Department of Mechanical Engineering

NIT Srinagar

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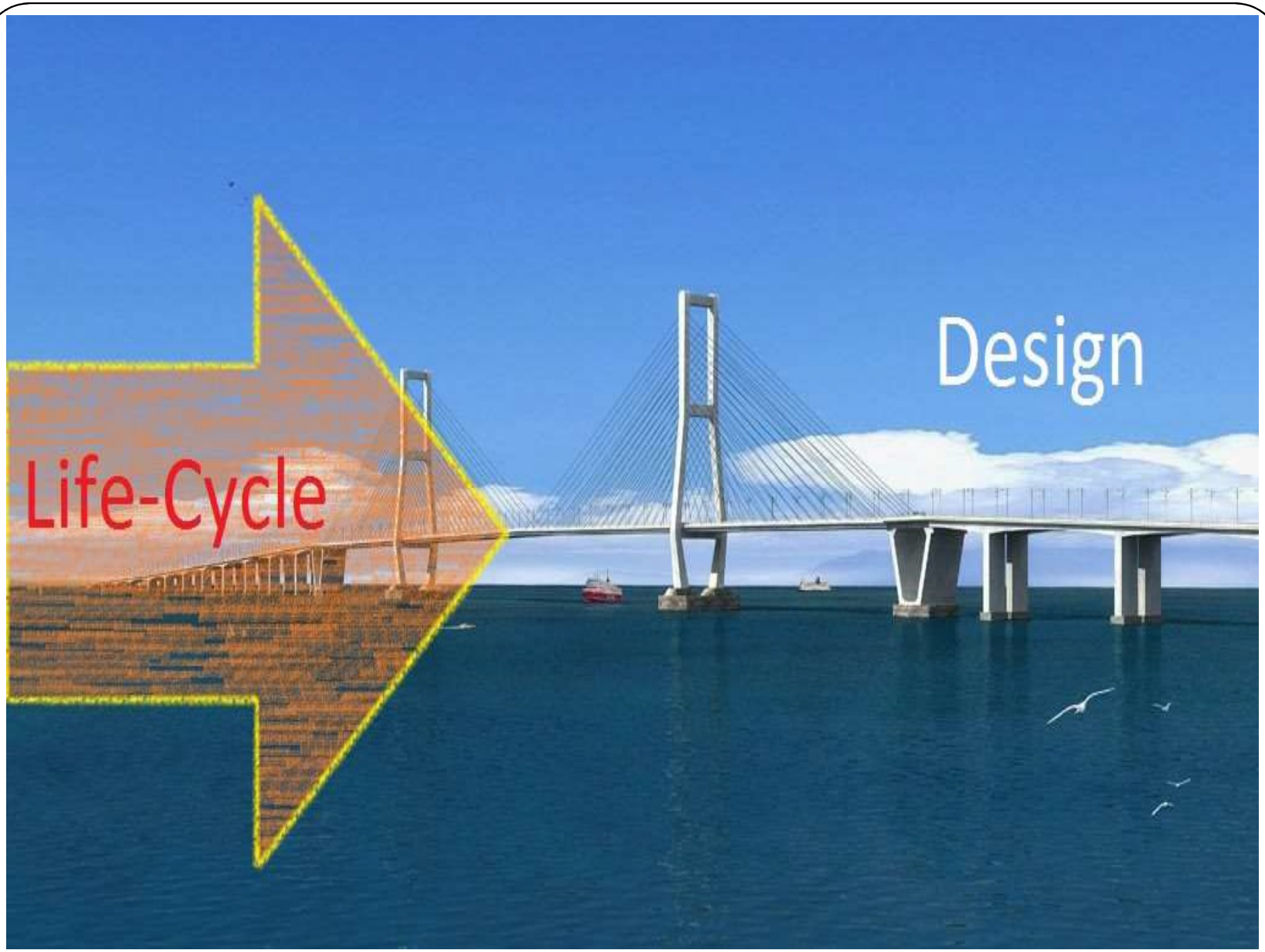

Life-Cycle
Design

Content

- Introduction
- Design of recycling
- Life cycle management
- Life cycle chain
- Cost models

Design for recycling

❖Recycling is the process of collecting and processing materials that would otherwise be thrown away as trash and turning them into new products. Recycling can benefit your community and the environment.

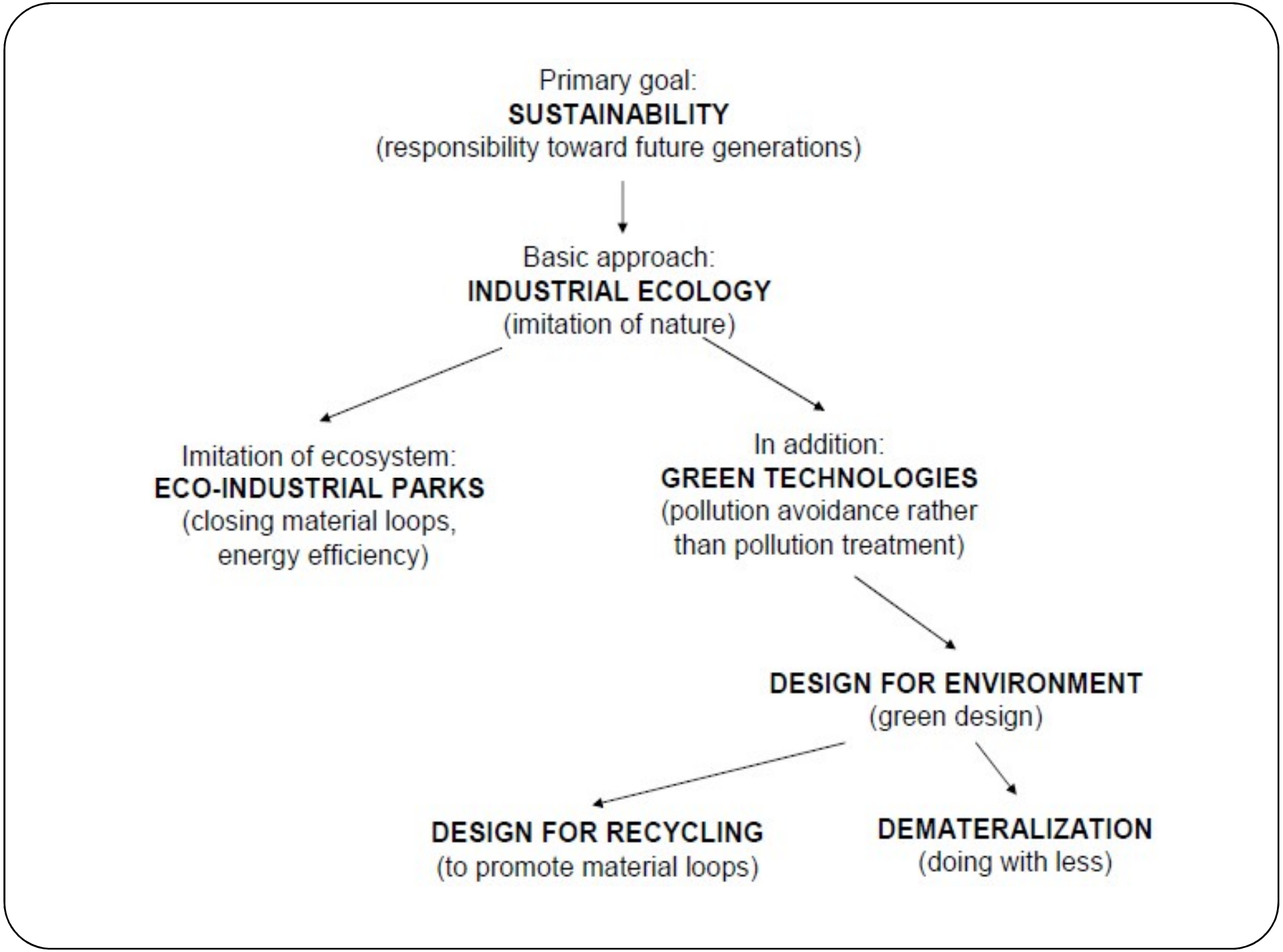
Benefits of Recycling

- Reduces the amount of waste sent to landfills and incinerators
- Conserves natural resources such as timber, water and minerals
- Increases economic security by tapping a domestic source of materials
- Prevents pollution by reducing the need to collect new raw materials
- Saves energy
- Supports American manufacturing and conserves valuable resources
- Helps create jobs in the recycling and manufacturing industries in the United States

