INSE 6411
Product Design Theory and Methodology

Concept testing
Product architecture and generation
Lectures 10

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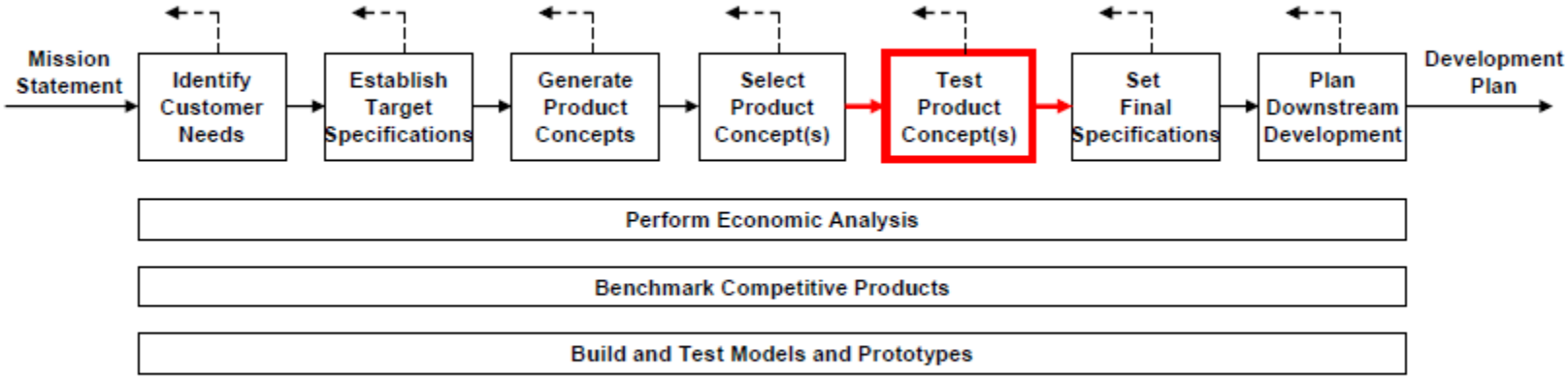
Lecture outline

- Concept testing
- Product architecture
- Product generation and parts identification

Concept testing

Textbook - Chapter 9

CONCEPT TESTING

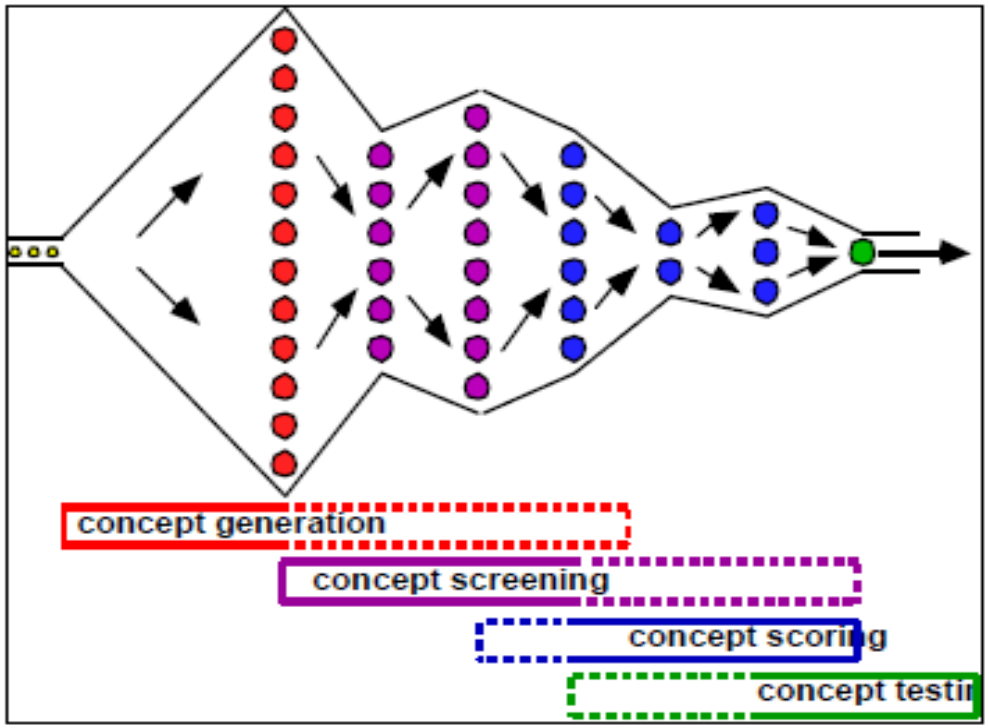


Concept testing

- In a concept test the team solicits a response to a description of the product concept from potential customers in the target market
- Used to:
  - Confirm the selection decision
  - Select among concepts
  - Select/confirm the market target
  - Get ideas on possible improvements of the product
  - Estimate the sales potential
  - Make go/no-go decision

Concept testing

- Closely related to concept selection
- Based on the data gathered from customers, not on the design team judgments
- It is possible not to do any testing



Concept testing example: electric scooter

Concept testing

- Five step concept testing procedure
  1. Choose a survey population
  2. Choose a survey format
  3. Create the survey
  4. Run the survey
  5. Analyze the survey

Concept testing

- Step 1: **Choose a survey population**
  - The survey population should reflect the target market.
    - Example: electric scooter has three main markets:
      - urban commuters
      - college students
      - factory workers
    - Screening questions
    - Reuse the participants if possible

  - Choose sample size (10–1000)
    - Smaller sample size favored for gathering *qualitative* data, for relatively small markets or when the survey is expensive and time consuming
    - Larger sample size is necessary for more accurate *quantitative* analysis such as market demand forecast

Concept testing

- Step 2: **Choose a survey format**
  - *Face-to-face* interaction
    - Stopping people on a street
  - *Telephone*
    - May be random or targeted to specific individuals
  - *Postal* mail
    - Somewhat slower than other methods
    - Often poor response
  - *E-mail:*
    - Similar to postal mail
    - Slightly more likely to get response than via postal mail
  - *Internet*
    - A team may create a Web site for virtual concept testing

Concept testing

- Step 3: **Create the survey**
  - Communicate the concept
    - Written or verbal description
    - Sketch
    - Photos and renderings
    - Storyboard
    - Video
    - Simulation
    - Interactive multimedia
    - Physical appearance models (“looks-like models”)
    - Working prototypes (“works-like models”)

