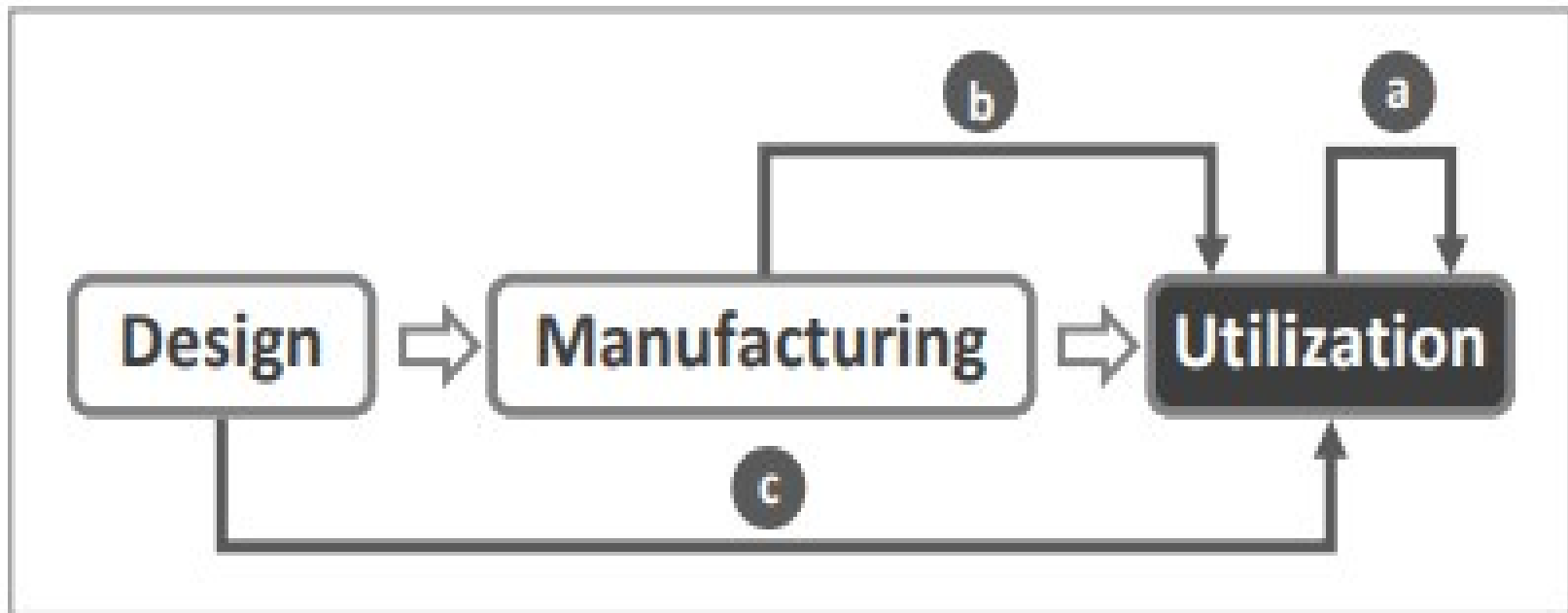
Failure Analysis Methods

Every product or process has modes of failure.

An analysis of potential failures helps designers focus on and understand the impact of potential process or product risks and failures.

Several systematic methodologies have been develop to quantify the effects and impacts of failures.

Failure Analysis Methods….

Why perform failure analysis?

Product Development:

- Prevent product malfunctions.
- Insure product life.
- Prevent safety hazards while using the product.

Process Development:

- Insure product quality
- Achieve process reliability
- Prevent customer dissatisfaction
- Prevent safety or environmental hazards

Common Failure Analysis Technique

- Cause-Consequence Analysis
- Checklist
- Event Tree Analysis
- Failure Modes & Effects Analysis *(FMEA)*
- Failure Modes, Effects and Criticality Analysis *(FMECA)*
- Fault Tree Analysis *(FTA)*

- Hazard & Operability Analysis *(HAZOP)*
- Human Reliability
- Preliminary Hazard Analysis *(PHA)*
- Relative Ranking
- Safety Review
- What-If / Checklist Analysis
- What-If Analysis

For the purpose of this class, two common but fundamentally different techniques will be presented in detail:
1. Failure Modes Effects Analysis (FMEA)
2. Fault Tree Analysis

Cost of Design manufacturing

1. PRODUCT CONCEPT
- Function
- Cost
- Use issues
- Industry problems

2. ENVIRONMENTAL ISSUES
- Environment of use
- Materials footprint
- Manufacturing footprint
- Product longevity

3. END-OF-LIFE ISSUES
- Disposal vs recycling
- Material dispersal
- Closing the loop
- Take-back systems

8. REUSE
- Recycled municipally
- recycled by ghg

MATERIALS

RECYCLE

MANUFACTURE

4. DESIGN
- Preliminary design
- Prototypes
- Refine design
- Final prototypes/mech.
- Material choice
- Manufacturing method
- End-of-life methods