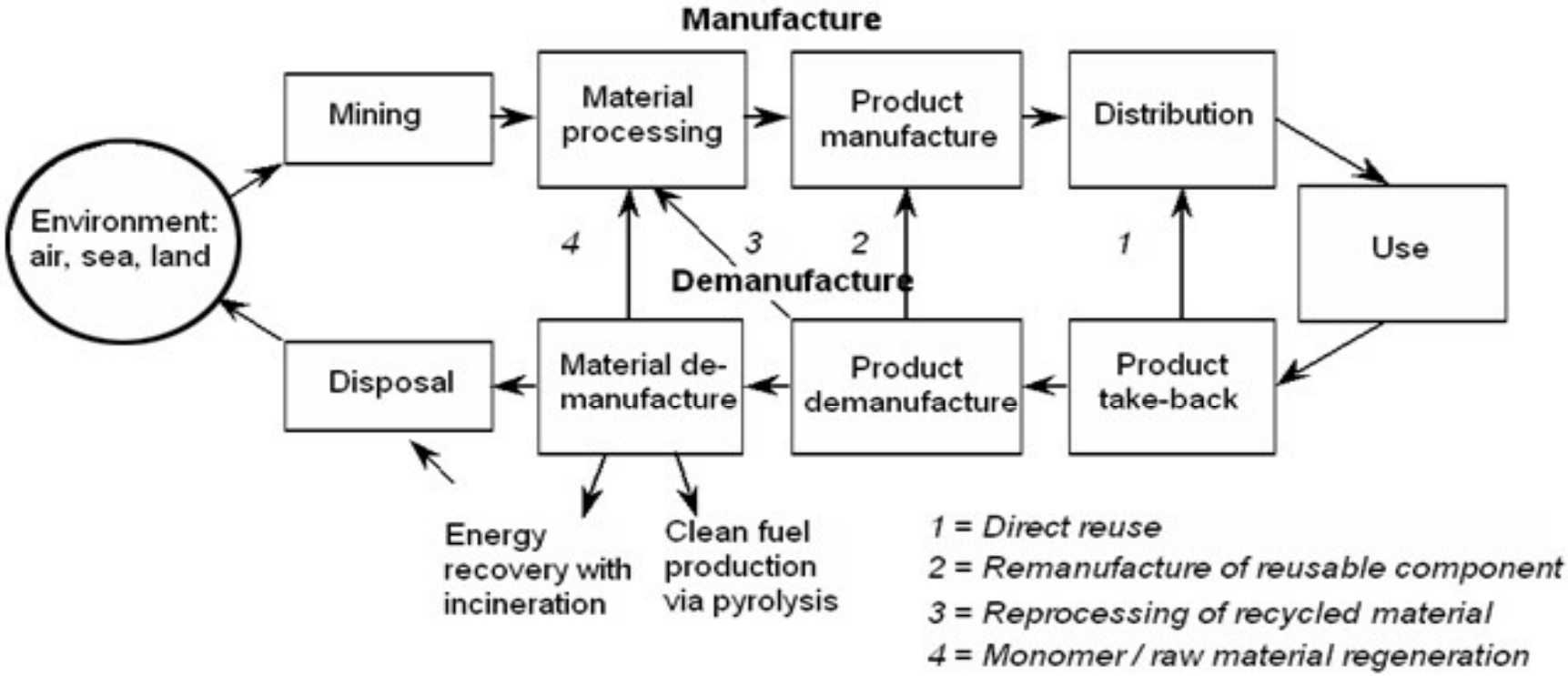
Steps to Recycling Materials

Recycling includes the three steps below, which create a continuous loop, represented by the familiar recycling symbol

- Collection and Processing
- Manufacturing
- Purchasing New Products Made from Recycling Materials


Primary goal:
SUSTAINABILITY
(responsibility toward future generations)
Basic approach:
INDUSTRIAL ECOLOGY
(imitation of nature)
Imitation of ecosystem:
ECO-INDUSTRIAL PARKS
(closing material loops,
energy efficiency)
In addition:
GREEN TECHNOLOGIES
(pollution avoidance rather
than pollution treatment)
DESIGN FOR ENVIRONMENT
(green design)
DESIGN FOR RECYCLING
(to promote material loops)
DEMATERALIZATION
(doing with less)

A product's Life cycle – From Cradle to Re-inclination



The term "demanufacture" is appearing more and more, especially in the electronics industry (DEC, Motorola, IBM), to characterize the process opposite to manufacturing involved in recycling materials and products. Companies (such as CinTech E-Waste) have sprung to corner the demanufacturing market.

Growing Importance of DfR

- Dwindling resources
  - Landfill space, especially in (over) crowded Europe
  - Raw material (lesser short term importance)

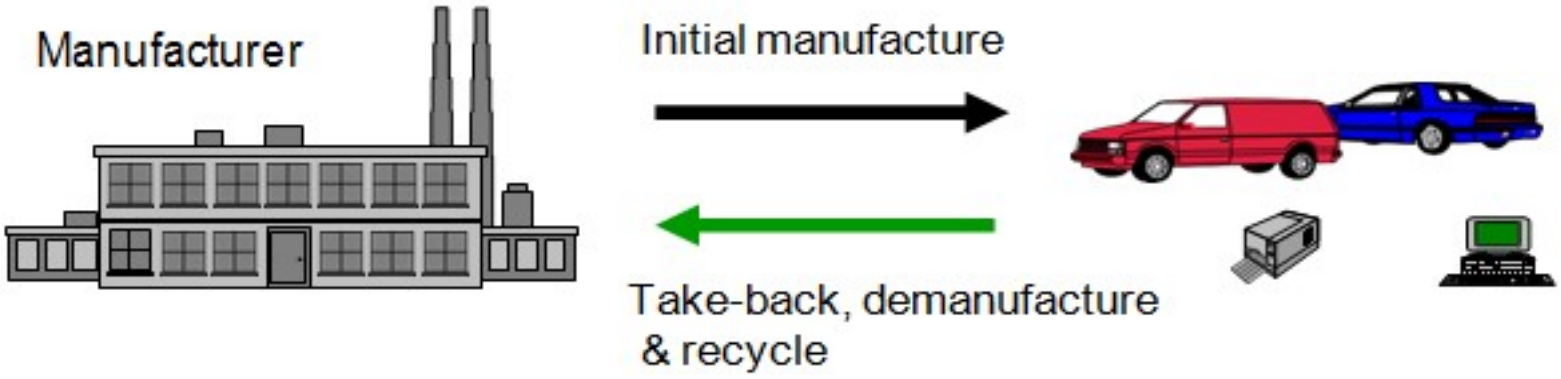
- For example:
  - Currently, around 80% of electronics are being sent to landfills
  - The US National Renewable Energy Laboratory estimates that 30 billion lbs. (14 billion kg) of plastics end up being land filled each year, and

  only 1% of plastic waste is recycled.

- Social and political climate is changing
  - Big social and political push in Europe
  - Some states, US Congress and President may want to follow Europe's lead.

European Take-Back Legislation

- European "Take-Back Law" requires automobile (and other) manufacturers to take back all vehicles (and other products) which were ever sold in that country.
- German regulation on electronic waste obliges the retailer to take back used electronic equipment from the end-user. The manufacturer/importer is obliged to take back the products from the retailer.
- Voluntary agreements have been widely accepted by industry and the threat of legislation has subsided slightly.



European Union - Automobiles

- *Objectives*:
  - Avoidance of waste
  - Reduction of landfill demand
  - Reduction of toxicity
- *Recycling Targets*:
  - Maximum of 15% of car weight may be land filled or incinerated without energy recovery.
  - For models beginning in 2002, maximum of 10% disposal.
  - Maximum of 5% of car weight disposal in 2015.
  - From 1995, cars must be depolluted before shredding.
  - From 1998, 100% of all wrecks to be collected.
- *A dream for politicians and a nightmare for car manufacturers*?

  Maybe, but:

  In Europe, people are VERY serious about cleaning up the environment. The US is generally expected to follow European experience and successes.

In the US, 95% of automobile hulks are captured and recycled.

(For reference: 17 million new vehicles are sold each year in the US.)

As a result, 750

The various steps in auto recycling

The last owner

Only when the last owner turns over the end-of-life vehicle to an officially authorized recycler is due process of recycling assured. Recyclers and their partners are then responsible for all further steps.

Airplane recycling in France

Photographs by Jean-Paul Pelissier / Reuters

Planes at stages of dismantling at the airport in Châteauroux, France. It takes as long as six weeks to break down the average commercial aircraft.

- In the US, largest companies formed the **Vehicle Recycling Partnership** and the Vehicle Recycling and Dismantling Center in Highland Park to look at recycling issues.

  More than 10 million vehicles are already recycled in the US annually.

Recovery Priorities

Re-use:

- Highest priority from environmental point of view
- All resources (material and energy) put into product during manufacturing are preserved.
- Requires non-destructive disassembly.

Material recycling:

- Most common.
- Only materials are preserved, all geometric details are lost.
- Allows for destructive disassembly.
- Also done for recovery of valuable material (*ex*. gold in electronics)

Energy recovery:

- Only energy embodied in materials is preserved through incineration or pyrolysis.