Concept communication – example scooter

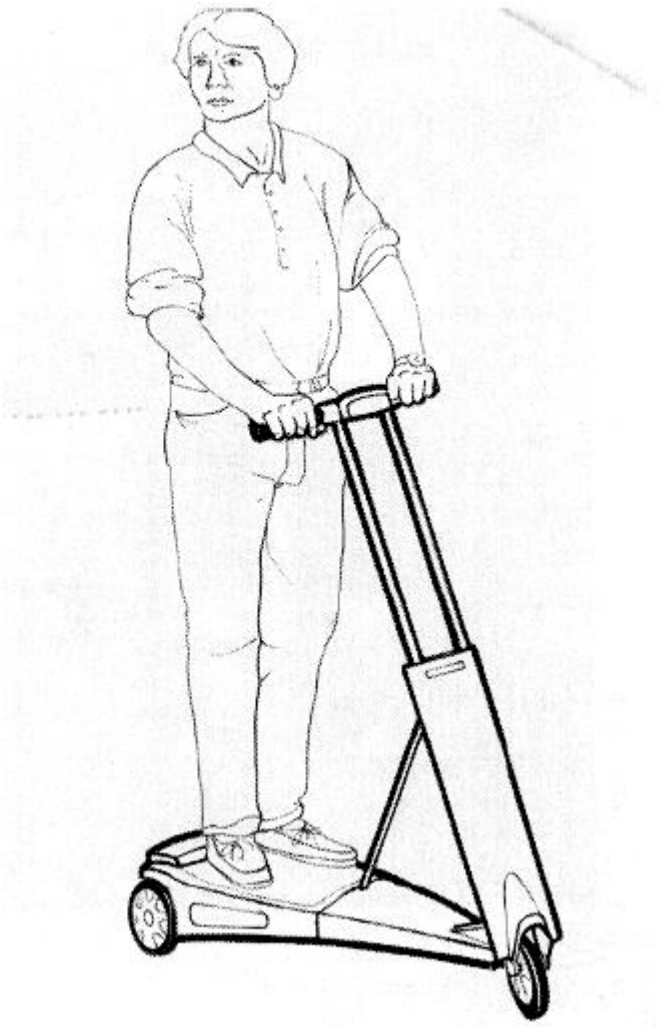
Verbal Description

- The product is a lightweight electric scooter that can be easily folded and taken with you inside a building or on public transportation.
- The scooter weighs about 25 pounds. It travels at speeds of up to 15 miles per hour and can go about 12 miles on a single charge.
- The scooter can be recharged in about two hours from a standard electric outlet.
- The scooter is easy to ride and has simple controls — just an accelerator button and a brake.

Concept communication – example scooter

Sketch

- Line drawing showing the product in perspective



Concept communication – example scooter

Rendering

- Nearly photo-realistic illustrations of the concept
- Created by pens, markers, computers