7. END-OF-LIFE
- Recycled by consumer
- Returned for recycle by GHG
- Disposed in waste stream

6. MANUFACTURING
- Materials/manufacturing sourcing
- Materials/manufacturing certification
- Pricing
- Prototypes
- Manufacturing

5. FINAL REVIEW
- Product concept issues
- Environmental issues
- End-of-life issues
- Packaging issues

Estimations of Manufacturing Costs

- Direct Costs
  - Vary with production rate but not necessarily directly proportional

- Fixed Costs
  - Do not vary with production rate but relate "directly" to production function

- General Expenses
  - Functions to which operations must contribute – overhead burden

Direct cost

- Raw Materials
- Waste Treatment
- Utilities
- Operating Labor
- Supervisory and Clerical Labor

- Maintenance and Repairs
- Operating Supplies
- Laboratory Charges
- Patents and Royalties

Fixed costs

- Local taxes and insurance
- Plant overhead costs

General expenses

- Administration costs
- Distribution and selling costs
- Research and development

Manufacturing costs

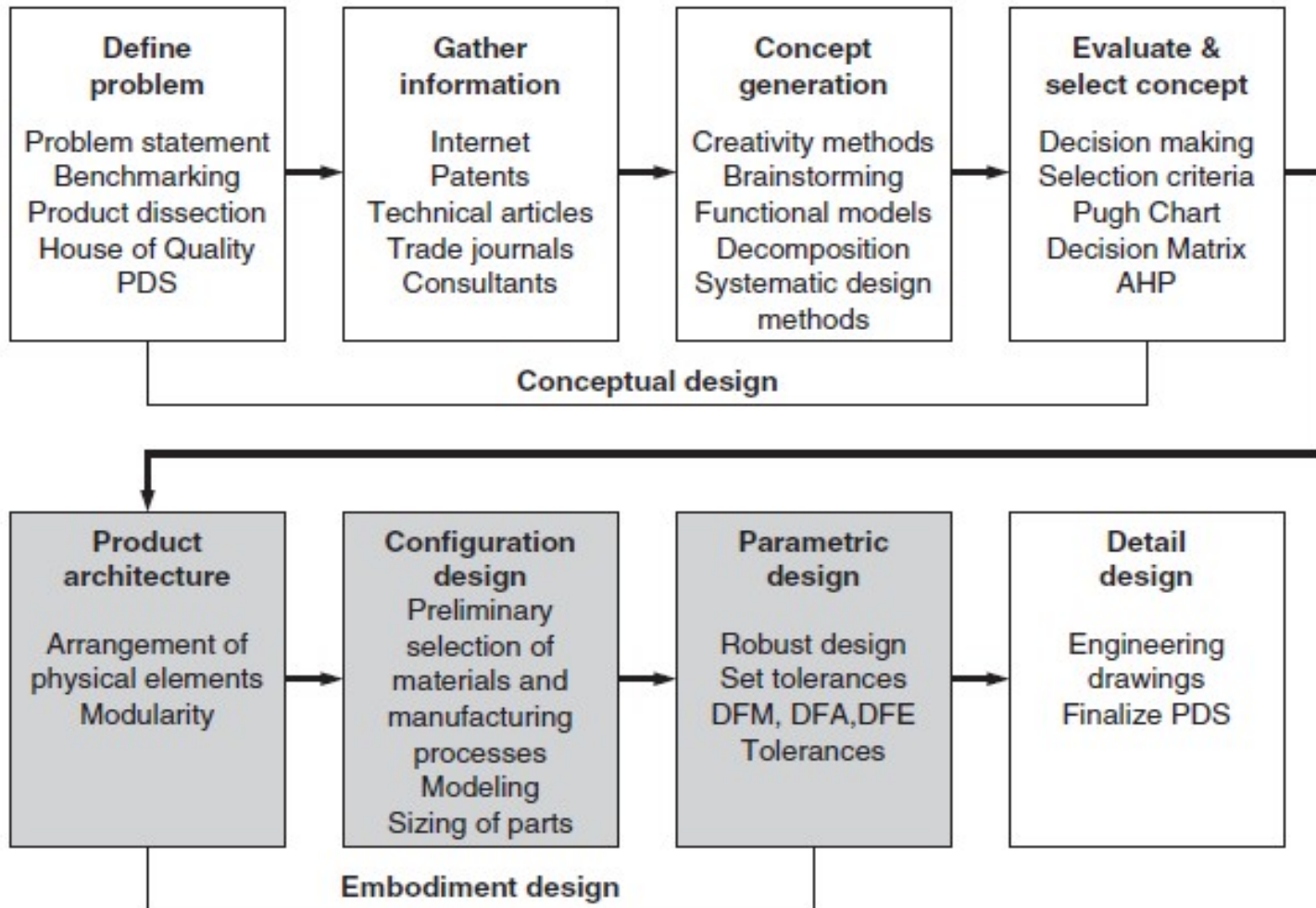| Raw Materials	Manufacturing Costs	Work In Process
Beginning raw materials inventory	Direct materials	Beginning work in process inventory
+ Raw materials purchased	+ Direct labor	+ Total manufacturing costs
= Raw materials available for use	+ Mfg. overhead	= Total work in process for the period
	= Total manufacturing costs	- Ending work in process inventory
		= Cost of goods manufactured.