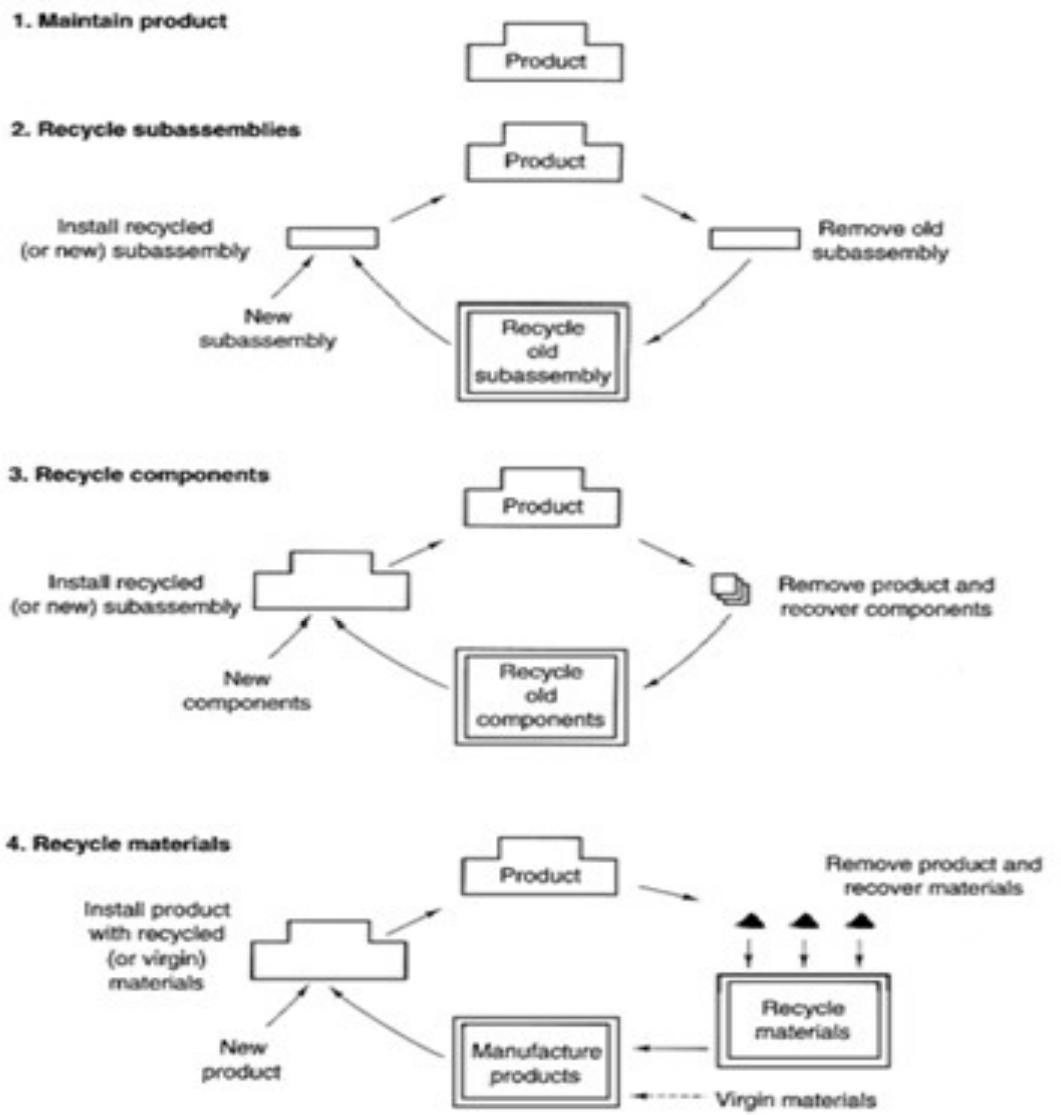


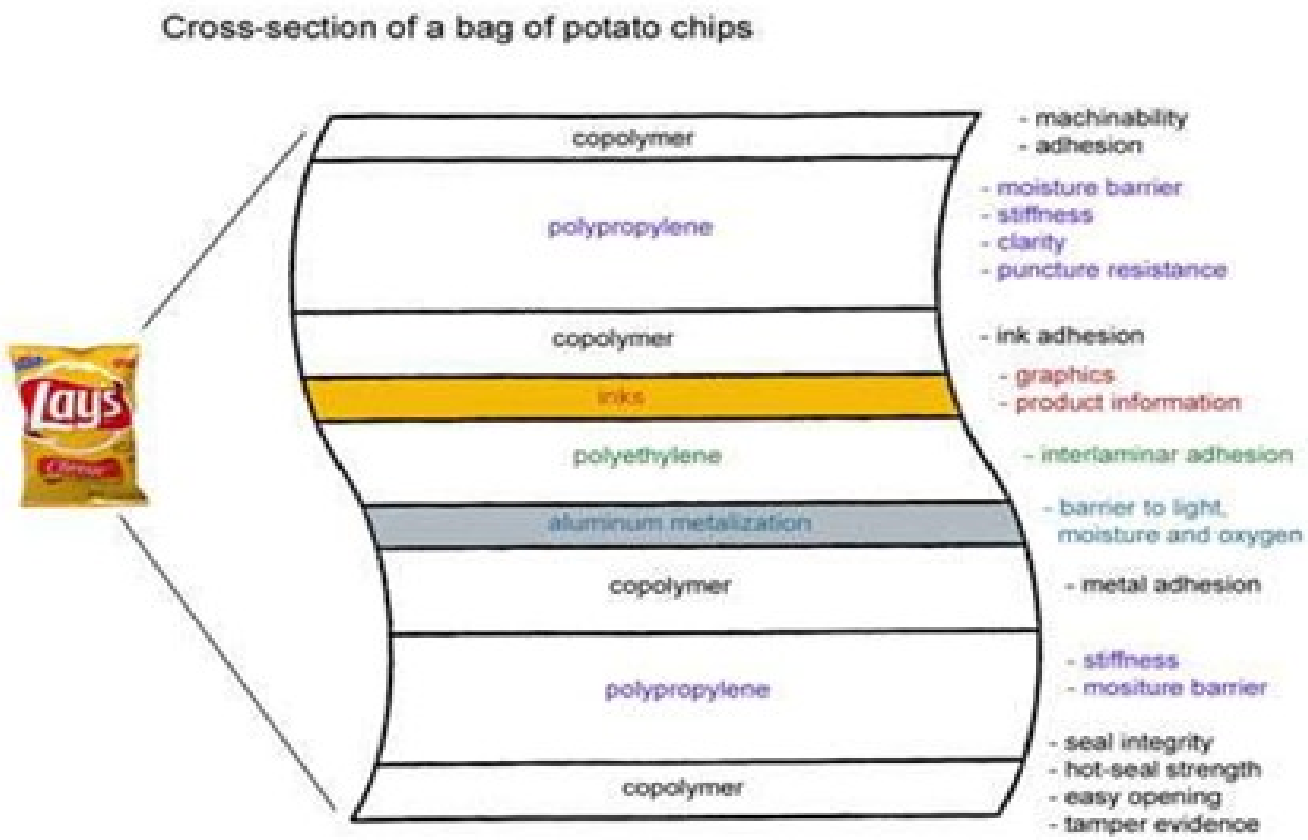
Figure 8.1 The heirarchy of preference in recycling of industrial products. Recycling should generally be accomplished as high up the chain as possible. Dashed lines indicate alternatives discouraged in the practice of industrial ecology.

Recyclables vs. non-recyclables

Class of Non-renewable material	Recycling Technically feasible?	Recycling Economically feasible?	Examples
I	**Yes**	**Yes**	Most industrial metals Catalysts, some solvents
II	**Yes**	**No**	Packaging materials Refrigerants, some solvents
III	**No**	**No**	Coatings, pigments Fuels, lubricants Pesticides, herbicides, fertilizers Reagents, explosives, detergents

Problem! None of these materials are renewable!

Some products just can't be recycled!



Solution: These products need to be redesigned to become recyclable.

- If separation can be performed, it is at a cost of energy.
- because the natural tendency of things is to mix rather than un-mix (second law of thermodynamics).
- There is a theoretical minimum amount of energy, *E*min, required to separate an element in concentration *c* in a containing material:

$$E_{\min} = -\frac{RT}{c}\left[c \ln c + (1-c)\ln(1-c)\right]$$

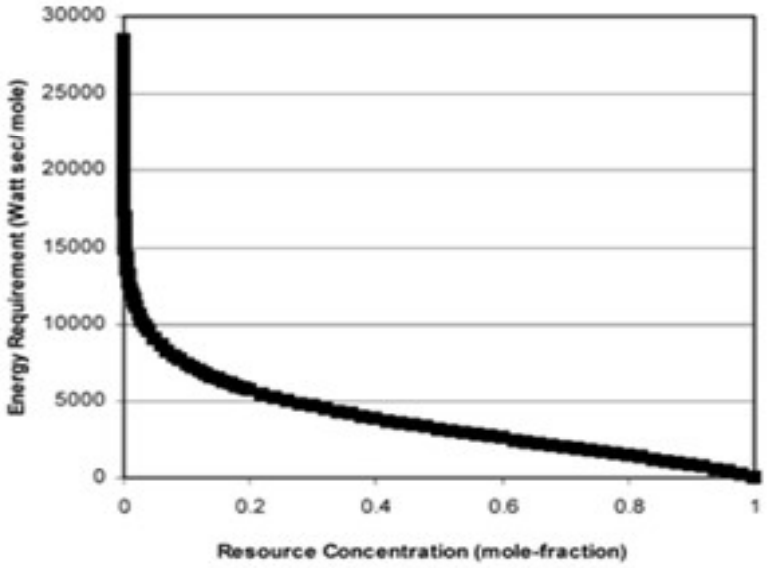
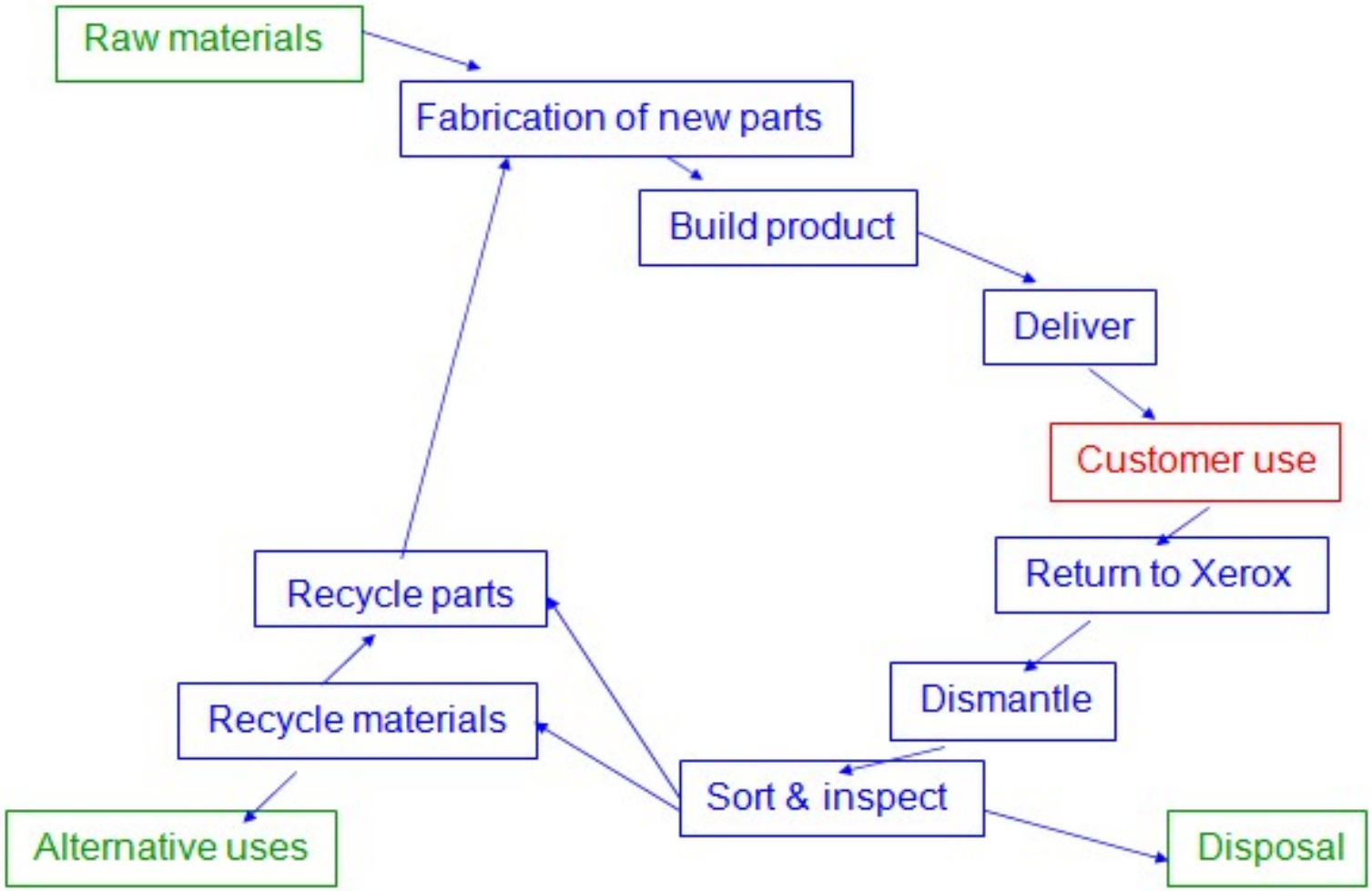
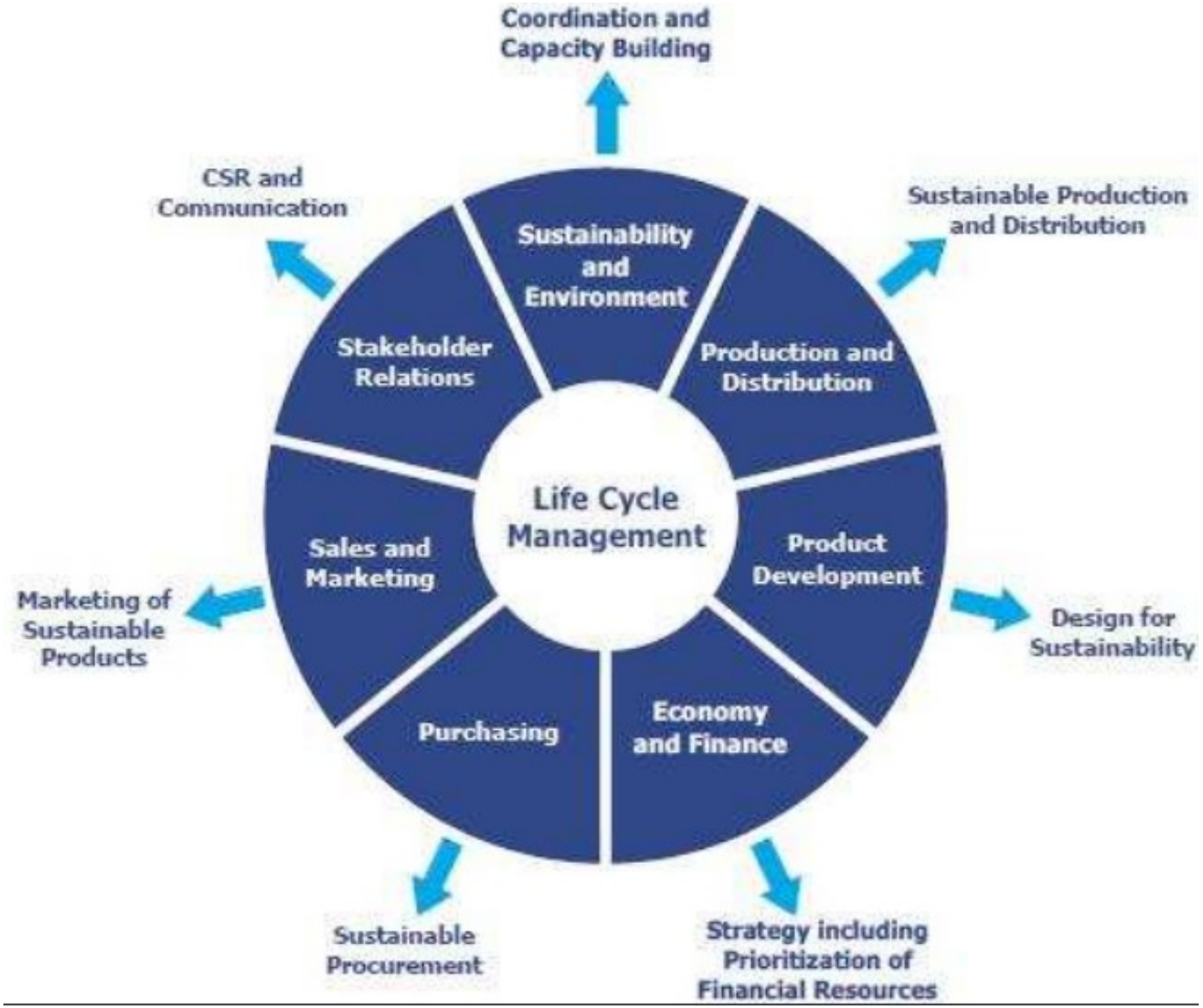


Fig. 2. Relationship between energy requirement and resource concentration at 273 K according to Eq. (1). (based on Fig. 4.5 in Faber et al. 1995)

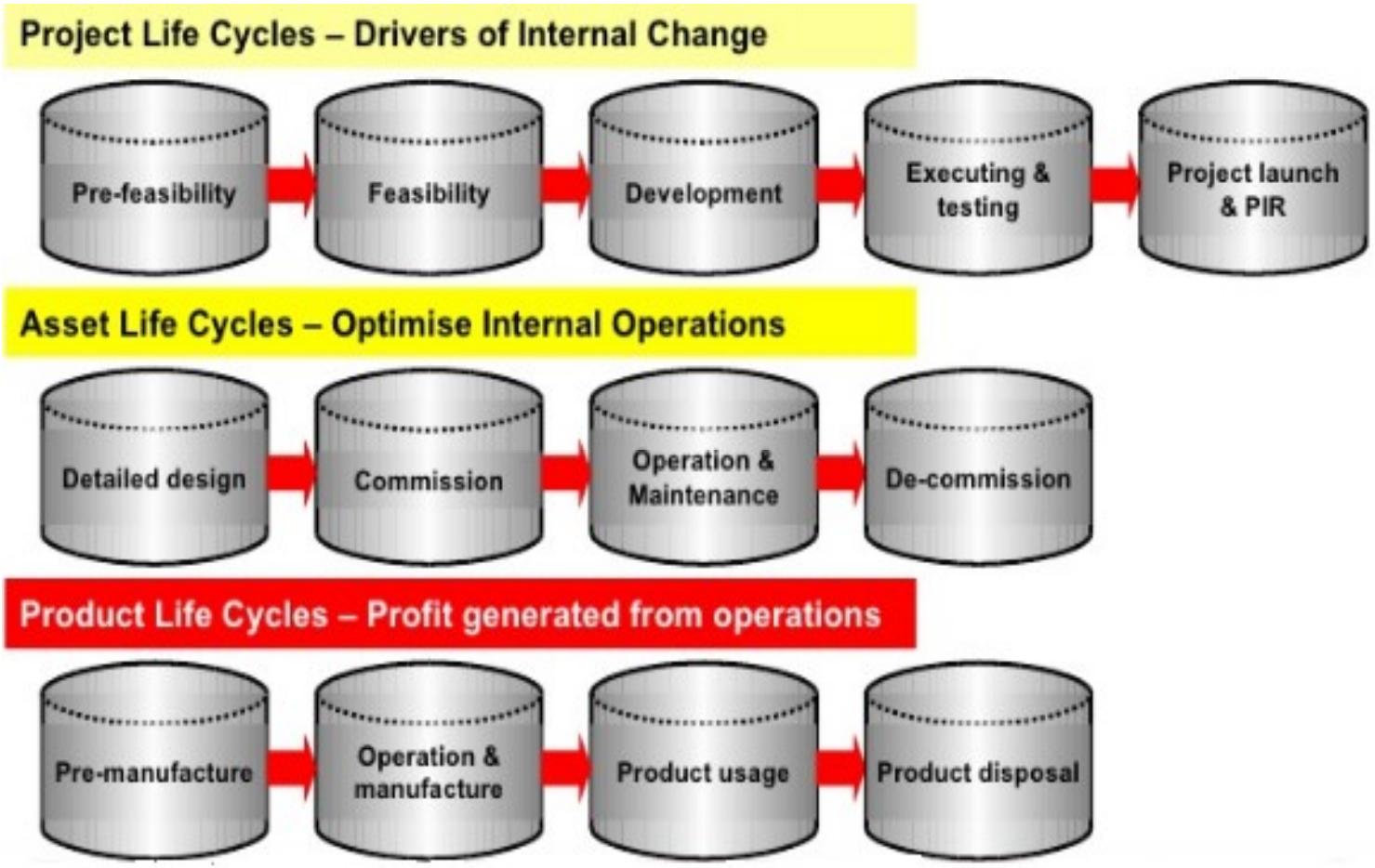
XEROX Equipment Recovery & Parts Reuse/Recycle Process