Concept communication – example scooter

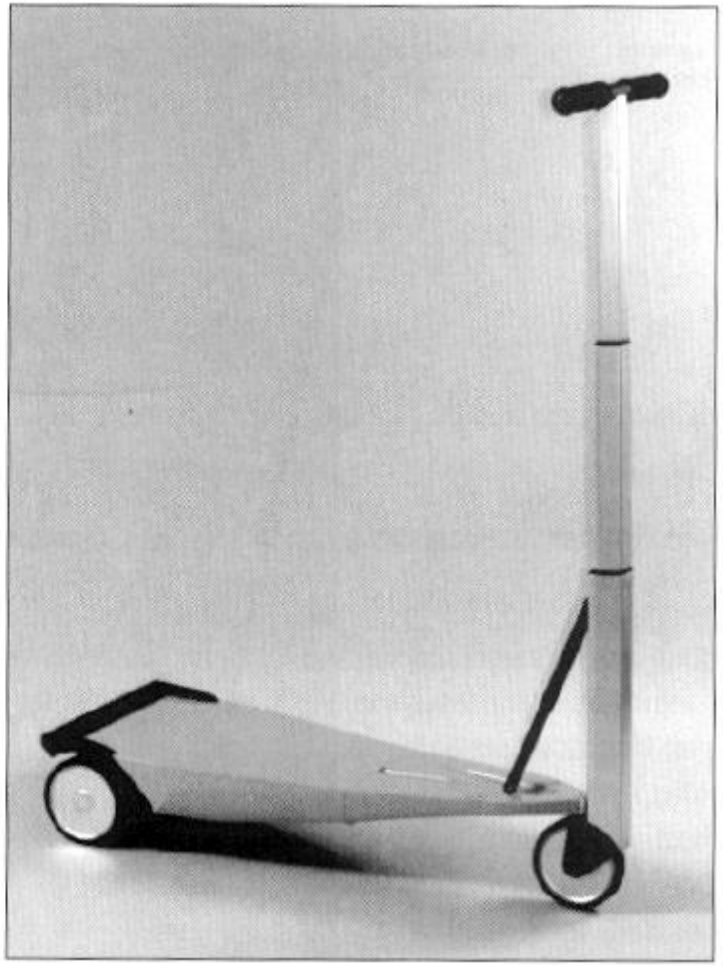
Storyboard

- A series of images showing a sequence of actions involving the product

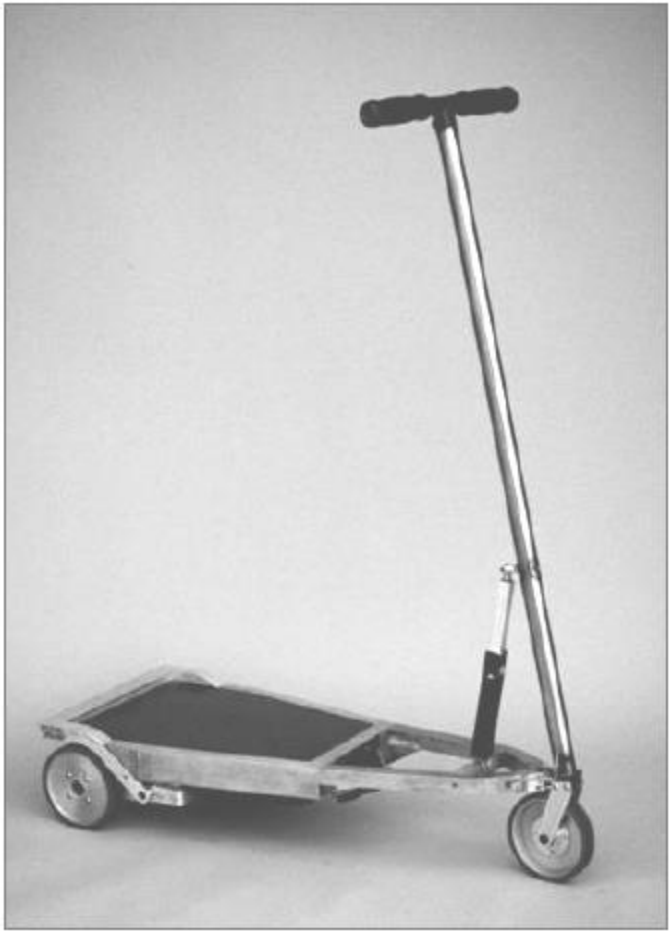
Concept communication – example scooter

Appearance model

- “Looks-like” model
- Vividly displays the form and appearance
- Made of wood or polymer foams, painted like a real product



Concept communication – example scooter



Working Prototype

- “Works-like” model
- Risky:
  - if it performs worse
  - if it performs better
- Usually it looks worse

Concept testing

- Step 3: **Create the survey**
  1. Start with ***screening questions (qualification)***
     - To identify if the customer fits the market segment
  2. ***Product description (concept communication)***
     - Show a single concept to receive a feedback about it
     - Show alternative concepts and ask about the customer preference
     - **Price** - Include price in concept description?
       - Pricing information can dramatically influence the results of a concept test
       - *Omit the price* from the concept description if is expected to be similar to existing products and to customer expectations
       - *Include the price* if it is expected to be unusually low or unusually high
  3. ***Purchase intent***
  4. ***Additional questions or comments***

Create survey – example scooter

- **PART 1, Qualification**
  - How far do you live from campus?
    - <If not 2-4 kilometers, thank the customer and end interview.>
  - How do you currently get to campus from home?
  - How do you currently get around campus?
- **PART 2, Product Description**
  - <Present the concept description>
- **PART 3, Purchase Intent**
  - If the product were priced according to your expectations, how likely would you be to purchase the scooter within the next year?

			$F_{probably}$	$F_{definitively}$
☐ I would **definitely not purchase** the scooter.	☐ I would **probably not purchase** the scooter.	☐ I **might or might not purchase** the scooter.	☐ I would **probably purchase** the scooter.	☐ I would **definitely purchase** the scooter.

- **PART 4, Comments**
  - What would you expect the price of the scooter to be?
  - What concerns do you have about the product concept?
  - Can you make any suggestions for improving the product concept?
- **Thank you.**

Concept testing

- Step 4: **Survey**
  - Run the survey
- Step 5: **Analyze the survey**
  - Determine whether the single analyzed concept is viable
  - For alternative concepts determine whether one concept is obviously superior to the others
  - Determine whether components of different concepts can be combined for a better overall product
  - Forecast the sales of new products
    - Forecast the sale of durables
    - ***Durables*** are products with negligible repeat-purchase rate

Forecasting the sales of durables

- ***Q = N x A x P***
  - ***Q***….quantity of the product to be sold (annual)
  - ***N***…expected number of purchases of existing products (annual)
  - ***A***…the fraction of customers *aware* of the product and for which the product is *available*
  - ***P***…probability the product is purchased (surveyed)

- $P = (C_{definitively} \times F_{definitively}) + (C_{probably} \times F_{probably})$
  - $F_{definitively}$ …fraction of respondents who would definitely purchase
  - $F_{probably}$…fraction of respondents who would probably purchase
  - $C_{definitively}$ & $C_{probably}$ …calibration constants reflecting the typical overestimation of the respondents
    - If no historical values then $C_{definitively} = 0.4$ and $C_{probably} = 0.2$

Forecasting the sales of durables

Example – existing market: scooter for factory transport

- Currently 150,000 of bicycles and scooters sold to factories annually ➔ N=150,000
- A company sells the product through one distributor that accounts for 25% of the sales in this category ➔A = 0.25
- Concept testing survey results:
  - Definitively would buy: 30%
  - Probably would buy: 20%
- How many scooters per year can be sold to factories?

- P = 0.4 x 0.3+ 0.2 x 0.2=0.16
- Q = 150,000 x 0.25 x 0.16= <u>6000 units/year</u>

Forecasting the sales of durables

Example – new market: scooter for college students

- 2 million off-campus students travelling 1-3 miles between home and campus and/or between classes ➔ N=2,000,000
- 30% of the students will be aware of the product and will have convenient access to a dealer ➔ A=0.3
- Concept testing survey results:
  - Definitively would buy: 10%
  - Probably would buy: 5%
- How many scooters per year can be sold to college students?

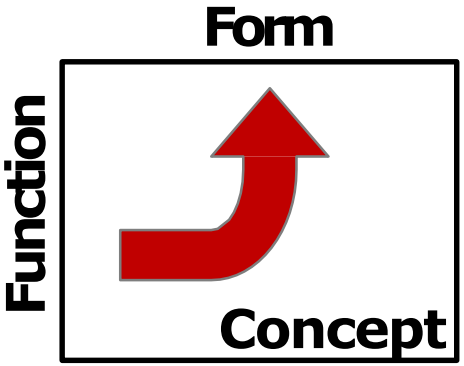
- P = 0.4 x 0.1 + 0.2 x 0.05 = 0.05
- Q = 2,000,000 x 0.3 x 0.05 = <u>30,000 units/year</u>

Product architecture

Chapter 10 from the textbook

Product architecture

Product architecture is **the assignment of the *functional* elements of a product to the *physical* building blocks** of the product.