Costs associated with the goods that are completed during the period are transferred to finished goods inventory.

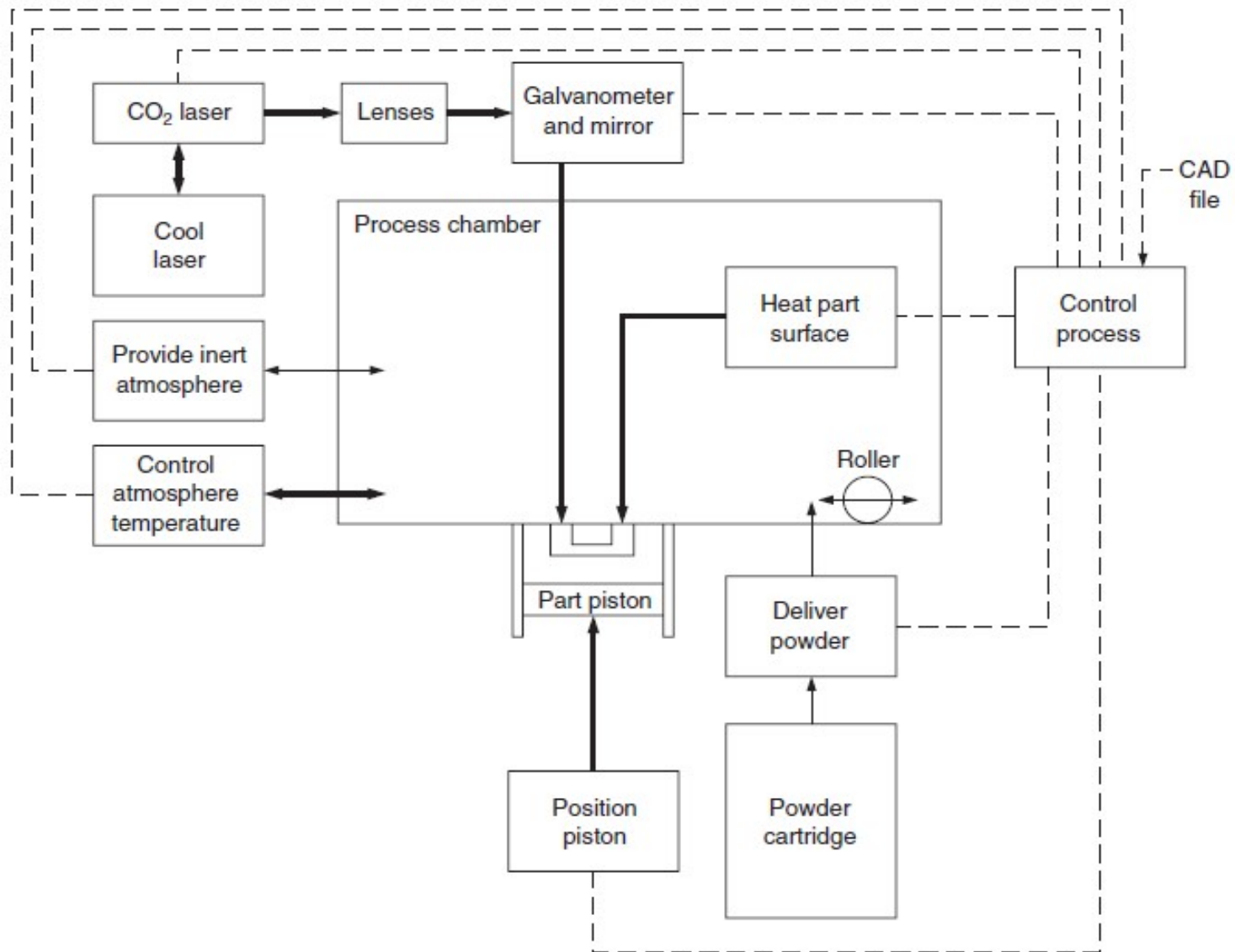# Design Models

- Design of Marketing
- Design of machniability
- Design of Recycling
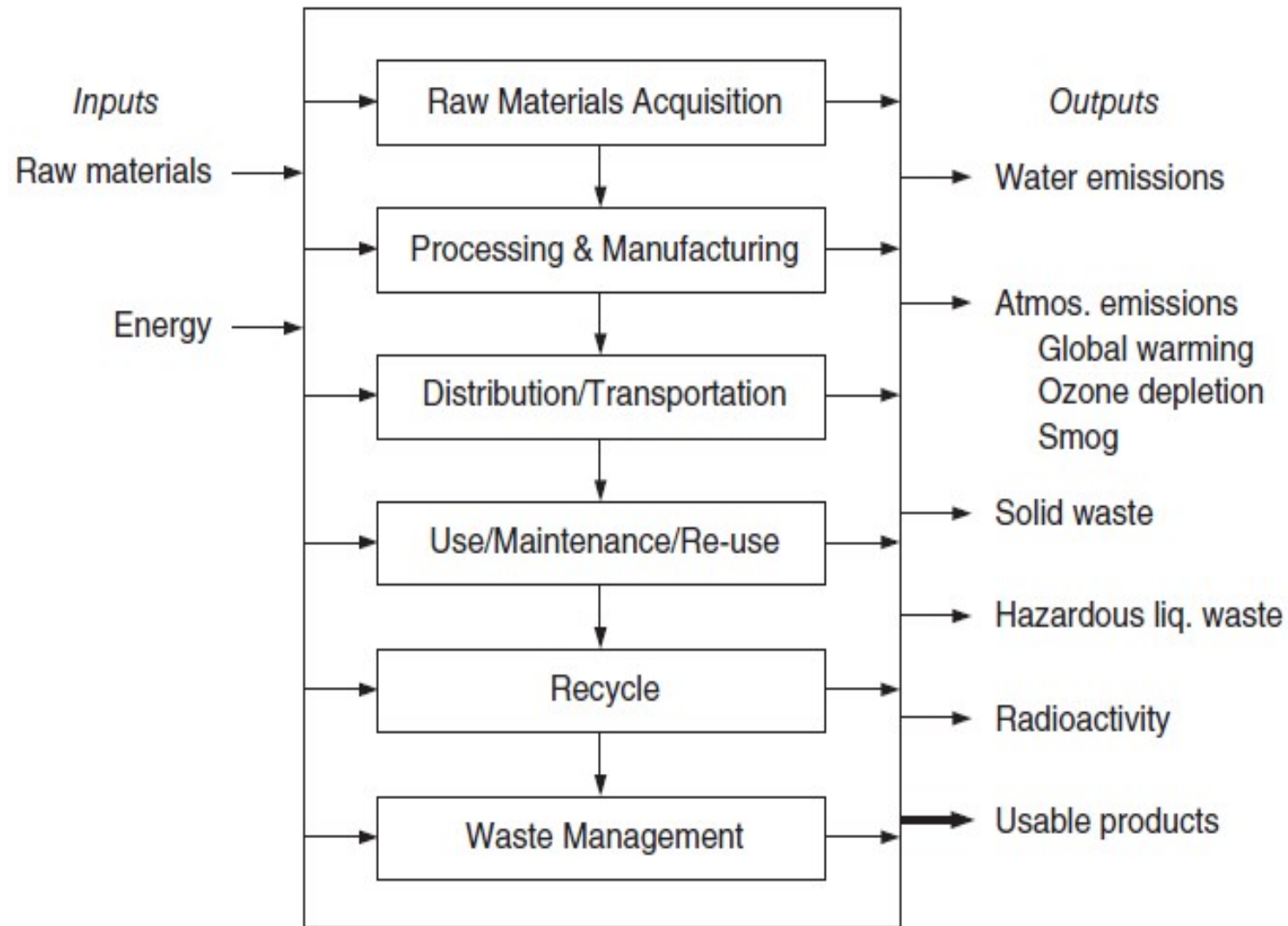- Design for Reliability
- Design for safety

Embodiment Design

Define problem	Gather information	Concept generation	Evaluate & select concept
Problem statement Benchmarking Product dissection House of Quality PDS	Internet Patents Technical articles Trade journals Consultants	Creativity methods Brainstorming Functional models Decomposition Systematic design methods	Decision making Selection criteria Pugh Chart Decision Matrix AHP

Conceptual design

Product architecture	Configuration design	Parametric design	Detail design
Arrangement of physical elements Modularity	Preliminary selection of materials and manufacturing processes Modeling Sizing of parts	Robust design Set tolerances DFM, DFA,DFE Tolerances	Engineering drawings Finalize PDS

Embodiment design

Laser-fusing rapid prototyping machine

Framework for developing a LCD

THANK YOU