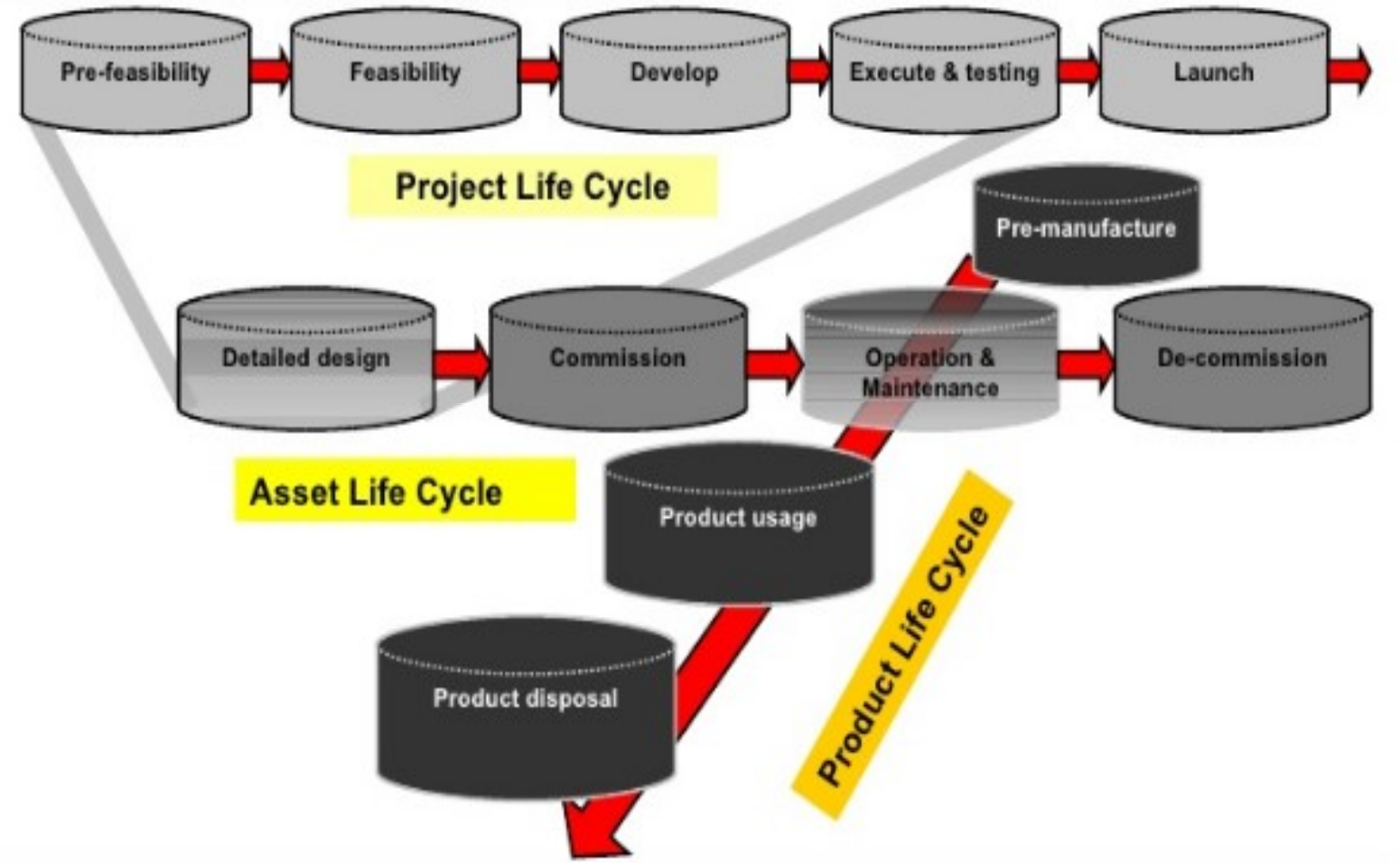
Life-Cycle Management



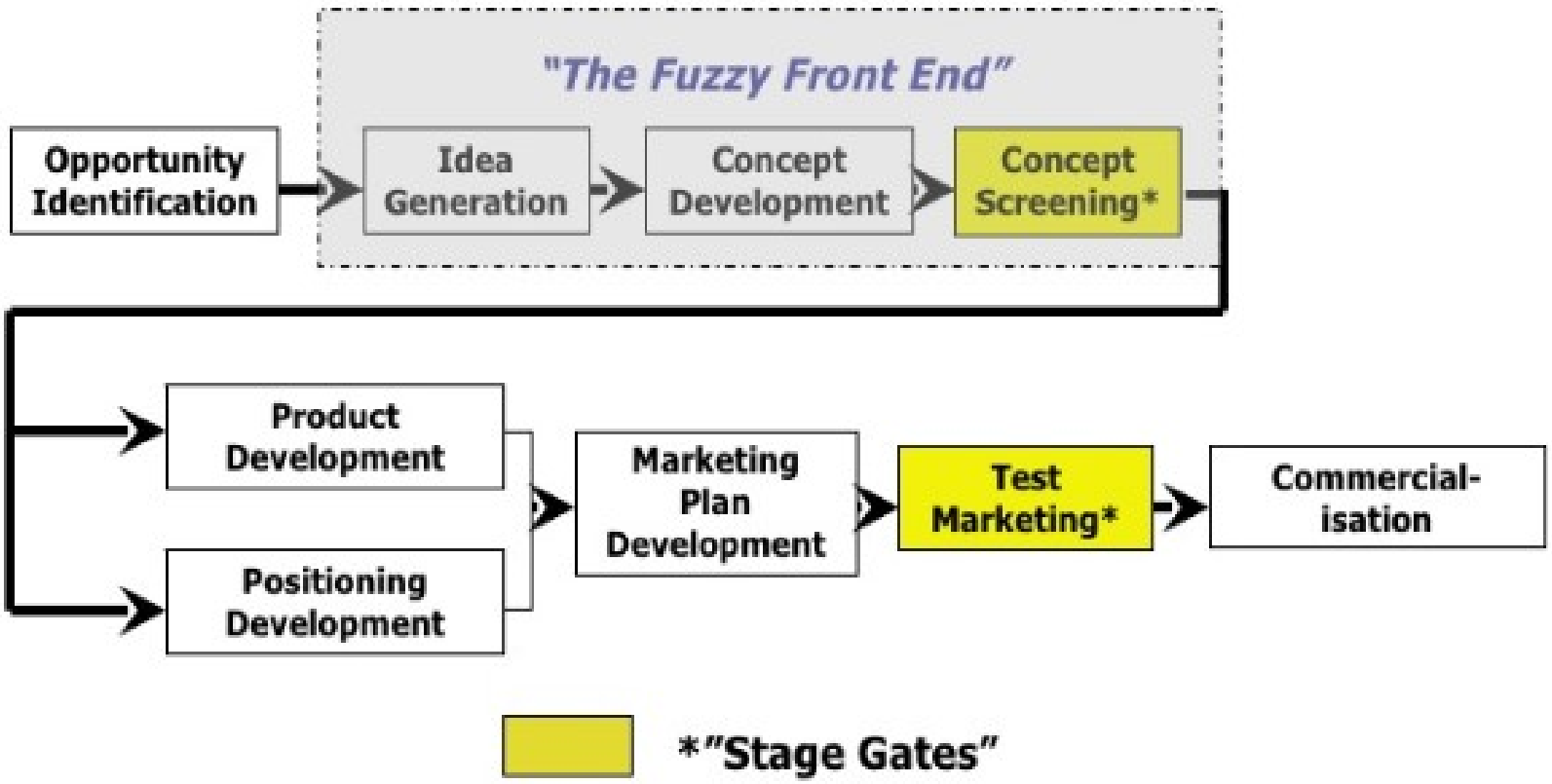
Life cycle in manufacturing industry



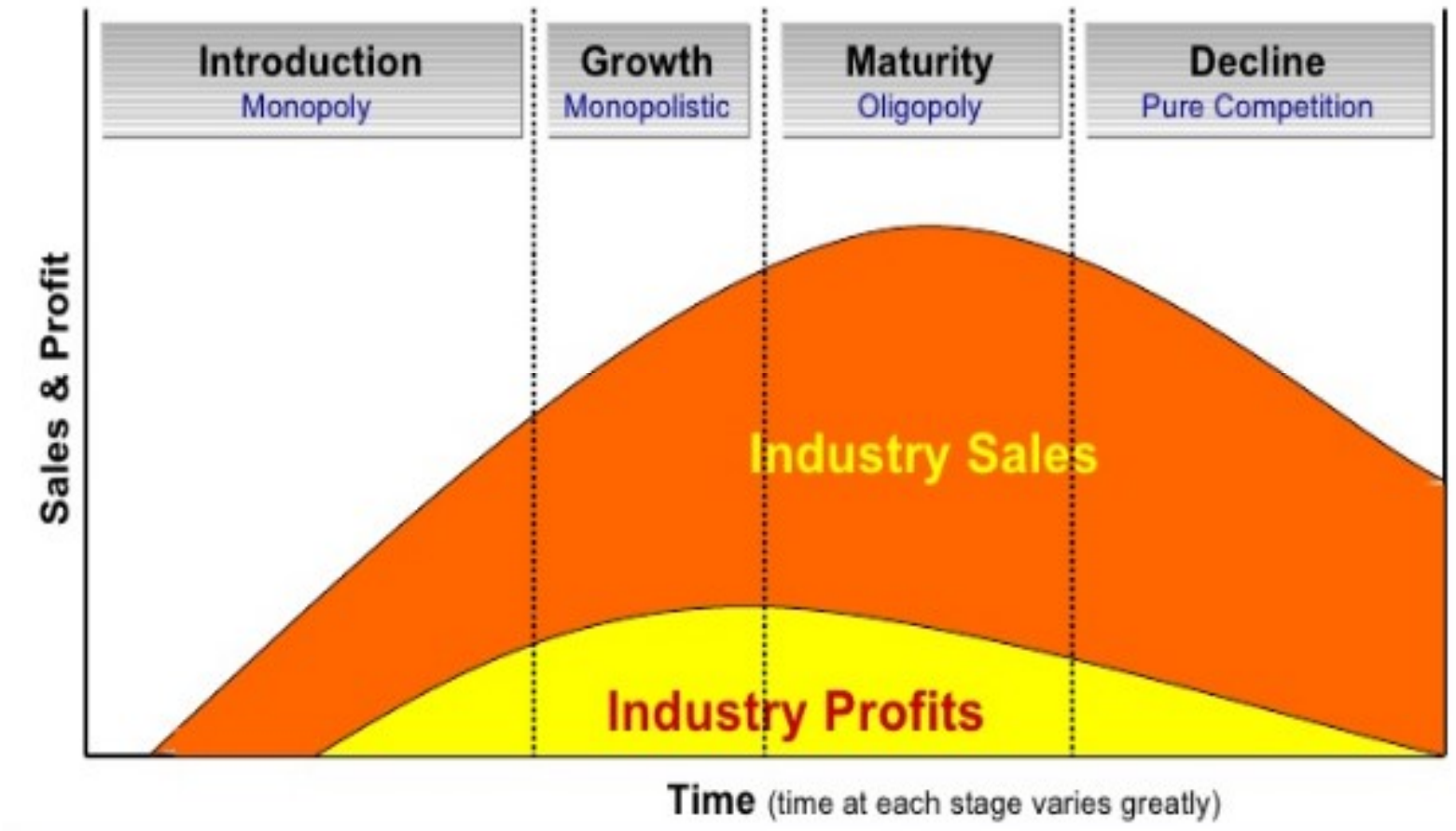
Life Cycle Integration



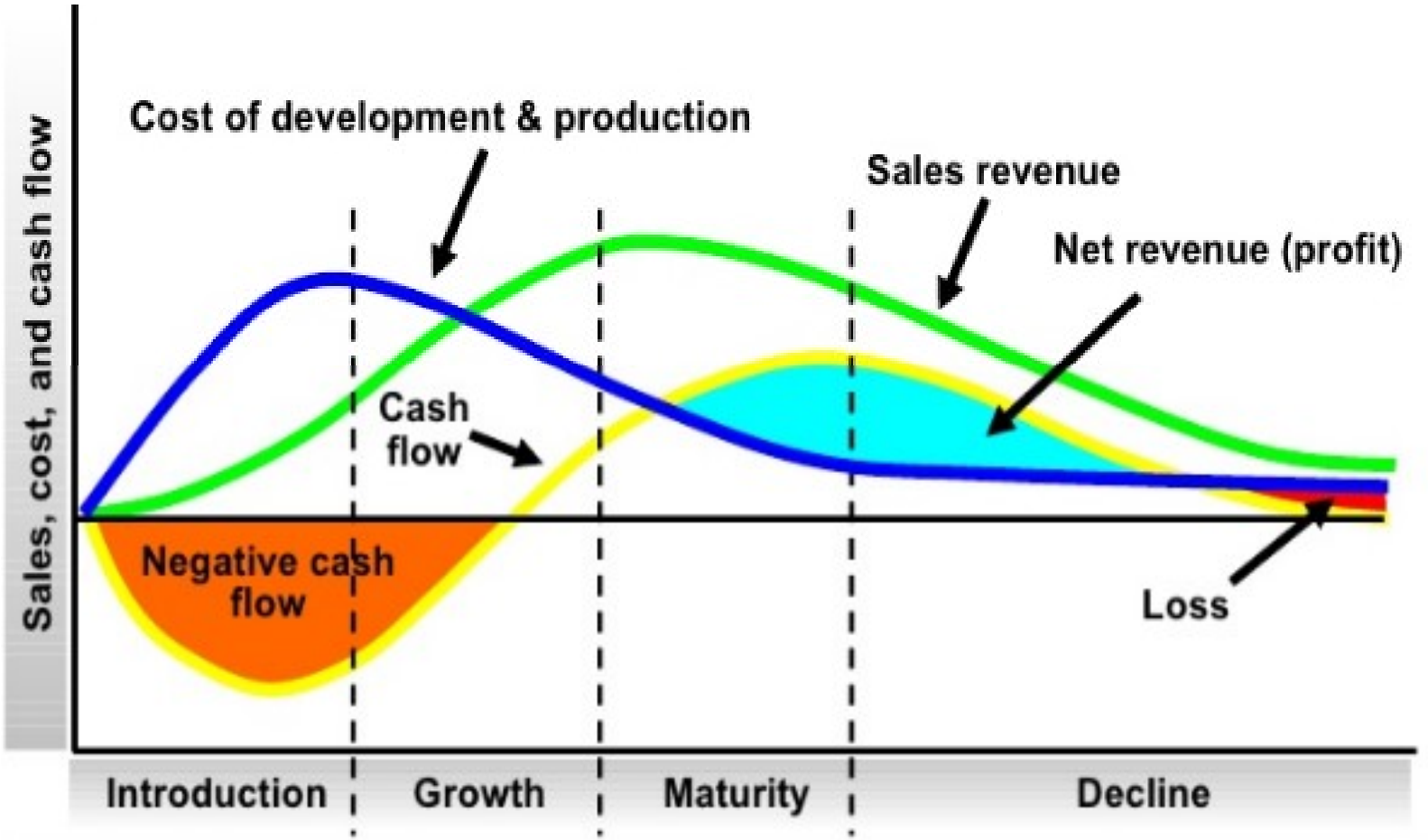
New Product Development Process



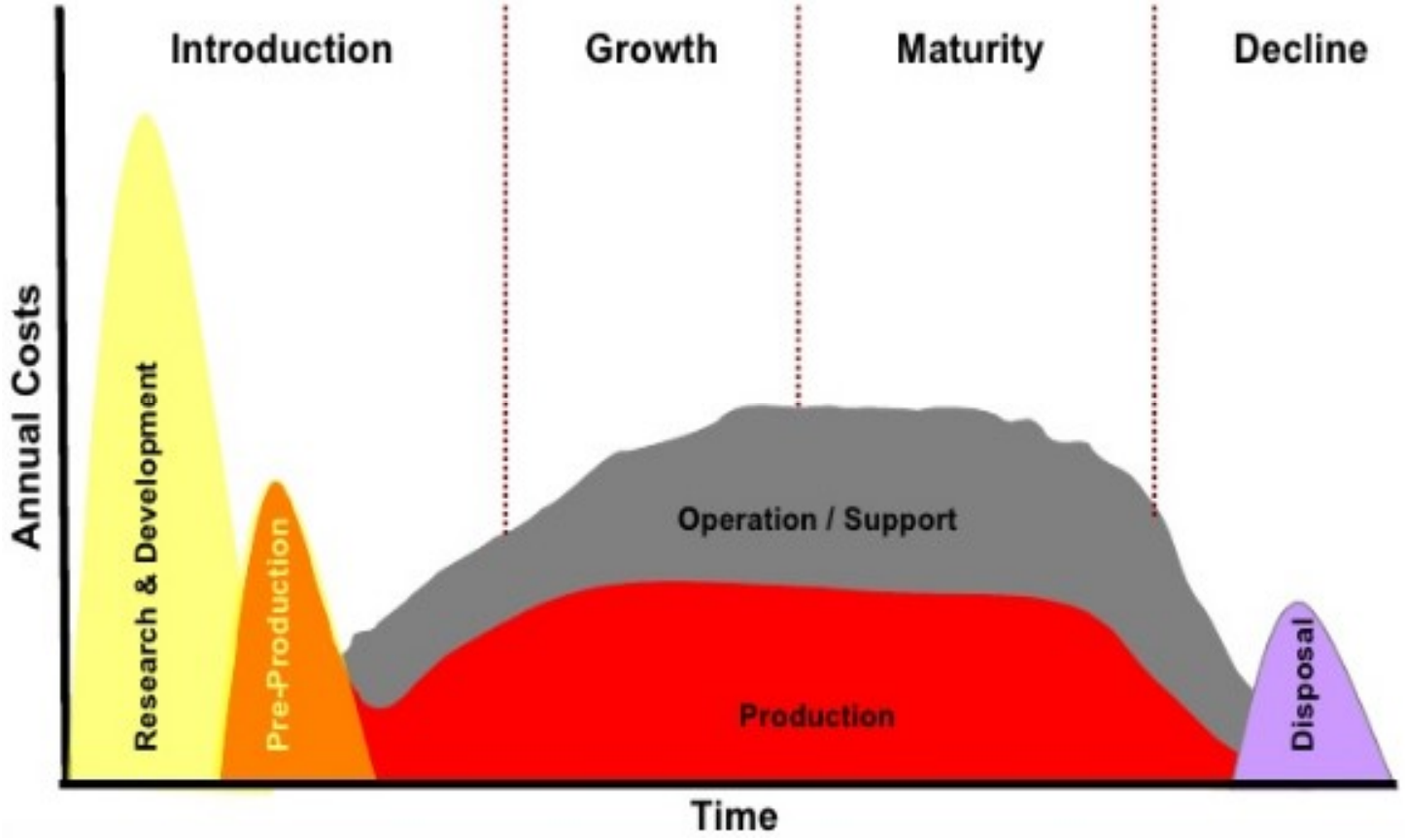
Product Life cycle - Stages