Concept is a mapping of function to its physical embodiment of form

- The ***functional*** elements are the individual operations and transformations (expressed by VERBS)
- The ***physical*** elements of a product are the parts, components, and subassemblies
  - The physical elements of a product are typically organized into several major physical building blocks, called **chunks.**
  - The purpose of the product architecture is to define the basic chunks in terms of what they do and what their interfaces are

Modular product architecture

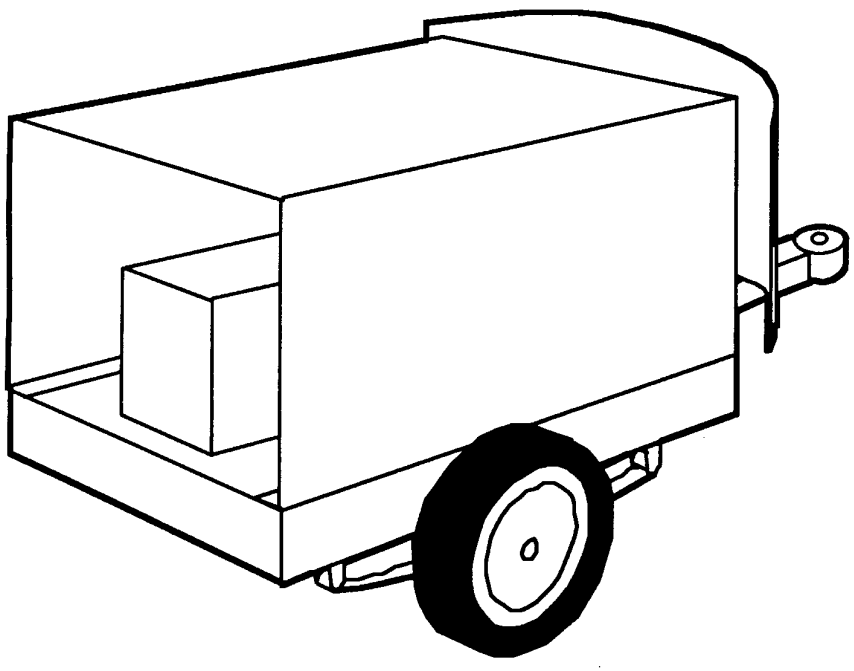
- Each chunk fully embodies one or more product functions.
- Advantages:
  - simplicity
  - reusability for a product family or platform.
  - easier design changes

Integral product architecture

- Typical functions involve more than one chunk
- Typical chunks implement more than one function
- Advantages:
  - increased performance
  - reduced costs for any specific product model
- However:
  - it may require extensive redesign of the product if a design change is made

Modular architecture

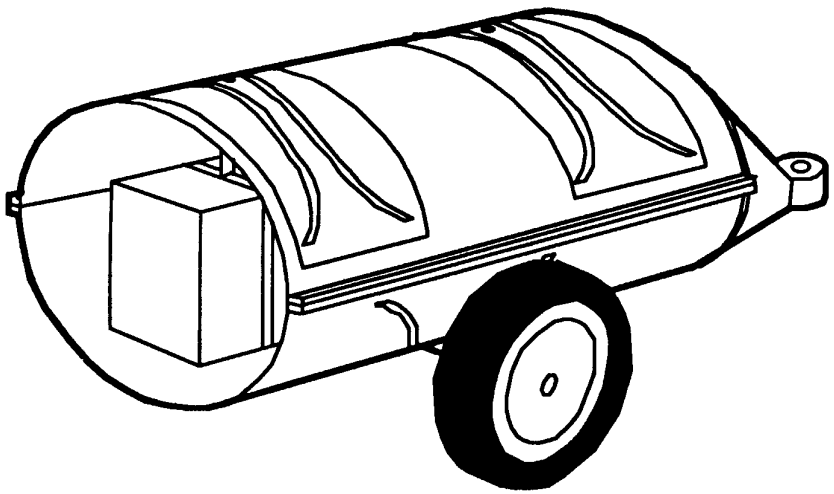
Example: Trailer

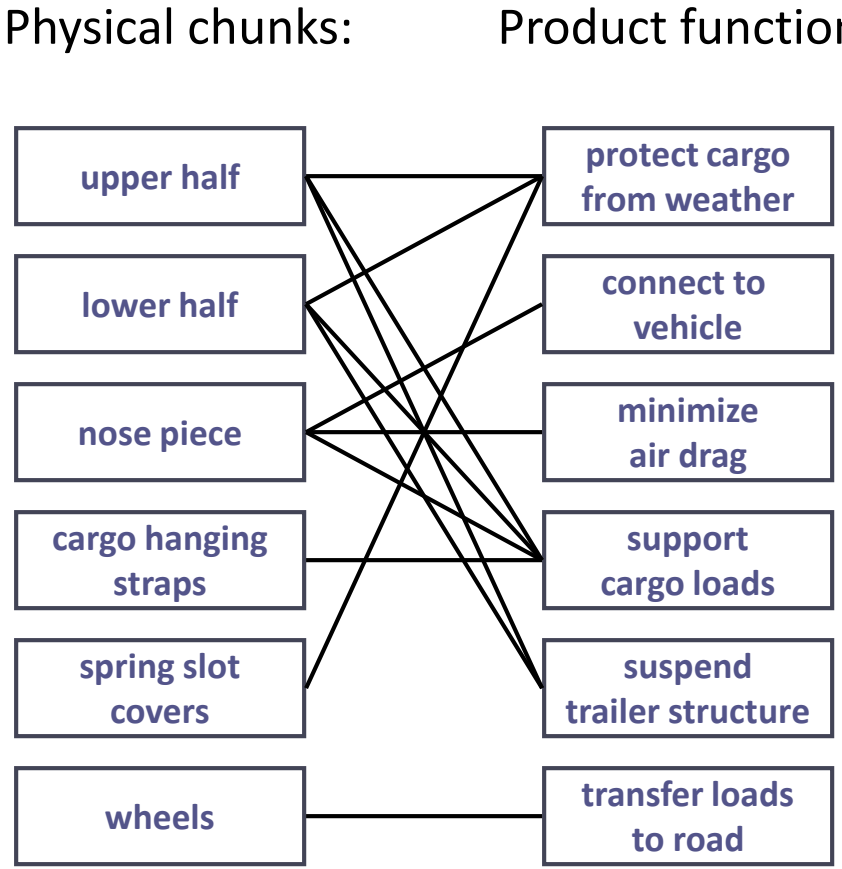


Physical chunks:	Product functions:
box	protect cargo from weather
hitch	connect to vehicle
fairing	minimize air drag
bed	support cargo loads
springs	suspend trailer structure
wheels	transfer loads to road

Integral architecture

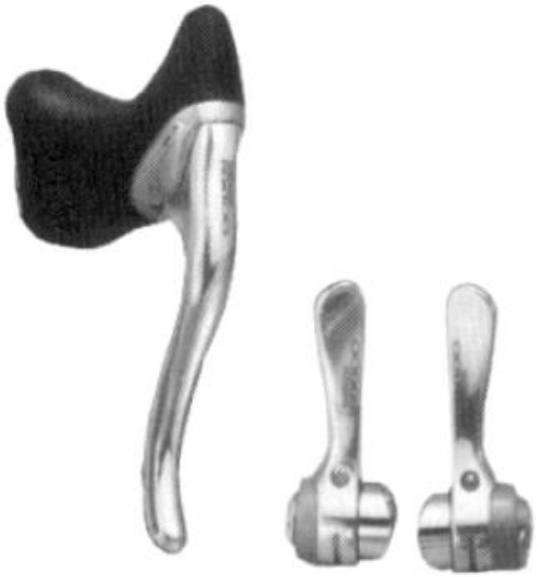
Example: Trailer

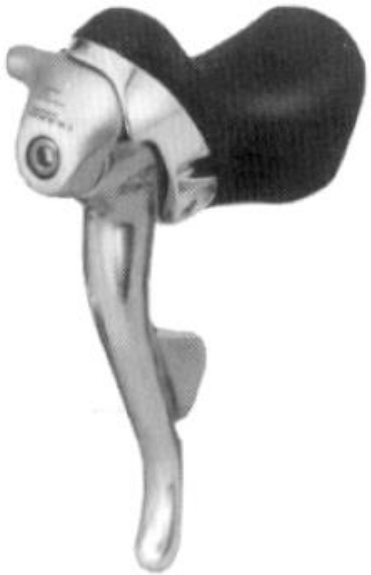




Product architecture

- Modular or integral architecture?