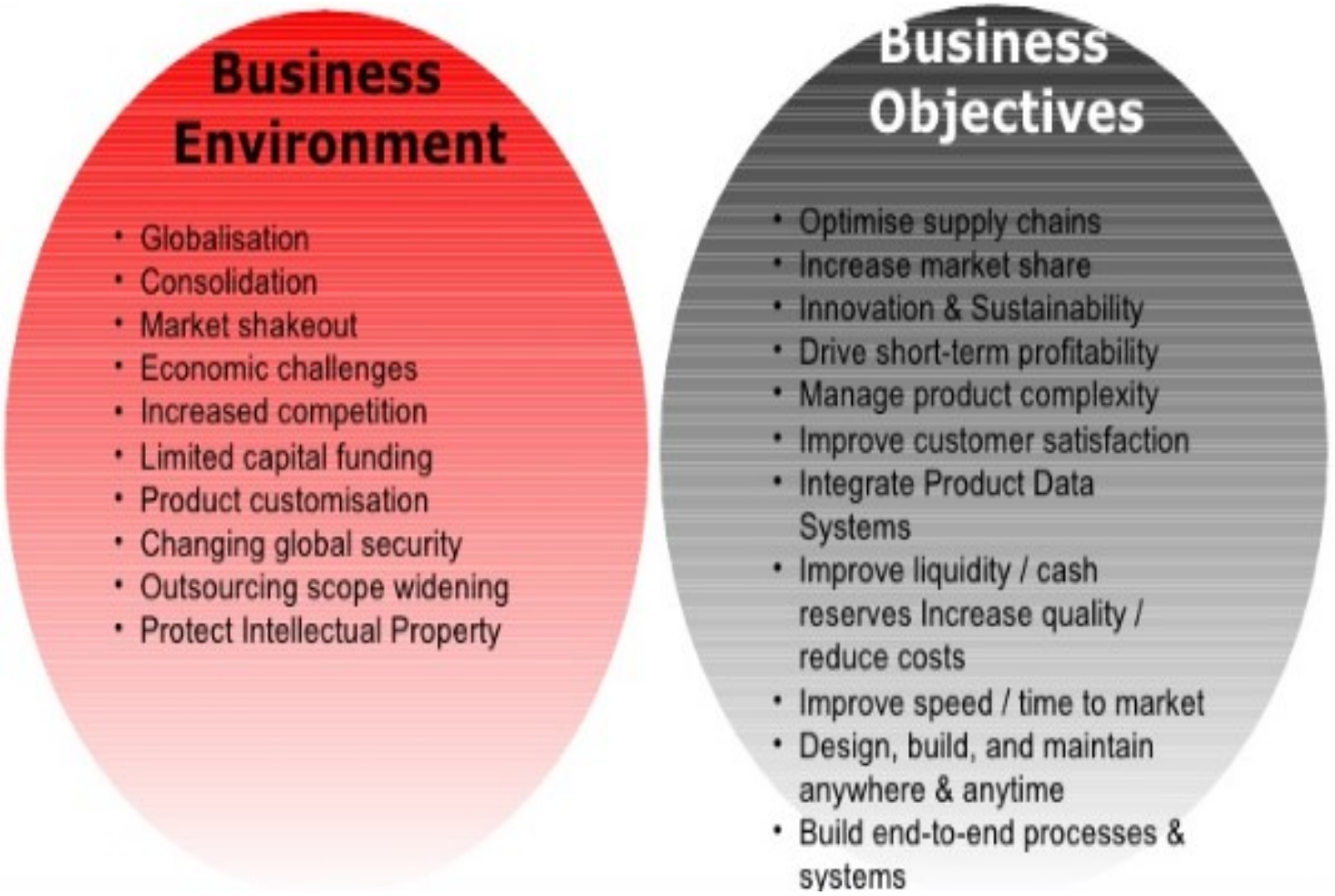
Managing Product Life Cycle



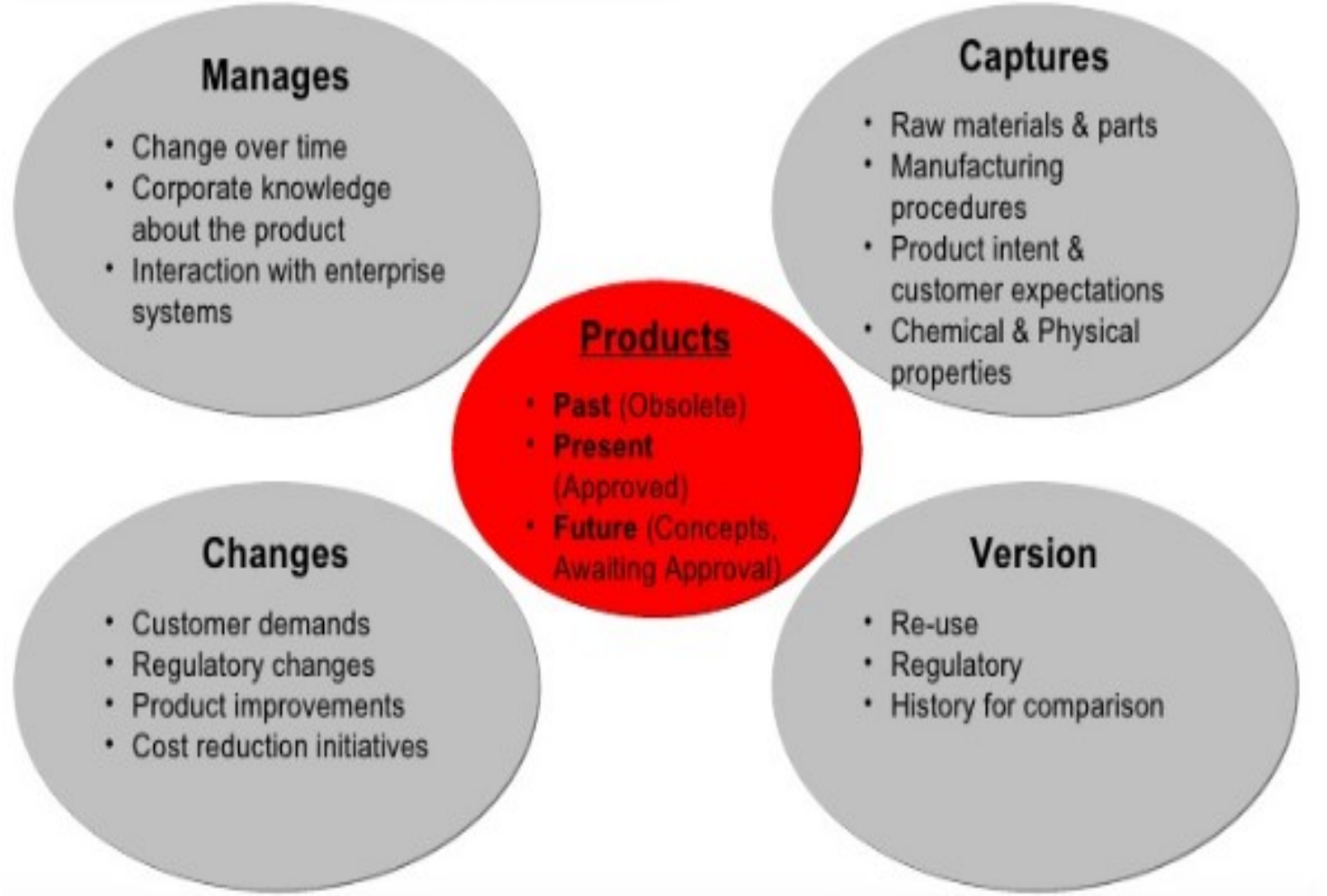
Product Life Cycle - Costs



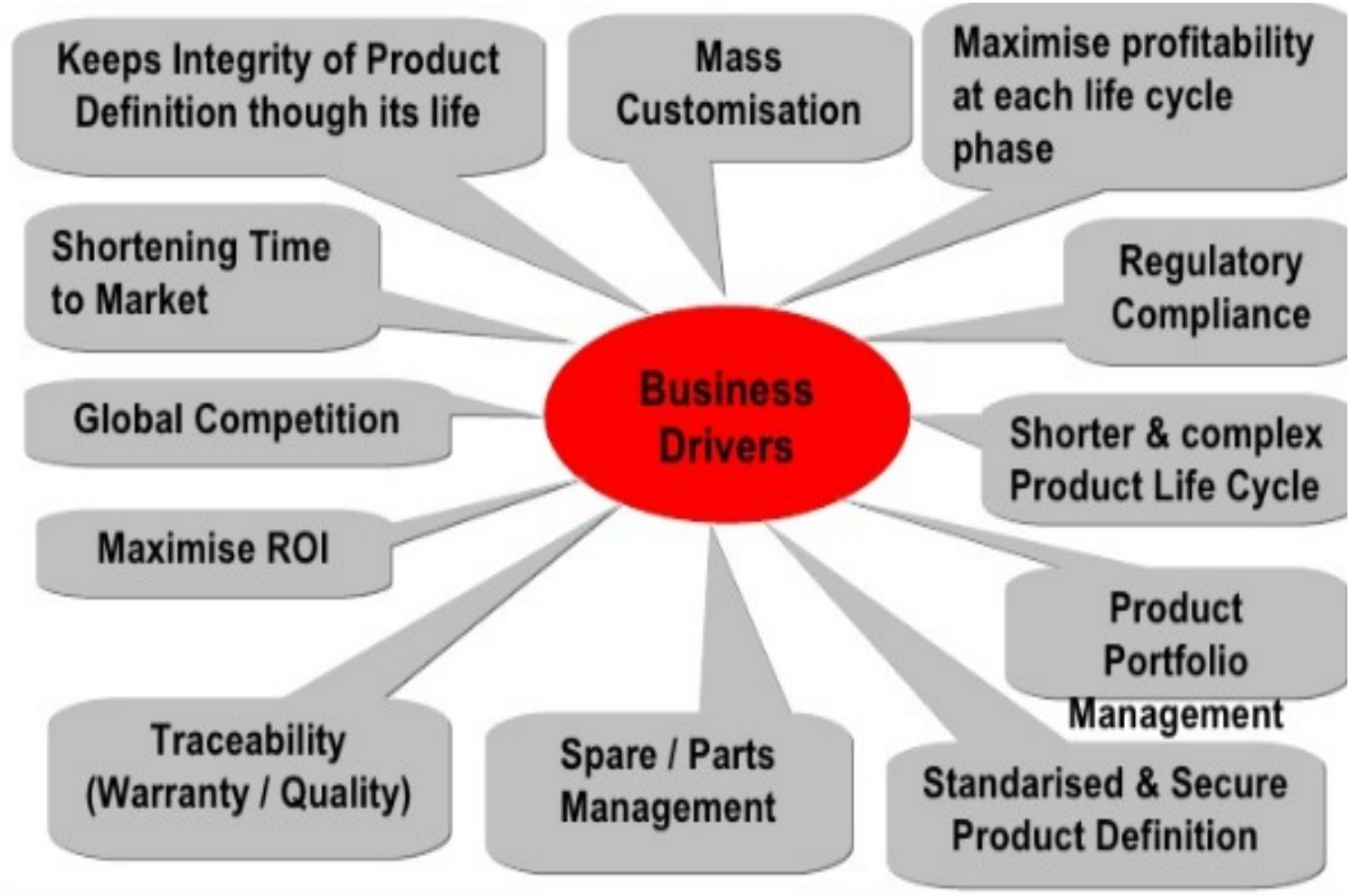
Product Life Cycle Management



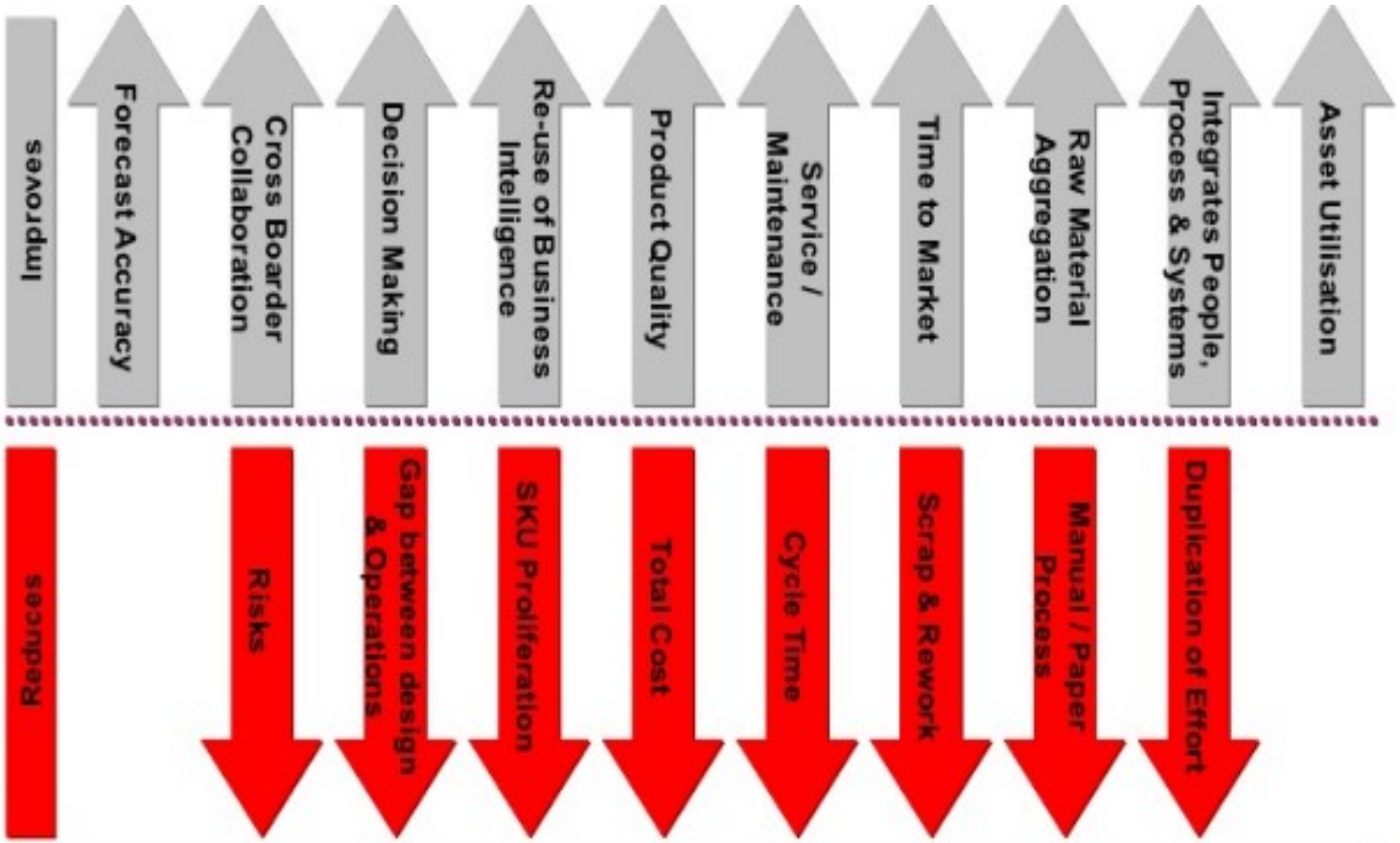
PLM - Speed to Market



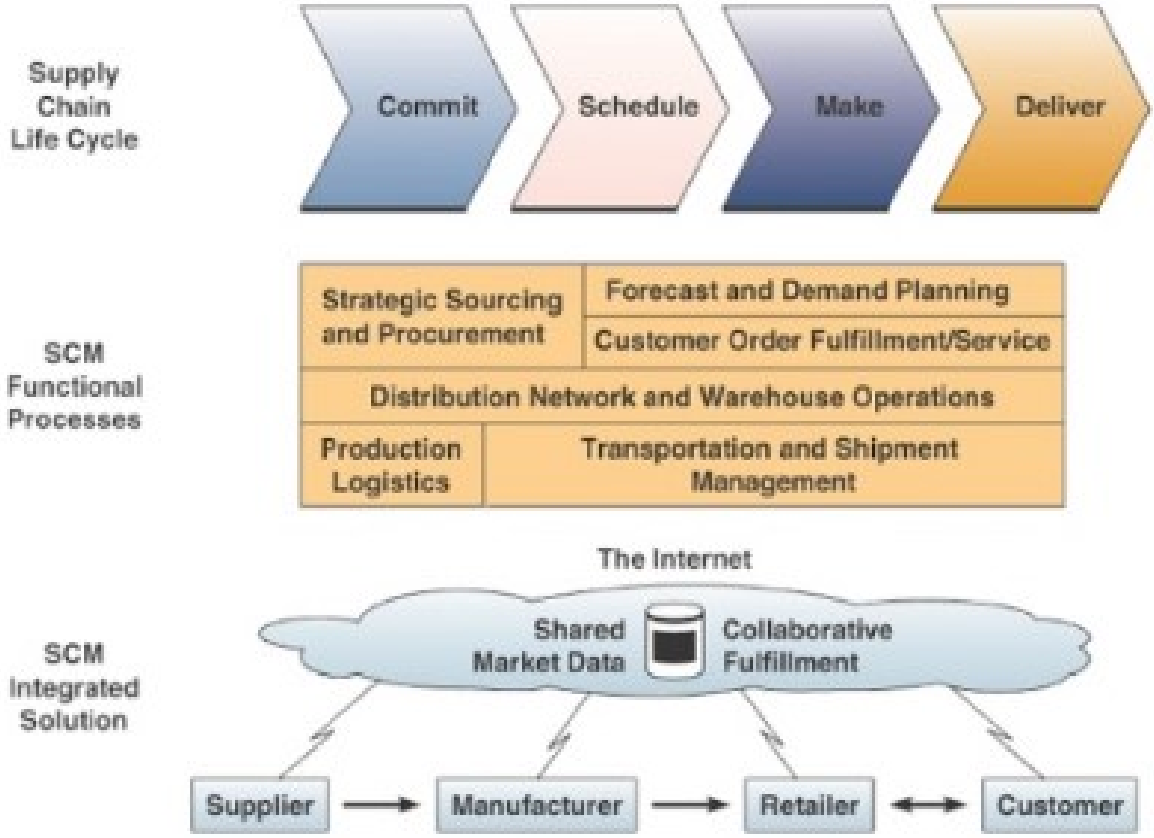
Business Drives for PLM



Benefits of PLM



Life cycle chain



Life Cycle Costing Model

LCC model is an accounting structure containing terms and factors which enable estimation of an assets component costs.

- **The LCC model should:-**

  - Represent characteristics of the assets being analyzed

  - It should be comprehensive

  - It should be easily understood

Life Cycle Costing Process

- Determine time for each cost element.
- Estimate value of each cost element.
- Calculate Net Present value of each element, for every year.
- Calculate LCC by adding all cost element, at every year
- Analyze the results

Find Costing Models?

- Manufacturing cost
- Maintenance coast
- Initial cost
- Cost of environment
- Cost of recyclycing

THANK YOU