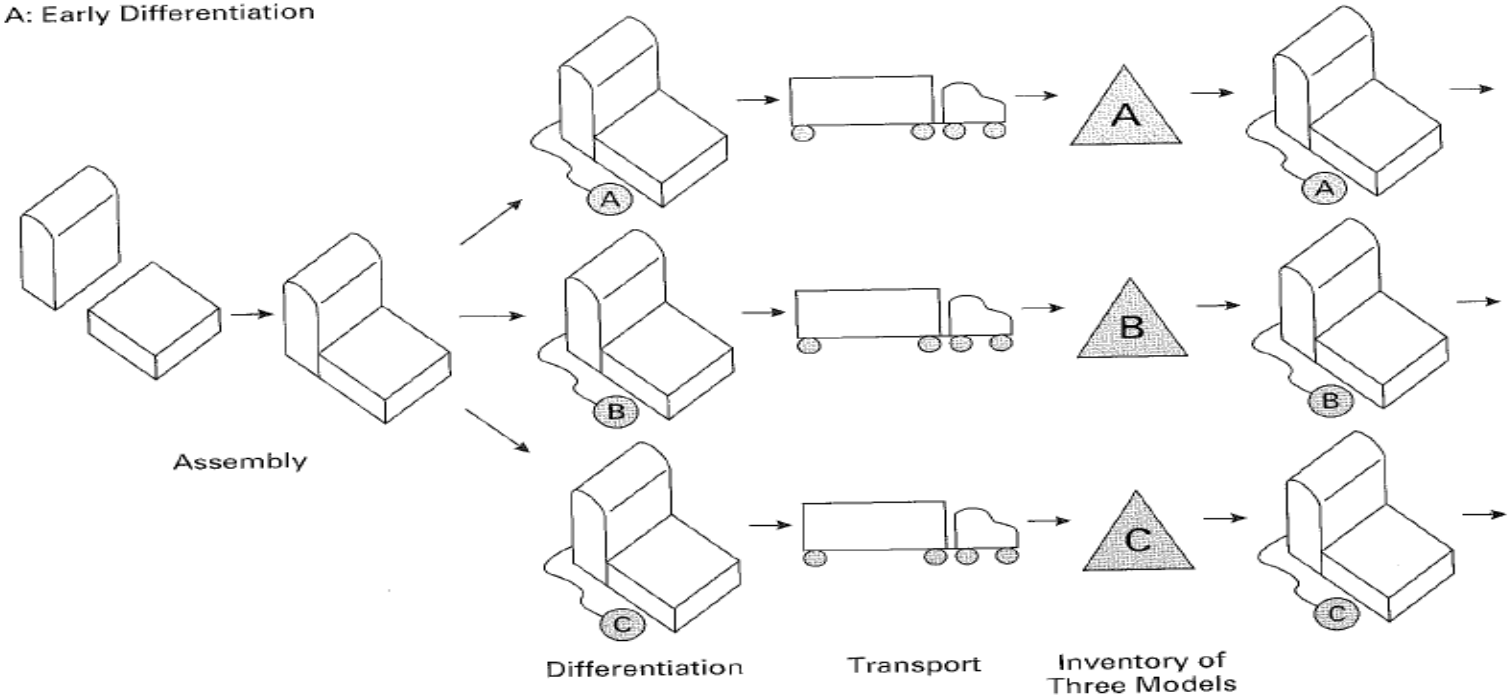




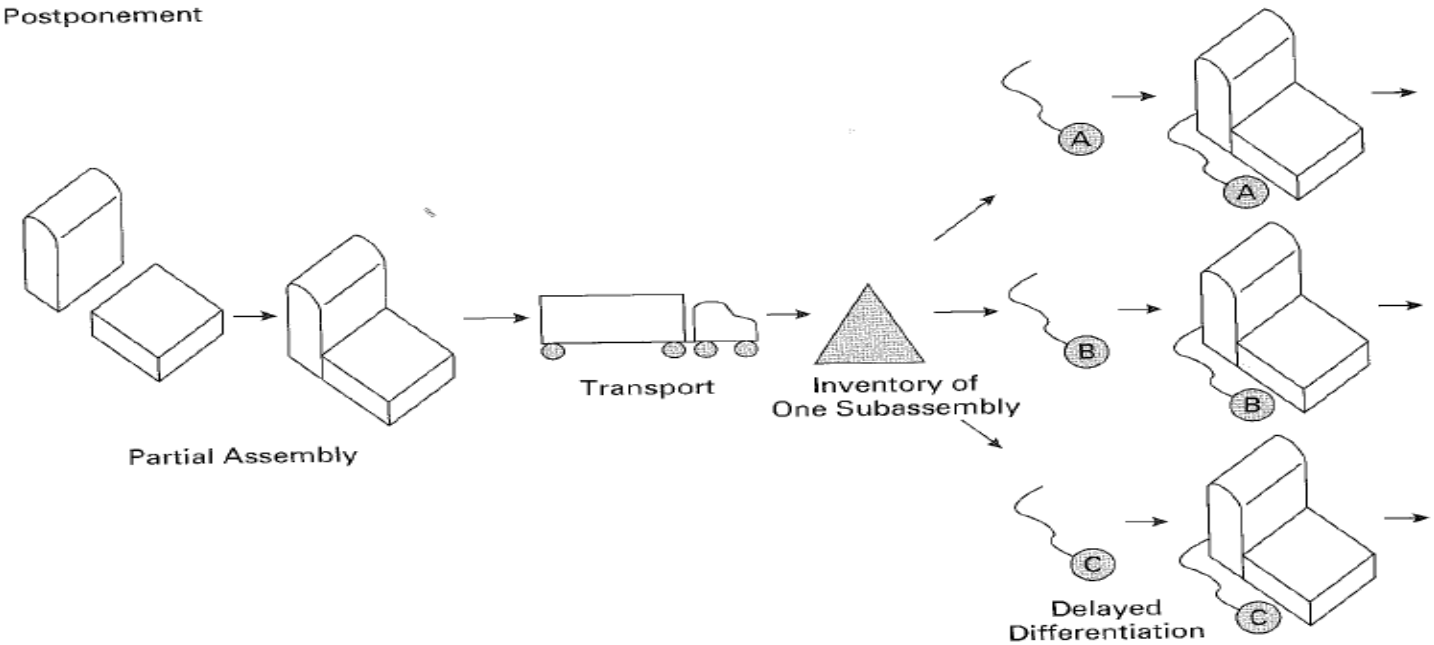
Delayed differentiation

- Product architecture can be a key determinant of the performance of the supply chain
- Delayed differentiation is postponing the differentiation of a product until late in the supply chain
- May offer ***substantial reductions in the costs*** of operating supply chain, primarily through the reductions in inventory requirements.

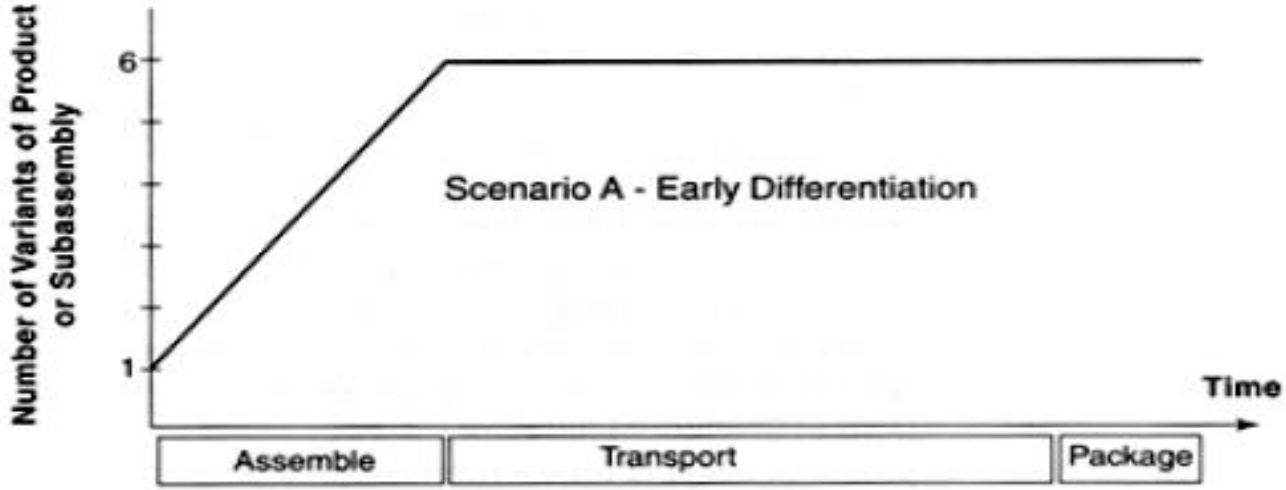
Scenario A: Early Differentiation

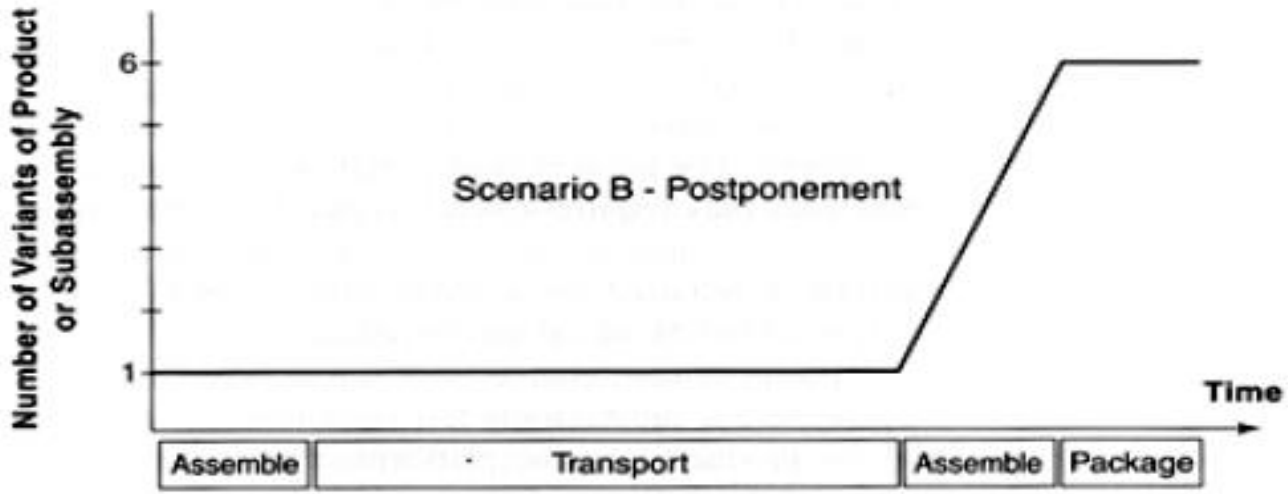


Scenario B: Postponement



Delayed differentiation



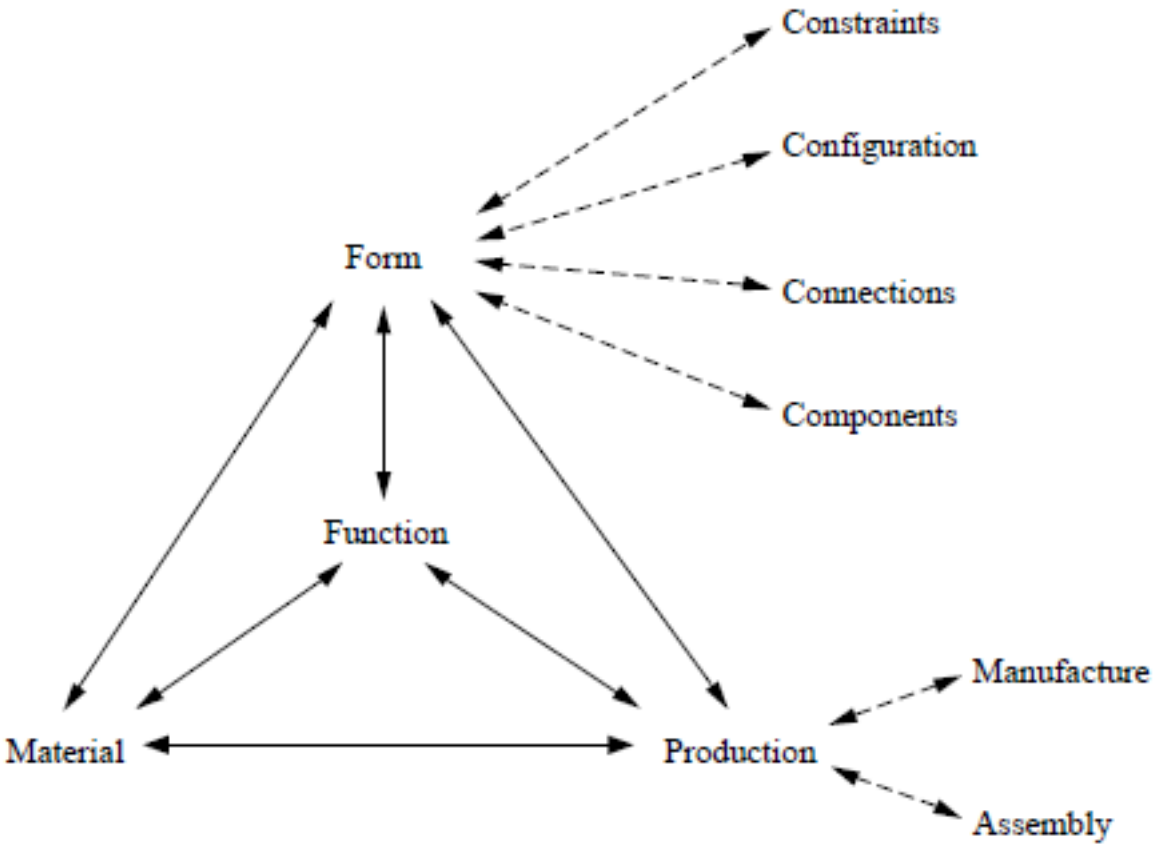


Product generation and parts identification

Chapter 9 from “The Mechanical Design” by D. Ullman

Product generation

- Transform the developed concepts into quality products that perform the desired functions
- Basic elements of product design:



Parts identification

- ***Parts List*** – component parts of a product:
  - part number
  - part name
  - number of parts per product
  - drawing references
  - material
  - size
  - make-or-buy decision
- ***Bill of Materials*** - structured parts list:
  - Similar as parts list but it contains also hierarchy referring to the level of product assembly

PARTS LIST

Company T. W., Inc. Prepared by J. A.
Product Air Flow Regulator Date

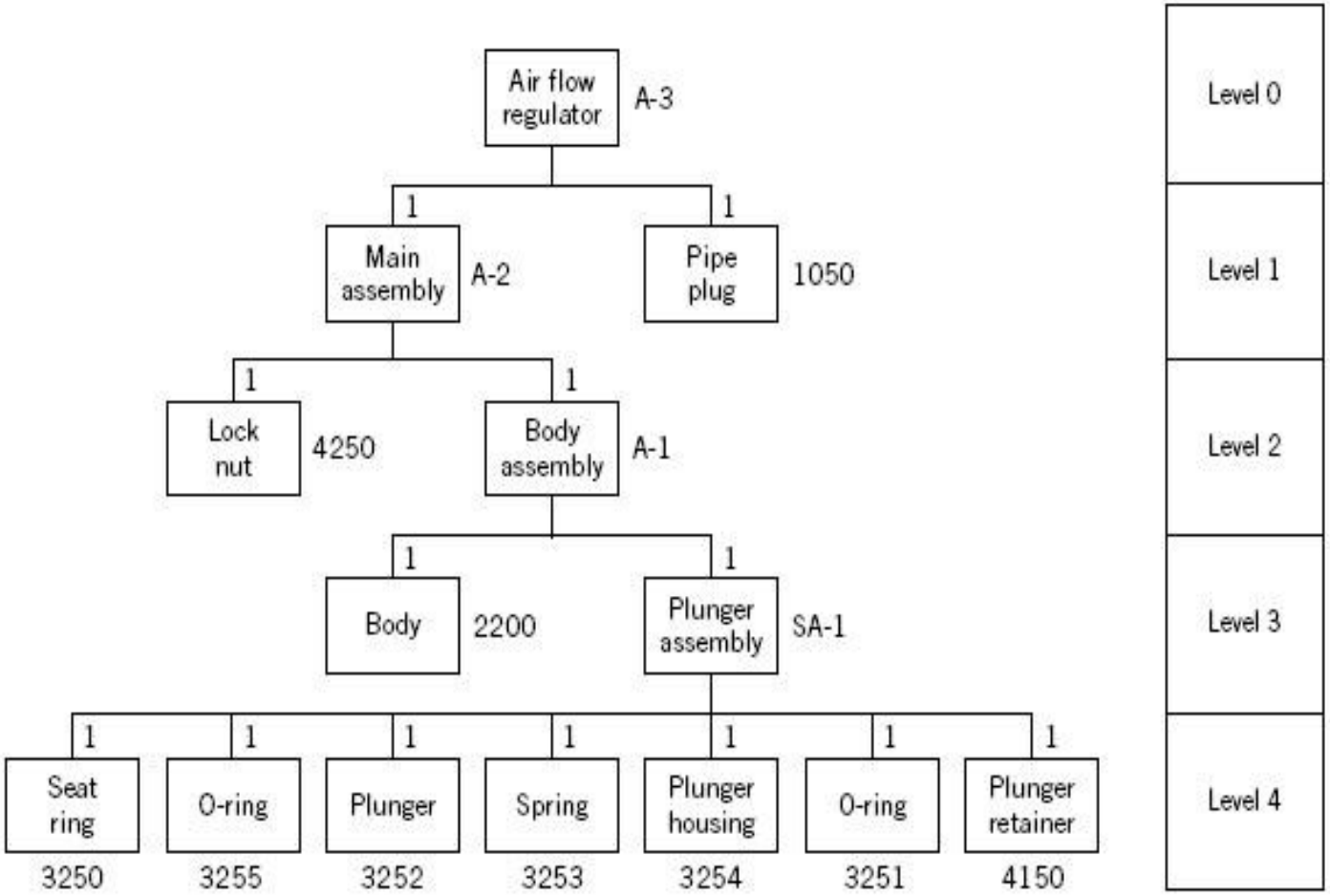
Part No.	Part Name	Drwg. No.	Quant./ Unit	Material	Size	Make or Buy
1050	Pipe plug	4006	1	Steel	.50" × 1.00"	Buy
2200	Body	1003	1	Aluminum	2.75" × 2.50" × 1.50"	Make
3250	Seat ring	1005	1	Stainless steel	2.97" × .87"	Make
3251	O-ring	—	1	Rubber	.75" dia.	Buy
3252	Plunger	1007	1	Brass	.812" × .715"	Make
3253	Spring	—	1	Steel	1.40" × .225"	Buy
3254	Plunger housing	1009	1	Aluminum	1.60" × .225"	Make
3255	O-ring	—	1	Rubber	.925" dia.	Buy
4150	Plunger retainer	1011	1	Aluminum	.42" × 1.20"	Make
4250	Lock nut	4007	1	Aluminum	.21" × 1.00"	Buy

BILL OF MATERIALS

Company T. W., Inc. Prepared by J. A.
Product Air Flow Regulator Date

Level	Part No.	Part Name	Drwg. No.	Quant./ Unit	Make or Buy	Comments
0	0021	Air flow regulator	0999	1	Make	
1	1050	Pipe plug	4006	1	Buy	
1	6023	Main assembly	—	1	Make	
2	4250	Lock nut	4007	1	Buy	
2	6022	Body assembly	—	1	Make	
3	2200	Body	1003	1	Make	
3	6021	Plunger assembly	—	1	Make	
4	3250	Seat ring	1005	1	Make	
4	3251	O-ring	—	1	Buy	
4	3252	Plunger	1007	1	Make	
4	3253	Spring	—	1	Buy	
4	3254	Plunger housing	1009	1	Make	
4	3255	O-ring	—	1	Buy	
4	4150	Plunger retainer	1011	1	Make	

BILL OF MATERIALS



Make-or-buy analysis

- Designers seldom design basic mechanical components (bolts, nuts, bearings, *etc*.)
- Finding an already existing product that meets the needs is less expensive than designing and manufacturing it.
- The existing vendor:
  - Has a history of designing and manufacturing the product
    - Expertise (knows what can go wrong)
    - Machinery
  - Specializes in the design and manufacture of the component
    - High volumes
    - Lower cost

Make-or-buy analysis

- In the past – dealing with a great number of potential vendors
- Nowadays:
  - Small number of vendors
  - Vendors included in the decision making
  - Enhanced <u>relationship with vendors</u>

- How are the make-or-buy decisions made?
  - Can the item be ***purchased***?
  - Can we ***make*** the item?
  - Is it ***cheaper*** for us to make than to buy?
  - Is the ***capital*** available so that we can make it?

Secondary Questions	Primary Questions	Decisions
1. Is the item available? 2. Will our union allow us to purchase the item? 3. Is the quality satisfactory? 4. Are the available sources reliable?	Can the item be purchased?	No → MAKE Yes
1. Is the manufacturing of this item consistent with our firm's objectives? 2. Do we possess the technical expertise? 3. Is the labor and manufacturing capacity available? 4. Is the manufacturing of this item required to utilize existing labor and production capacities?	Can we make the item?	No → BUY Yes
1. What are the alternative methods of manufacturing this item? 2. What quantities of this item will be demanded in the future? 3. What are the fixed, variable, and investment costs of the alternative methods and of purchasing the item? 4. What are the product liability issues which impact the purchase or manufacture of this item?	Is it cheaper for us to make than to buy?	No → BUY Yes
1. What are the other opportunities for the utilization of our capital? 2. What are the future investment implications if this item is manufactured? 3. What are the costs of receiving external financing?	Is the capital avaliable allowing us to make?	No → BUY Yes → MAKE

Make/Buy or Vendor Selection

Decision to be made: Make or buy | **Date:** 09/23/10

Product: Part 234-4B in Espiral

Scale: 1 (low) to 5 (high)

Criterion	Wt.	Vendor 1 Make	Vendor 2 Allied	Vendor 3 Barns	Vendor 4 Crane
Low development cost	5	2	3	2	4
Low product cost	22	4	2	3	4
High product life cost stability	2	5	3	4	4
Low development lead time	7	3	2	4	2
Low order lead time	11	3	2	5	1
High product quality	14	2	3	3	2
Good product support	6	1	4	2	3
Easy to change product	8	3	5	5	4
Strong IP control	18	4	2	4	2
Good control of order volumes	5	4	1	2	4
Good control of supply chain	2	4	4	2	2
Total		35	31	36	32
Weighted total		3.2	2.56	3.47	2.79

Rationale: Choose Barns as it is significantly better than the others in weighted total and has no great weakness.

Next lecture

- Thursday March 26
  - Design for X
  - Assignment 2 – Case study presentations